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# Unbundling 'Indigenous Space Capability'

Actors, Policy Positions and Agency in Geospatial  
Information Science in Southwest Nigeria

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PhD

Science and Technology Studies

The University of Edinburgh

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## Declaration

I declare that this thesis has been composed solely by myself and that it has not been submitted, in whole or in part, in any previous application for a degree. Except where stated otherwise by reference or acknowledgment, the work presented is entirely my own.

Daniel Thorpe

March 2019



## Abstract

Ever since the operation of the first civilian Earth observation (EO) satellites gained momentum in the 1970s, their history has been accompanied by debates over whether in developing countries social and economic development can be promoted through the transfer of space science and technologies, such as remote sensing techniques. Despite continuously growing political and social scientific interest, this debate has so far largely taken place at a comparative level with developing economies and their space programmes as the prime level of analysis. Based on a relevant critical review of development theory perspectives on knowledge and technology transfer to developing countries and corresponding discourses in postcolonial science and technology studies, this thesis moves to the micro-level and provides an ethnography of geospatial information science (GIScience) in Southwest Nigeria. It addresses the limited understanding of social processes that accompany technology transfer by investigating how researchers, who use data from EO satellites, situate themselves in relation to relevant actors, how they conceive their work in relation to society and how they address practices that support their objectives. Research was conducted through multi-sited ethnographic fieldwork and situational analysis at GIScience institutions in Southwest Nigeria, comprising semi-structured interviews, focus groups, participant observation and document analysis. This research challenges the concept of a dependent periphery. Based on individual experiences, researchers in Southwest Nigeria carefully promote EO satellites as a liberating technology that allows them to regain responsibility for unbridled developments at the intersection of Nigeria's natural and social environments. The thesis demonstrates how Nigerian GIS researchers have developed a collective agency towards relevant capacity building that transcends various institutional limitations and inhibiting national and transnational structures. This agency is set against a backdrop of abstract notions of indigenous capabilities and challenging questions about the implications of GIScience in relation to postcolonial discourses on modernisation and dependency. Overall, this research discusses how we should (figuratively) bring EO satellites back down to Earth for policy-related reasons, whilst creating adequate space for EO technologies and related practices in postcolonial STS.

## Lay Summary

Ever since the operation of the first civilian Earth observation (EO) satellites gained momentum in the 1970s, it has been debated whether these space technologies that continuously take images of Earth's surface, can promote social and economic development in developing countries. Social and political scientists, as well as policymakers, have considered this question by looking at space programmes in developing countries that have been established over the last two decades. At a more general level, the transfer of technologies between developing countries and industrialised countries is debated in terms of what technologies are appropriate for the developing partner. With the aim of better understanding relevant issues in the context of EO activities, this research focusses on scientists in Southwest Nigeria who interpret satellite images. It discusses why they do this kind of work and what they consider important in this respect. I have talked to researchers at different institutions in Southwest Nigeria, where satellite images are analysed and have paid attention to their practices and the materials that they use. Based on different experiences, researchers appreciate satellite images in relation to environmental and social processes on the ground that are increasingly experienced as inaccessible through conventional means of observation and analysis. Whilst they themselves and their institutions are affected by social, economic and physical developments, EO scientists in Southwest Nigeria have independent and local ways of improving their knowledge about the use of satellite images and acquiring relevant materials. These practices are discussed in relation to long-standing debates amongst social scientists and policymakers over how appropriate transfers of technologies and knowledge should look like in a postcolonial global development context. This research concludes that the global EO community faces policy-related challenges that impair the effective and ethical use of EO satellites.

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## List of Abbreviations

AARSE	African Association of Remote Sensing of the Environment
AfriGEOSS	African Global Earth Observation System of Systems
AFRIGIST	African Regional Institute for Geospatial Information Science and Technology (formerly RECTAS)
AGEOS	L'Agence Gabonaise D'Étude et D'Observation Spatiale
AGIS	Abuja GIS
ALC	African Leadership Conference
ANG	Association of Nigerian Geographers
AOCRS	African Organization of Cartography and Remote Sensing
ARCSSTE-E	African Regional Centre for Space Science and Technology Education in English
ARM	African Resource Management Satellite Constellation
ASAL	Agence Spatiale Algerienne
ASEAN	Association of Southeast Asian Nations
ASTAL	Advanced Space Technology Application Laboratory
AU	African Union
AUC	African Union Commission
CESRA	Centre for Space Research and Applications (FUTA)
CGIAR	Consultative Group for International Agricultural Research
CILSS	The Permanent Interstate Committee for Drought Control in the Sahel
CNES	Centre National D'Études Spatiales (French Space Agency)
COPINE	Cooperative Information Network
COPUOS	United Nations Committee on the Peaceful Uses of Outer Space
CRTS	Centre Royal de Télédétection Spatiale Morocco
CSTP	Centre for Space Transport and Propulsion (NASRDA)
DBAR	Digital Belt and Road Initiative (China)
DLR	Deutsches Zentrum für Luft- und Raumfahrt (German Aerospace Centre)
DMC	Disaster Monitoring Constellation
ECOSOC	United Nations Economic and Social Council
ECOWAS	Economic Community of West African States
EIA	Environmental Impact Assessment
EM	Electro Magnetic

EO	Earth Observation
EOSAT	Earth Observation Satellite Company
EPOR	Empirical Programme of Relativism
EROS	Earth Resources Observation and Science Centre
ESA	European Space Agency
ESRC	Economic and Social Research Council
ESRI	Environmental Systems Research Institute
EU	European Union
EUMETSAT	European Organisation for the Exploitation of Meteorological Satellites
FAO	Food and Agriculture Organisation
FORMECU	Forestry Management, Evaluation and Coordinating Unit (Nigeria)
FRIN	Forestry Research Institute of Nigeria
FSS	Federal School of Surveying
FUTA	Federal University of Technology Akure
GCI	GEOSS Common Infrastructure
GDA	Geospatial Data Acquisition
GEF	Global Environment Facility
GEO	Group on Earth Observations
GEOSS	Global Earth Observation System of Systems
GIS	Geographic Information Systems
GIScience	Geospatial Information Science
GLCF	Global Land Cover Facility
GMES (and Africa)	Global Monitoring for Environment and Security (and Africa)
GPS	Global Positioning System
GRSS	Geoscience and Remote Sensing Society
GSDI	Global Spatial Data Infrastructure Association
GSSTI	Ghana Space Science & Technology Institute
ICT	Information and Communication Technology
IITA	International Institute for Tropical Agriculture
ILWIS	Integrated Land and Water Information System
IMF	International Monetary Fund
ISNET	Inter Islamic Network on Space Sciences and Technology
ISPRS	International Society for Photogrammetry and Remote Sensing
ISU	International Space University
IT	Information Technology

ITC	Faculty of Geo-Information Science and Earth Observation/ (formerly International Institute for Geo-Information Science and Earth Observation)
JAXA	Japan Aerospace Exploration Agency
JEP	Joint Education Partners (ITC)
KHTT	Know-How Transfer and Training Programme (SSTL Ltd)
LABCARS	Laboratory for Cartography and Remote Sensing
LEC	Lancaster Environment Centre
LEO	Low Earth Orbit
MEDO	Meta Economic Development Organisation
MESA	Monitoring for Environment and Security in Africa
MOU	Memorandum of Understanding
NARSS	National Authority for Remote Sensing and Space Sciences (Egypt)
NASA	National Aeronautics and Space Administration
NASRDA	National Space Research and Development Agency (Nigeria)
NCRS	National Centre for Remote Sensing (NASRDA)
NGDI	National Geospatial Data Infrastructure (Nigeria)
NGO	Non-Governmental Organisation
NIGCOMSAT	Nigerian Communications Satellite Ltd
NIRAD	Nigeria Radar
NISORS	Nigerian Society of Remote Sensing
NRCRI	National Root Crops Research Institute (Nigeria)
NSPRS	Nigerian Society of Photogrammetry and Remote Sensing
OAU	Obafemi Awolowo University
OLI	Operational Land Imager (Landsat)
OPEC	Organization of the Petroleum Exporting Countries
OSGOF	Office of the Surveyor General of the Federation (Nigeria)
OST	Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies (Outer Space Treaty)
PCSTS	Postcolonial Science and Technology Studies
RCMRD	Regional Centre for Mapping of Resources for Development (Kenya)
RECs	Regional Economic Communities (AU)
RECTAS	Regional Centre for Training in Aerospace Surveys
REDD	Reducing Emissions from Deforestation and Forest Degradation
RS	Remote Sensing
SANSA	South African National Space Agency

SAR	Synthetic Aperture Radar
SCOT	Social Construction of Technology
SDI	Spatial Data Infrastructure
SKA	Square Kilometre Array
SLAR	Side-Looking Airborne Radar
SPAEL	Space Applications and Environmental Science Laboratory (OAU)
SPOT	Satellite Pour L'Observation de la Terre
SRP	Scouting Resource Provision
SSK	Sociology of Scientific Knowledge
SSTL	Surrey Satellite Technology Ltd
STEM	Science, Technology, Engineering and Mathematics
STI	Science, Technology and Innovation
STL	Space Technology Ladder
STS	Science and Technology Studies
TA	Technical Assistance
TRIPS Agreement	Agreement on Trade-Related Aspects of Intellectual Property Rights (WTO)
TSX	TerraSAR-X
UAV	Unmanned Aerial Vehicle
UI	University of Ibadan
UN	United Nations
UNECA	United Nations Economic Commission for Africa
UNFCCC	United Nations Framework Convention on Climate Change
UNIDIR	United Nations Institute for Disarmament Research
UNIDO	United Nations Industrial Development Organization
UNISEC	University Space Engineering Consortium
UNOOSA	United Nations Office for Outer Space Affairs
UN-SPIDER	United Nations Platform for Space-based Information for Disaster Management and Emergency Response
UPS	Uninterruptible Power Supply
USAID	United States Agency for International Development
USGS	U.S. Geological Survey
UT	University of Twente
WTO	World Trade Organisation
ZINGSA	Zimbabwe National GeoSpatial and Space Agency





# Introduction

Hope to preserve the environment is not completely lost as our forefathers have proved to be better managers of the environment than us. We have examples from some communities in Nigeria. (Oyelaran 2011, 22)

One day in February 2016, with the sun almost at zenith outside, I wandered in the bookshop of the University of Ibadan in Southwest Nigeria. Whilst enjoying some relief from the daily heat, I came across the copy of an inaugural lecture from 2011: *Written in Flames: A Tale of an Environment in Peril*. In this lecture, Oyelaran, a professor of environmental archaeology in Ibadan, has unwittingly described a hope that has become central to this thesis. Oyelaran refers to nothing less than his hope that the environment can be preserved. Community-based practices in Nigeria that have been passed on from previous generations keep his hopes alive. However, this thesis introduces a community in Southwest Nigeria that Oyelaran probably did not have in mind during his lecture. Furthermore, the origins of this research initially seemed to point away from any local communities on Nigeria's ground. When I proposed the design of this research in 2015, the introduction began with the headline of a brief BBC news article, stating 'Africa joins the space race' (Greenwood 2009). Whilst the headline associates a whole continent with nothing less than a race to outer space, the article refers to the launch of South Africa's micro Earth observation satellite SumbandilaSat in 2009 (ESA 2018b). Preliminary research had indicated that this headline is not simply a catchy outlier but does actually represent yet limited and skewed perspectives in academic, public and policy-related literature. One perspective relates to an understanding of space science on the African continent, whilst the second concerns an understanding of the transfer of high technologies and related knowledge in a postcolonial world, with severe policy-related consequences in the environmental and developmental arena.

Discourses over potential developmental and environmental benefits from space technologies in developing countries, and related challenges, date back to the early stages of civilian Earth observation (EO) programmes in the 1970s. For example, in 1983, the institute of geophysics at the National Autonomous University of Mexico had organised an international symposium to critically discuss a 'Third World Point of View' on the 'transfer of space science and technology' to developing countries (Gall 1983). More than thirty years later such a point of view is still abstract and its construction challenging. This thesis will address a continuously limited understanding of what the transfer of space



science and technologies means beyond macro-comparative economic, developmental and technical terms, by looking at social processes that accompany it. To provide a better understanding, I have focussed on one domain that is frequently mentioned in the context of space science in developing economies – Earth observation (EO). EO and GIScience (Geospatial Information Science) are often used synonymously and describe the science of processing and analysing remote sensing data from EO satellites, such as by means of ground-based geographic information systems (GIS) (Bossler 2002, Tolpekin et al. 2012, Lein 2012).

Several scholars and policymakers have already looked at national investments in space science in developing countries, such as Nigeria's establishment of a national space agency in 1999 and related acquisition of three EO satellites (Isoun et al. 2013, Jason et al. 2010). At the same time, they have not yet provided an empirical case that takes into account those actors that accompany the implementation of EO/GIScience in developing countries through their use of EO technologies. This includes a neglect of relevant policy positions and agency. West Africa's largest agglomeration of capacity building and research in GIScience can be found in Southwest Nigeria. It comprises regional centres like the Regional Centre for Training in Aerospace Surveys (RECTAS)<sup>1</sup> and the African Regional Centre for Space Science and Technology Education (ARCSSTE-E) as well as different Earth science departments, environmental institutions and space centres/laboratories, where researchers make use of remote sensing data from EO satellites.

My argument for a micro-level study on EO research in Southwest Nigeria is based on a review (chapters one to four) of contemporary perspectives on 1) space science on the African continent and 2) technology and knowledge transfer in relation to development theory and postcolonial science and technology studies (PCSTS). In addition to academic literature, this discussion will also include public perspectives (media).

## Research Aim and Methodology

In light of decades-long failures of modernisation theory-motivated technology and knowledge transfer, I first of all appreciate Jasanoff's valuable reminders that in relation to development policies 'alternative visions' of modernity should be supported, and that local communities need time to make choices about transferred technologies and practices (2002, 271-272). At the same time, this reminder will meet different postcolonial conditions, such as complex 'technopolitical entanglements' (Hecht 2011, 11) as we seem to

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<sup>1</sup> In 2016 RECTAS was renamed as African Regional Institute for Geospatial Information Science and Technology (AFRIGIST). As this centre was known as RECTAS during my research, I will continue using this acronym for consistency.

find them in the context of GIScience. This, however, can only be adequately understood at the micro-level by considering relevant actors that shape the implementation of GIScience through experiences and practices. Instead of focussing on economic and policy-related decisions regarding national space agencies in developing countries, this research shifts the focus to those actors who use remote sensing data from EO satellites and build relevant capacity at institutions and Earth science departments in Southwest Nigeria.<sup>2</sup> Against this backdrop, this thesis unbundles unexplained ‘indigenous’ capabilities, as mentioned in literature in relation to societal benefits through space science (GIScience). By acknowledging the abstract use of the attribute ‘indigenous’ in relation to different constituent parts of space science in emerging economies and the divisive understanding of the attribute in the social sciences, I have broadened my methodological and theoretical perspective, and have considered indigenous in a relational sense (Kenrick et al. 2004). This has allowed me to not fall victim to a confined postcolonial lens, but to instead construct an unexplained *locale* in relation to GIScience. In this context, ‘indigenous’ has been used as a sensitising concept that has guided me towards ‘empirical instances’ (Blumer 1954, in Bowen 2006, 2-3). In consideration of the term’s challenging relationship with concepts like knowledge, culture, ethnicity and place, this guidance has taken place in relation to different methodologies and standpoints that all compete for an understanding of technologies in a postcolonial world – whether for theoretical or for developmental purposes. This has eventually led to a multi-sited ethnographic approach (Marcus 1995), which has been accompanied by situational analysis (Clarke 2005). Overall, the resulting empirical (ethnographic) data contributes to a more balanced image of high technologies in a postcolonial world.

### *Policy issues*

My literature review will suggest that the implementation of GIScience in Nigeria should neither be reduced to economic and developmental imperatives, nor to any ideas of a determinist and potentially inappropriate transfer of complex technologies. It should be considered as agency of/for something that we do not yet understand as we have not sufficiently listened to relevant actors. Through qualitative research, this thesis contributes empirical data to promote more equitable discourses on *global* Earth observation activities. Both multi-sited ethnography and situational analysis have allowed me to understand unheeded localities, actors, policy positions and practices in relation to both GIScience in Southwest Nigeria and a wider EO arena. This is of particular relevance in light of

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<sup>2</sup> I met researchers from Nigeria for the first time at the 2014 conference of the African Association of Remote Sensing of the Environment (AARSE).

potentially one-sided legal and policy-related discourses on the future of global EO activities that have been concerning various actors from developing countries since the 1980s (Danilenko 1990, Williams 2005). Hwang (2008, 106) argues that most developing countries are still excluded from many knowledge-related discourses in the *Western* centres of knowledge production. At the same time, despite Africa's small contribution (EO satellites) to an increasingly congested low Earth orbit, as the Nigerian GIScience scholar Akinyede (2013) reminds us, the United Nations now even proposes to discuss the 'Role of Norms of Behaviour in African Outer Space Activities' (UNIDIR 2013b). Whilst they promise to involve those who are affected, policymakers so far seem to primarily locate relevant actors through macro-comparative research with a focus on national space agencies, whilst overlooking the users of space technologies. Furthermore, the empirical data in this research shall also contribute to more equitable environmental policies in relation to EO, and to the policy-related work from Nigeria, where researchers discuss the local implementation of remote sensing and GIS technologies since the 1970s (inter alia Abiodun 1977, Adeniyi 1986, Ogundele et al. 2008, Kufoniyi 2013, Muhammad 2013, Asiyabola 2014).

#### *Development, Modernisation and PCSTS*

In addition to practical implications, this research extends the scope of postcolonial science and technology studies (PCSTS) and development theory by complicating our relationship to localities and related concepts like development, modernity and (indigenous) knowledge (Redfield 2002, 795). In chapter four, we face a recurring postcolonial paradox, where sites of otherness are constructed in relation to knowledge production and technological appropriation, as much as they are simultaneously dismantled (Dove et al. 2009). This urges me to leave some PCSTS perspectives behind to respond to some pressing questions that do likewise relate to (post)-development theory: What can PCSTS look at (in terms of local) and on behalf of whom? What is the place of GIScience in a (post)-development context? These questions have been answered by, amongst others, scrutinising whether the recurring attribute indigenous is developmental jargon, is linked to a 'particular local, sectoral, professional or national policy context', indicates 'ideological and moral loads', is used to circumnavigate the 'real problems', and whether it matters after all (Ellen 2002, 236-237, 255).

## *Research Question*

Against this backdrop, the following major research question drives this research:

1) How is geospatial information science in Southwest Nigeria socially constructed and – related to this – 2) how do relevant actors/social worlds construct the recurring notion of indigenous space capability, and how does this construction reflect the development of the research community?

## **Chapter Outline**

The *first chapter* introduces the social, political, economic and environmental spheres of Nigeria as they are presented in literature. It will discuss how remote sensing technologies enter this stage from a policy perspective. This will further comprise a brief introduction to the most important technical aspects of GIScience as well as EO data policies.

The *second chapter* zooms out and introduces the complexity of space science on the African continent. I will provide a review of different actors that promote the use of EO satellites and GIS systems as part of developmental strategies. Furthermore, the related notion of ‘indigenous’ capabilities will be introduced as a sensitising concept. The second part of this chapter will comprise a relevant discussion of both non-academic and academic perspectives on space science activities on the African continent with a focus on the transfer of EO satellites and implementation of GIScience. Overall, this chapter will constitute a review of a yet limited empirical base, where various actors, their policy positions and agency pass unheeded amidst public (media), policy-related (EO organisations) and macro-comparative (social and political sciences) accounts that focus on national space agencies and convey anything between developmental optimism and resource-related scepticism.

The *third chapter* sheds light on this situation. It will discuss theoretical perspectives on technology and knowledge transfers to developing countries. A central aim is to understand whether the notion of *indigenous*, as related to GIScience for societal benefits, can be further articulated. I eventually highlight the challenges of understanding GIScience in Southwest Nigeria in the context of (post)-development theory and hence the importance of unbundling the recurrent attribute indigenous through qualitative micro-level research.

The *fourth chapter* formulates the empirical and theoretical objectives of this research in the form of a research question. It will then discuss an analytical perspective that has been useful in understanding the social construction of GIScience in Nigeria. This comprises a discussion of ethnographic research in relation to places of knowledge production

and a related geographic and social *locale*. This further includes a relevant discussion of PCSTS. I will subsequently introduce the research design that has guided the collection and analysis of empirical data, covering methodological considerations (multi-sited ethnography and situational analysis), methods and places of data collection as well as ethical issues.

The *second part of this thesis* comprises three empirical and one concluding chapter. All three chapters introduce how relevant actors, their policy positions and agency construct GIScience in Southwest Nigeria.

The *fifth chapter* looks at how remote sensing from EO satellites relates to the environment beyond a mere technical relationship. It will discuss how remote sensing and GIS are embedded in social networks in which these technologies are not only encountered, but gradually appreciated and promoted. The chapter begins by introducing how the use of data from EO satellites has become a *choice* for those researchers, who now use it as an integral part of their work. I subsequently discuss the historical foundation of this choice in relation to collective experiences at the intersection of Nigeria's social and natural environments, where remote sensing and GIS are constructed as a liberatory tool (Hollick 1982) in relation to existing methods of data collection and analysis in Earth sciences in Southwest Nigeria.

The *sixth chapter* looks at the day-to-day agency that GIScientists have in relation to remote sensing and GIS to further understand the position of these technologies in relation to Nigeria's ground. It will be a journey to the intricacies of capacity in GIScience in terms of a researcher's agency towards their daily objectives in GIScience as a liberatory practice. At first sight GIScience in Southwest Nigeria seems constructed as belonging to the periphery of a larger GIScience arena (Hwang 2008). However, any determinist reading of this situation is untenable. My dialogue partners reflect on their situation from the micro to the macro level. I adopt this structure for this chapter to allow them to empirically express their voice.

The *seventh chapter* provides an extended perspective on agency in GIScience in Southwest Nigeria by looking at how researchers understand capacity building and maintain capacity in their situation. Specific material and intellectual relations to the global GIScience arena support a collective understanding of what the GIScience situation in Southwest Nigeria can look like in the foreseeable future in terms of capacity building. This chapter reveals a yet unappreciated agency towards capacity building in GIScience, where technology and knowledge transfer has much more to do with careful preparation than mere integration, and eventually transcends institutional limitations and inhibiting national and transnational structures.

The *concluding chapter* (chapter eight) will discuss this capacity building situation in relation to development theory (chapter three) and PCSTS (chapter four). The first section recalls how researchers reconfigure their ailing relationship with the ground-based field by promoting the use of remote sensing and GIS. In the second section I will discuss how this situation might constitute a paradox in relation to the daily capacity in GIScience (chapters six and seven), but also how a heightened awareness of this paradox can become relevant for ethical policy decisions in global EO research. The last part of this chapter will discuss this situation in relation to development theory and PCSTS. The final section will argue that GIScience is located between the poles of different determinist methodological and theoretical perspectives that, notwithstanding their value in other situations, do not directly account for postcolonial GIScience in Southwest Nigeria.

#### *Explanatory Note*

Though most of my dialogue partners allow me to use their names in this thesis (written consent), I have anonymised a large part of the interview data. Only a few senior researchers (who have given their consent) are mentioned by name as they can be easily identified from their statements and the context in which their statements are discussed.



# Chapter One

## Nigeria's Endangered Environment and Space Technologies

The history of our towns is to some extent, the history of forest use such as refuge, hunting ground, farmland, market, or shrine. (Adeyoju 1981, 8)

Several Nigerian scholars and scholars from other parts of the world are particularly concerned with Nigeria's natural environment in relation to social, political and economic developments. This interplay will be outlined in the first two sections of this chapter. The last three sections will then briefly introduce Nigeria's role in multilateral environmental frameworks. They will further look at how the practice of remote sensing from space is supposed to take effect in this respect. Overall, this chapter will introduce two central elements of this thesis, as they are presented in literature: Nigeria's natural and socio-economic environment and GIScience.

### Nigeria's Social and Political Environment

During my stay in Nigeria I came across an eye-catching book. The front cover shows the contours of the African continent. Oil seems to drop off the coasts of the Republic of Congo and Somalia, whilst the rest of the continent is shaded by illustrations of technologies, such as an oil well. The graphics alone are powerful in illustrating the content – the 'Destructive Extraction and Climate Crisis in Africa'. However, even more unsettling is the actual title of Bassey's book (2013): *To Cook a Continent*. I may borrow it to describe some of the mixed feelings that I have experienced, when observing the beautiful environment that presented itself in front of my eyes, in my nose and on my skin during my stay in Southwest Nigeria.

The days in Nigeria are hot by nature. Southwest Nigeria is part of the tropics and has two major seasons: a dry season that lasts from November till March and a rainy season that lasts from April till October. Temperatures do usually not fall below 20 degrees (mean minimum) and reach a mean maximum of around 32 degrees (Ayanlade et al. 2017, 3). Whilst I got used to the heat within a couple of days, my eyes and nose seemed to sabotage a quick adaptation. On the one hand, I experienced the beauty of the campus





**Figure 1** Fruit bats (*Eidolon helvum*) resting at the Obafemi Awolowo University (Thorpe 2015).

of the Obafemi Awolowo University with its surrounding hills, thick rain forest, and thousands of campus-based fruit bats (*Eidolon helvum*). At the same time, there was the smell of burning waste that entered my room at night, heaps of rubbish along roads outside the campus and burned vegetation. Beauty and destruction seemed to go hand in hand. These observations only scratch the surface of a larger destructive battle that humans have started a long time ago with Nigeria's natural environment. Whilst this battle will only be discussed in the second section, this section will describe social and political factors that support it.

### *Nigeria's 'democratic experiment'*

Whenever two Nigerians meet, their conversation will sooner or later slide into a litany of our national deficiencies. *The trouble with Nigeria* has become the subject of our small talk in much the same way as the weather is for the English. (Achebe 1983, 2; italics in original)

During my stay in Nigeria I learned that more than thirty years after Achebe's words the local small-talk about Nigeria's 'constant failure mode', as Watts describes Nigeria's political modus operandi in the same year, had not receded ([1983] 2013, 466).<sup>3</sup> Achebe's

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<sup>3</sup> Smith reminds us that the concept 'stability' is 'highly normative' (2013, 191).

1983 invitation to convert Nigeria into a prosperous country is now addressed to approximately 150 million citizens that make Nigeria the most populous country on the African continent (Achebe 1983, 2, Pate et al. 2012, 212). One of Nigeria's citizens is Adaobi Nwaubani. She published an article in *The Guardian* on the 14<sup>th</sup> of February 2015 in which she expresses her concerns about the future of Nigeria's 'emerging democracy' after Nigeria's general election, which was scheduled for that day, but was postponed due to political decisions that relate to Nigeria's security situation<sup>4</sup> (Agbibo 2014, 1, Nwaubani 2015).

The postponement of the general election in 2015 is only one indicator of the fragility of the 'democratic experiment', as Oyebade further describes Nigeria's democracy (2002, 137). This experiment had only resurfaced in 1999 with an elected civilian government after almost thirty-three years of military rule. Nigeria's 'first republic', after its independence from British colonial rule in 1960, had ended after only six years in a 'bloody coup d'état'. Thirteen years later, the 'second republic' lasted only between 1979 and 1983 (Adekunle 2002, 407-409, Oyebade 2002, 137-138; 149, Adejugbe 2002, 1-2). Adejugbe describes this as Nigeria's 'vicious circle of politics' in which the 'elected government would betray the trust that was thrust upon it' (2002, 8). Many Nigerians doubt that this vicious circle has ceased in 1999, when Nigeria's current fourth republic began under Obasanjo (*ibid.*, 12-13). Since 1999 Nigeria's governments have not been able to address issues that have been entrenched over decades.

### *Religion, ethnicity and geography*

Over the years, complex religious and group-related tensions have resurfaced under the new civilian governments. For example, in 2000, some of Nigeria's states declared their intention to implement the Sharia system for legal matters. This caused a particular violent outcry in Kaduna, where Christians make up almost half of the population (Soyombo et al. 2002, 100-101). The Sharia issue is exemplary for Nigeria's complex situation in terms of ethnicity and religious affiliation, where the most prominent groups are the largely Muslim Hausa in the North and the Yoruba<sup>5</sup> and largely Christian Igbo (Ibo) in the South. Complex tensions between some members of these larger social groups and various minority groups, that Britain had forced into her colonial state *Nigeria* in 1914, do exist (Figure 2) (Adekunle 2002, 407; 412-415, Oyebade 2002, 149, Ikogho 2011, v).

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<sup>4</sup> In April 2014, Nigeria's domestic security concerns entered the world-stage after a terror group that is publicly known as Boko Haram had abducted a large group of school girls in Northeast Nigeria (Ross 2014).

<sup>5</sup> Yoruba are almost equally affiliated with either Christianity or Islam (Hunwick 1992, 143).

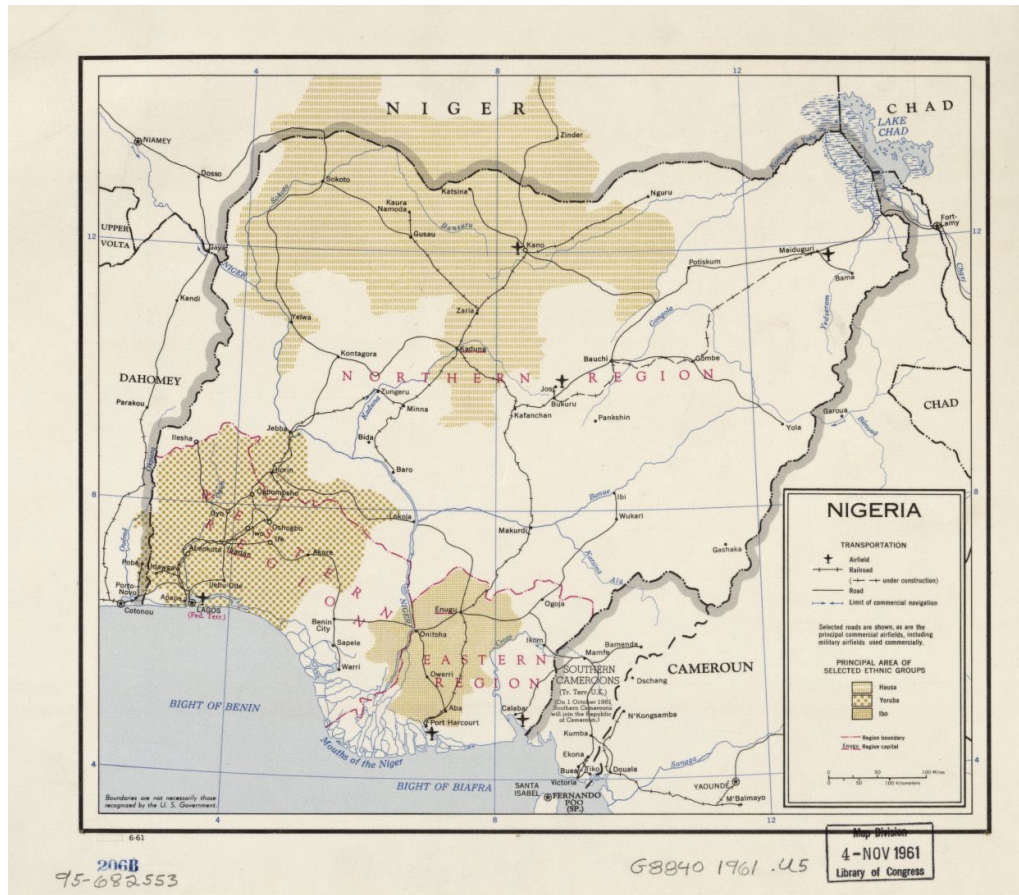
Soyombo et al. see one potential contemporary source of dispute in religious beliefs as a means of creating tensions to follow political interests (2002, 102). Understanding these dynamics is challenging, and the role of religion in relation to ethnicity, place, politics and economic interests does eventually date back to times before the arrival of Islam and Christianity (Falola et al. 2011, 26-36).<sup>6</sup> Elections in Nigeria then usually bring related issues of national integration to light. Simon speaks of an ‘ethnic/regional dimension’ in Nigeria that entails much potential for conflict (2014, 165), where, for example,...

...the south-east geopolitical zone posits that the political pot of Nigeria rests on a tripod of the so-called largest ethnic groups – the Hausa, Yoruba, and Igbo. Since the formation of Nigeria, and especially after the 1967–70 civil war, no Igbo has ever occupied the office of president (...). (Simon 2014, 165)

The related system of rotating power had originally been installed to prevent violence and coups in light of the ‘traditional fault lines of north-south, Christian-Muslim, and majority-minority ethnicities’ (Owen et al. 2015, 456-457). The limitations of this system became visible in the last two elections in which the current president Muhammadu Buhari, a Muslim from the North (elected 2015), ran against the former president Goodluck Jonathan, a Christian from the South (elected 2011) (Mark 2014, Olowojolu et al. 2015, 13-14). This has not only once more caused fears over ethnic tensions, but in Nigeria’s fourth republic the fragile political past, that has complicated national integration, is yet ever-present. Nigeria’s current president Buhari himself overthrew the second republic’s government as a general in 1983 (Oyebade 2002, Nwaubani 2015, Mark 2014, Nossiter 2015, Adejugbe 2002, 9). During Nigeria’s military past, groups, such as academics (whether Yoruba or from other groups), had been viewed with some mistrust in relation to national integration. Achebe states that Obasanjo, one of Nigeria’s former military rulers and later first president of Nigeria’s fourth republic, had ‘held [academics] with great suspicion’ during his military rule in the late 1970s, when academics had not shown sufficient patriotism – as Obasanjo understood it (Achebe 1983, 15). In February 2016, and hence the fourth republic, academics are not only concerned about Nigeria’s national integration, but critically confront Obasanjo with his deficient political legacy in the fourth republic, as I witnessed in February 2016, when Obasanjo visited the Obafemi Awolowo University (OAU) in Ile-Ife – a city that is widely appreciated as the holy ‘ancestral home’ of the Yoruba (Obayemi 1979).

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<sup>6</sup> In Nigeria, religion plays an ever more important role, blended with spirituality that is grounded in ‘African traditional beliefs’ (Lagunju 2005). Magbadelo goes as far as arguing that based on ‘socio-economic and political adversities’ religion has been the only growing ‘sector’ in Nigeria since independence in 1960 (2004, 19-20).



**Figure 2** Map of selected ethnic groups in Nigeria (United States Central Intelligence Agency 1961).

### *Economic inequalities*

Nigeria's socio-religious complexity is influenced by specific political and economic developments since independence. In Nigeria's case, no administration has yet managed to allocate Nigeria's oil revenues in a sustainable way. Whilst Watts warns against using the term corruption in this context ([1983] 2013, 466-467), several Nigerian academics do not refrain from using it. Nwabueze goes as far as stating that '[c]orruption in Nigeria is endemic and anomic, somewhat systemic' (2002, 133). The Nigerian scholar Omeje not only refers to Nigeria as a rentier state that still predominantly relies on 'revenues from natural resource rents', such as from crude oil (2006, 2), but sees ongoing or even growing corruption as a major source of oil-related conflicts and hence instability, supported by malfunctioning institutions and a 'patrimonial political culture'<sup>7</sup> (ibid., 3). Based on Nigeria's

<sup>7</sup> Omeje describes this culture as 'entrenched values, norms and networks of inherited traditional patterns of politics (...), which reflect the outward features of institutionalized administrative states,

relatively high GDP (\$509.9 billion in 2013), several studies nevertheless predict a bright economic future for Nigeria. However, Nigerian researchers like Obamuyi et al. point at several indicators that tell a less optimistic story. They emphasise that the manufacturing sector only makes up 3 percent of Nigeria's GDP, and stress other indicators that might be overlooked, such as that '70% of the country's population lives under on \$1.25 a day' and that corruption has become part of everyday life (2016, 33-36). Furthermore, related 'ethnic and religious bigotry' have to be addressed before Nigeria can think of any stable base for economic development, as the Nigerian scholar Simon argues (2014, 167-168).

## Nigeria's Fragile Natural Environment

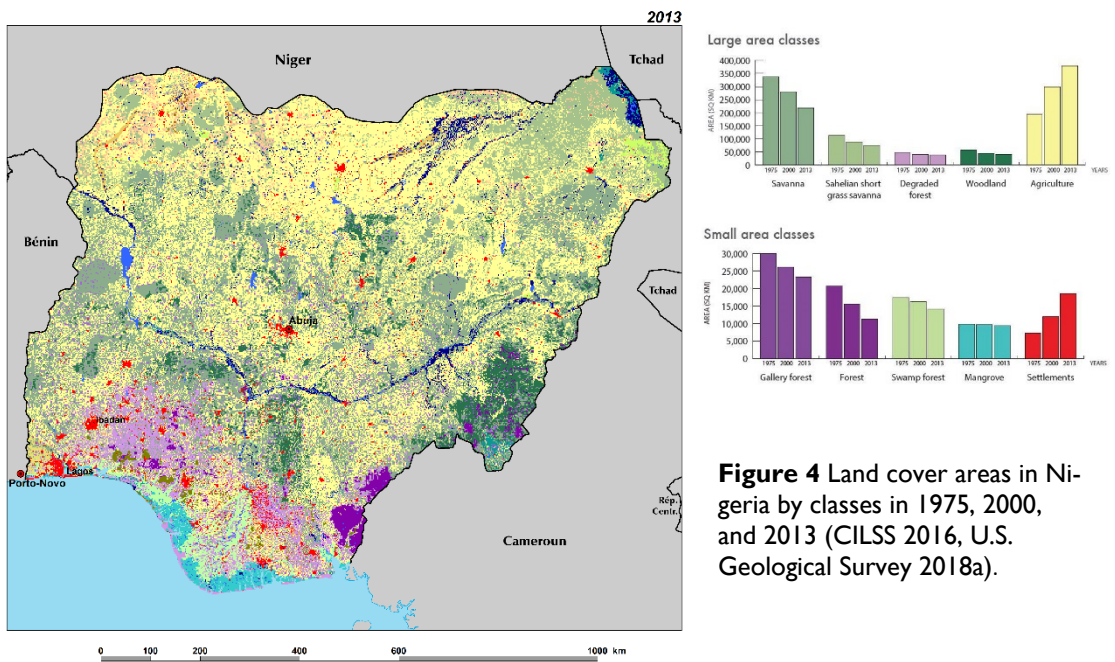
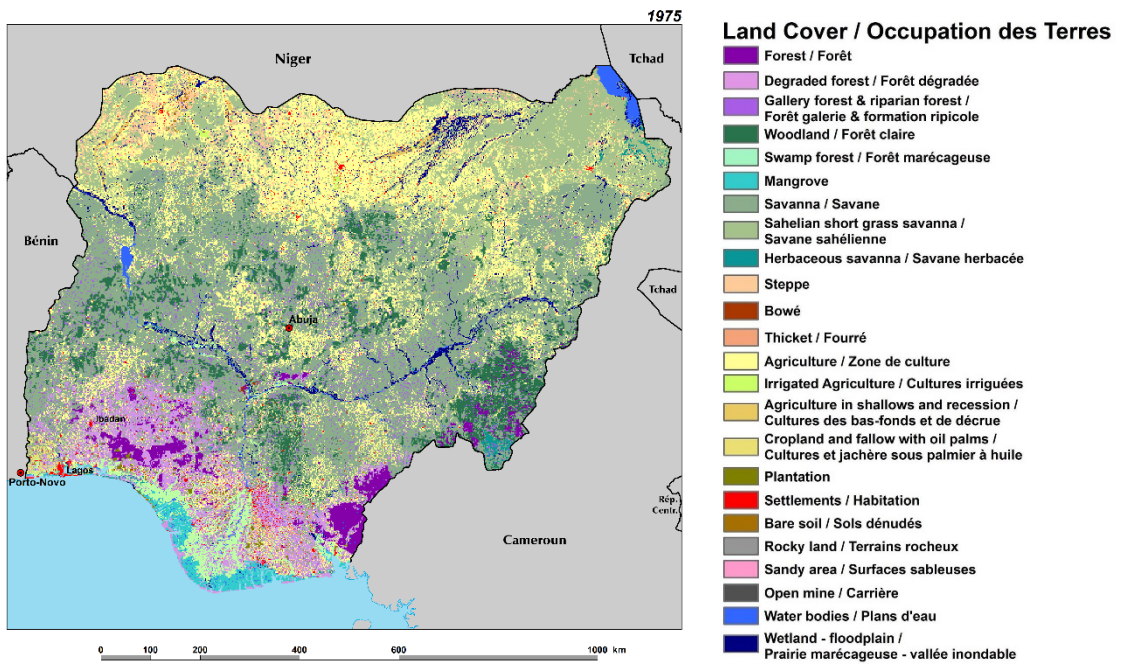
Notwithstanding these socio-political barriers, Nigeria does not only have much potential of being prosperous in light of a large population, but a landmass of 92.4 million hectares of which more than two-thirds are arable. Furthermore, some estimates predict that forests make up at least 10 percent of this landmass (World Bank 2015, Tappan et al. 2016, Omotola 2008, 497-498, Maukonen et al. 2017, 4). However, these favourable figures have been in decline for decades. Table 4 in the appendix is based on various sets of remote sensing data (Landsat) and complex transnational collaboration<sup>8</sup> in producing relevant datasets for West Africa. They show the changes in the region's land use and land cover and indicate that Nigeria has already lost a significant amount of forest (Cotillon 2017). This is only one of many interrelated environmental challenges in Nigeria.

Before Nigeria's focus on oil from the 1970s onwards, agriculture was the 'major contributor' to Nigeria's GDP (Obamuyi et al. 2016, 33) and still plays a significant role as a source of personal income. At the same time, more and more Nigerian researchers worriedly look at the impact of climate change on crops and livestock farming. Ayanlade et al. explain that many local farmers with more than ten years of experience 'perceived a notable change' in Southwest Nigeria's climate, such as increasingly 'unreliable' rainfall. They have compared this perception with historical data from local weather stations and find a positive correlation (2017, 2-7).

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while operating along patron client-networks and trajectories rooted in historical patterns of authority and social solidarity' (2006, 3).

<sup>8</sup> The West Africa Land Use Dynamics project began in 1999 and is a collaboration between AGRHYMET Regional Centre in Niger, institutions in 17 participating countries, the Sahel Institute, the U.S. Geological Survey (USGS) and is supported by the U.S. Agency for International Development and The Permanent Interstate Committee for Drought Control in the Sahel (CILSS) (Cotillon 2017).



**Figure 4** Land cover areas in Nigeria by classes in 1975, 2000, and 2013 (CILSS 2016, U.S. Geological Survey 2018a).

**Figure 3** Land Use, Land Cover, and Trends in Nigeria, 1975 and 2013, U.S. Geological Survey data release (Tappan et al. 2016, Cotillon 2017, CILSS 2016, U.S. Geological Survey 2018a).

In relation to climate change, some researchers use remote sensing data from EO satellites to understand the implications of changes in Nigeria's land cover and land use as well as the rise in sea levels (Ifatimehin et al. 2009, Fashae et al. 2011). Nigerian researchers have also participated in the transnational West Africa Land Use Dynamics project. Figure 4 and Figure 3 summarise the significant changes that they have observed in Nigeria between 1975 and 2013. Nigeria's growing population has amongst others led to a rapid expansion of agriculture to the detriment of forests and savanna (CILSS 2016, 164-173).

This is one of many developments in a vicious environmental circle in which aforementioned socioeconomic developments play a significant role. For example, in the Northeast of Nigeria higher temperatures and less rainfall over the last decades are associated with various changes in the regional hydrosphere. Earth's formerly 6<sup>th</sup> largest lake, Lake Chad, has been a major regional irrigation source, but over the past fifty years has shrunk to approximately 1/10<sup>th</sup> of its size (Sayne 2011, 5) (see also Figure 3). This change fuels conflicts between nomads and farmers, which in the end increase migration to cities and the aggravation of urban social problems (Alao 2007, 227-228). Further south, the Niger Delta is Nigeria's region where oil companies 'move even deeper into the fragile ecosystem' to satisfy the world's demand for crude oil, as Bassey (2013, 118) emphasises. Both on-shore and off-shore oil spills are a disaster for the region. Nigeria's oil production comes with many additional environmental problems. 23 billion cubic metres of natural gas is annually flared, causing severe health risks for the population. Average life expectancy in the Niger Delta is estimated at only 41 years for females and 39 years for males, compared to an already low national life expectancy (53,1 years for females in 2014). A combination of climate change, exploitation of natural resources, general environmental degradation, related social issues (such as scarcity of land) and poor governance spreads in an ecologically sensitive region, where the majority of Nigeria's export products originate from in form of oil and gas (Olorunfemi et al. 2011, 262-279, Usang et al. 2015, World Bank 2017, Bassey 2013, Eneh 2011).

Furthermore, Nigeria's high rate of deforestation supports land degradation and feeds back to climate change. Estimates predict that Nigeria has lost around 55% of primary rainforest within only five years (2000-2005). This also has severe consequences for Nigeria's biodiversity (Abah 2011, 408-409, Baba et al. 2016, 573, Onojeghuo et al. 2015, 24) (see Figure 3). During overland journeys I often spotted cleared patches in the otherwise thick rainforest and smoke that indicated new slash-and-burn activities. Deforestation has many drivers, such as the high demand for fuel wood, agriculture and urbanisation (Abah 2011, 408-415, Baba et al. 2016, 573). Finally, another major environmental issue in Nigeria is the 'War on Filth', as Oyediran titled his book in 2004. During my stay,

I have experienced how thirteen years later, the immense beauty of Nigeria's landscape is still disturbed by waste, abandoned lorry wreckages and other pollutants.

## Nigeria and Environmental Politics

The following statement from 1979 probably has not lost any significance:

The environmental problems of developing countries are not the product of affluence, but of poverty, and socioeconomic needs are often seen as more pressing than the need for environmental controls. However, attitudes vary greatly among developing countries, and have been known to change rapidly. (Walter et al. 1979, 102)

Walter and Ugelow emphasise the link between socioeconomic needs and environmental protection, which became important in the Paris agreement on climate change in 2015. The 25-page document frequently refers to the special needs and concerns of developing countries, including the assistance that shall be provided to support their implementation of the agreement's principles, such as technology transfer and cooperative technology development (United Nations 2015). Several programmes do directly address specific environmental issues in developing countries, such as deforestation, where Nigeria receives international conservation aid. This aid is provided by donors, such as the World Bank and the Global Environment Facility (GEF) (Bare et al. 2015, 5-6). In order to tackle the issue of deforestation, Nigeria is further involved in one of the UNFCCC<sup>9</sup> initiated programmes that focusses on 'Reducing Emissions from Deforestation and Forest Degradation' (REDD+) by supporting the sustainable management of forests in Nigeria (Corbera et al. 2011, 89, Maukonen et al. 2017). This strategy is based on incentives in the form of a 'financial value for the additional carbon stored in trees or not emitted to the atmosphere' (Corbera et al. 2011, 189). In Nigeria, the related socioeconomic entanglements are reflected in a combination of increasing deforestation and declining oil revenues, that together constitute one reason for Nigeria's engagement with REDD+ since 2009 (Asiyanbi et al. 2016, 4, Maukonen et al. 2017, 2). In 2017 the Federal Ministry of Environment of Nigeria concludes a report on REDD+ by making some recommendations on how the initiative might benefit from additional tools and knowledge in Nigeria:

Future REDD+ planning efforts in Nigeria, as more states join the country's REDD+ programme, may capitalize on the enhanced in-country capacity for *spatial analysis* and use of decision support tools. Future work to incorporate multiple benefits in REDD+ planning nationally could include:

(...)

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<sup>9</sup> United Nations Framework Convention on Climate Change



Extension of the use of easily accessible *GIS tools* and *available datasets* to planners and technical staff in other states; (...). (Maukonen et al. 2017, 42; my emphasis)

The idea of using GIS tools and available datasets to support spatial environmental analysis indeed has become increasingly important. The next two sections will discuss what this might mean in Nigeria's case.

## Sensing Nigeria's Environment from Space

In the context of Nigeria's REDD+ work, Nigeria's Federal Ministry of Environment refers to Nigeria's 'enhanced in-country capacity for spatial analysis' (Maukonen et al. 2017, 42). In line with this, the Warsaw Framework for REDD+ includes a section on methodological guidance (Decision 4/CP.15) that, inter alia, suggests to...

...[u]se a combination of *remote sensing and ground-based* forest carbon inventory approaches for estimating, as appropriate, anthropogenic forest-related greenhouse gas emissions by sources and removals by sinks, forest carbon stocks and forest area changes; (...) (UNFCCC 2016, 7; my emphasis)

Combining remotely sensed data from space and ground-based research has become an integral part of global environmental research, Nigeria included (Belward et al. 2015). Whilst Nigeria's relation to satellite-based remote sensing will be discussed in more detail in the next chapter, this section shall provide a brief overview of the technical and methodological aspects that constitute remote sensing and GIS as GIScience.

### *GIScience*

Space-borne sensors on board satellites have been a major contributor to data about Earth's atmosphere and surface for the last few decades, allowing Earth scientists to 'map, measure and monitor how, when and where land resources are changing across the globe' (Belward et al. 2015, 115). This practice is often described as belonging to the domain of Geospatial Information Science (GIScience). Whilst Bossler defines the latter as comprising the following three geospatial sciences and technologies, he also indicates that a clear definition is not expedient: Global Positioning System (GPS), Remote Sensing (RS) and Geographic(al) Information Systems (GIS). When Tolpekin et al. talk about GIScience they refer to 'Earth observation' (EO) (of which remote sensing is a means) and 'geodata processing' (Bossler 2002, 3-6, Tolpekin et al. 2012, 21-25). These terms are often used interchangeably in literature. As stated in the introduction, I will refer to GIScience throughout this thesis and EO, where it seems adequate.

In terms of remote sensing, Tolpekin et al. point at the various definitions that exist and speak of ‘art, science and technology of observing an object, scene or phenomenon by instrument-based techniques’ without being in ‘physical contact with the object of interest’ (2012, 25). In 1986, the United Nations General Assembly provided its own definition of remote sensing in their related *Principles (I)*:

- (a) The term ‘remote sensing’ means the sensing of the Earth’s surface from space by making use of the properties of electromagnetic waves emitted, reflected or diffracted by the sensed objects, for the purpose of improving natural resources management, land use and the protection of the environment; (United Nations 1986)

Whilst ‘remote sensing’ usually refers to observations from space, the history of this practice began in 1858, when Tournachon (Nadar) took the first aerial photograph from a balloon (Vincent 1997, 2). From the 1930s onwards, the use of this aerial practice (increasingly from planes) became known as photogrammetry and air photo interpretation.<sup>10</sup> The term remote sensing became popular in the early 1960s, when the satellite era began and instruments, such as scanners and radiometers, were introduced to measure radiation beyond the visible region of the electromagnetic spectrum. One outcome was a continuous series of Landsat satellites from 1972 onwards (Light et al. 2002, 233-238, Morain 1998, 28-31, Tolpekin et al. 2012, 5, 25, Collier 2016), supported by growing environmental awareness amongst policymakers<sup>11</sup> (Hopwood et al. 2005, 38-39; 44). Nowadays hundreds of EO satellites orbit our planet and create huge amounts of data, which leads to the challenge of making choices in ‘Geospatial Data Acquisition (GDA)’. Researchers need to choose appropriate data in relation to their research aim and relevant methods of processing and analysing (Bakx, Tempfli, et al. 2012, 71-72). Though GIScience is far more complex, a brief overview of the functionality of EO satellites and of methods of data analysis shall be provided.

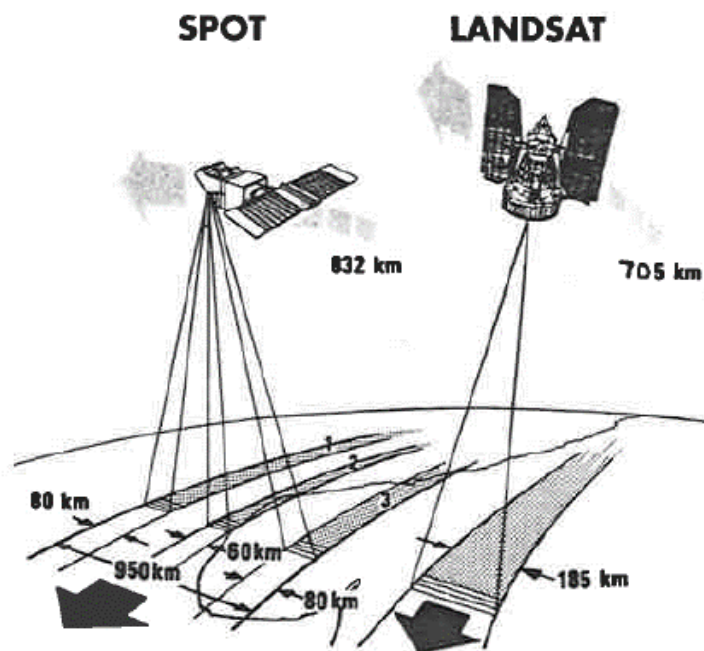
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<sup>10</sup> See Collier (2016) for a detailed historical account of ‘aerial photography’ in relation to methodological and technical considerations in a Western context. Collier’s discussion includes the role that the military has been playing in the promotion of an aerial perspective and related remote sensing technologies since the late 19<sup>th</sup> century.

<sup>11</sup>The influential Brundtland report from 1987 (*Our Common Future*) by the World Commission on Environment and Development (1987) for the first time discussed the urgency for a comprehensive focus on economic and environmental sustainability.

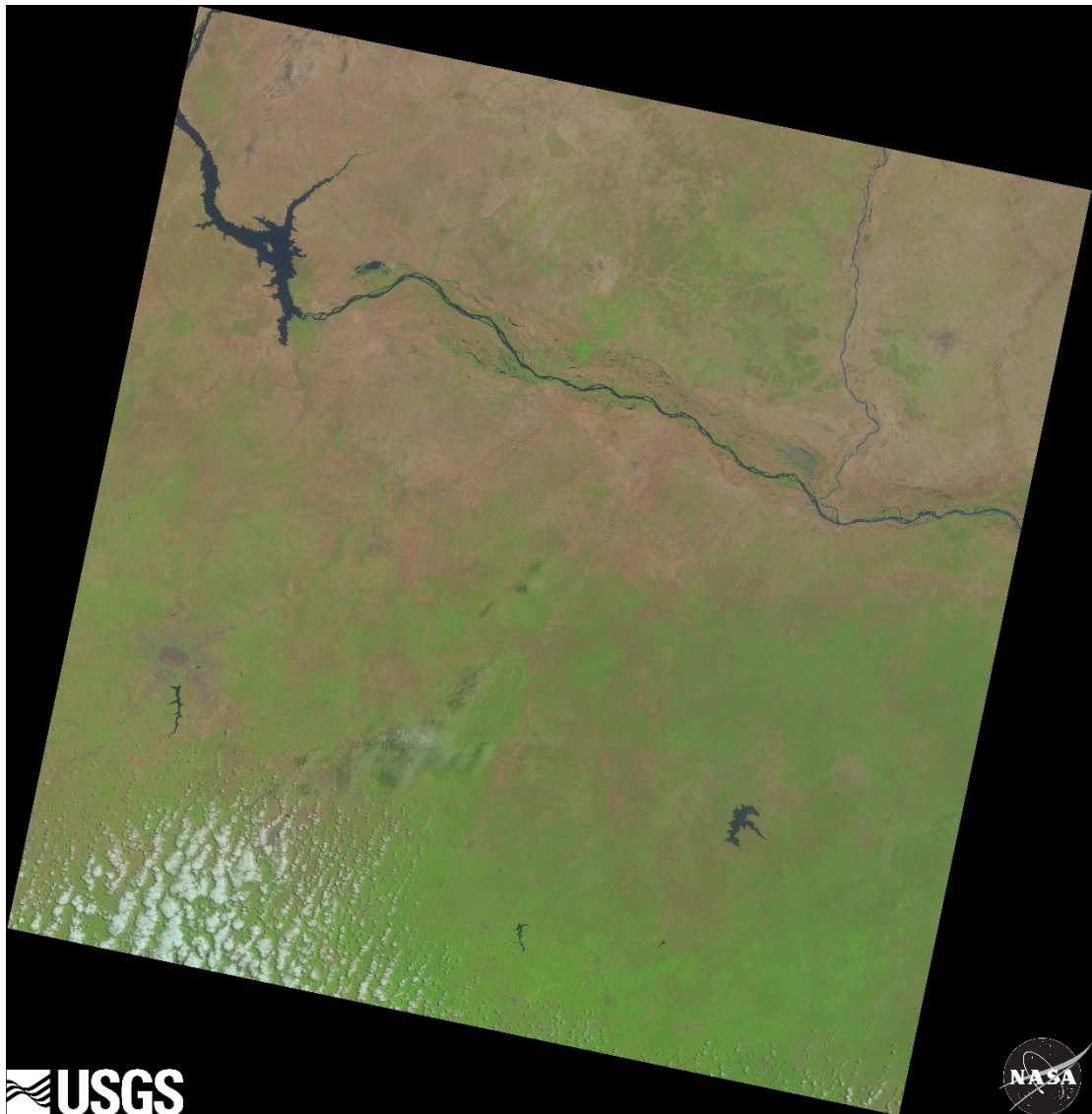
## Remote sensing

Remote sensing begins with radiation from the sun, of which parts interact with Earth's surface by being absorbed, transmitted and reflected. For example, in the case of healthy vegetation, blue and red are largely absorbed by chlorophyll for photosynthesis and reflect low, hence green dominates. Reflectance is of course not limited to the visible part of the EM spectrum. Analysing vegetation types and their stress level works much better by focussing on the longer wavelengths that human eyes are not able to sense, such as in the near- and mid-infrared region. Depending on the features on ground, these portions of wavelengths of the electromagnetic spectrum vary in their usefulness to monitor events. Sensors on board EO satellites hence usually have different channels (bands) that represent the average radiance of these portions to precisely record the reflected radiance of different materials on ground and improve the subsequent data analysis. For example, whilst forest fires with their average temperature of 1000 Kelvin are, based on their radiation maximum, best visible with bands around  $2.9\mu\text{m}$  (micrometre), land surface temperatures without fire are best visible with bands that cover 8 to  $14\mu\text{m}$  in terms of wavelengths (Bakx, Tempfli, et al. 2012, 71-83).



**Figure 5** EO satellites in Low Earth orbit by Bernhardsen (2002, 190).

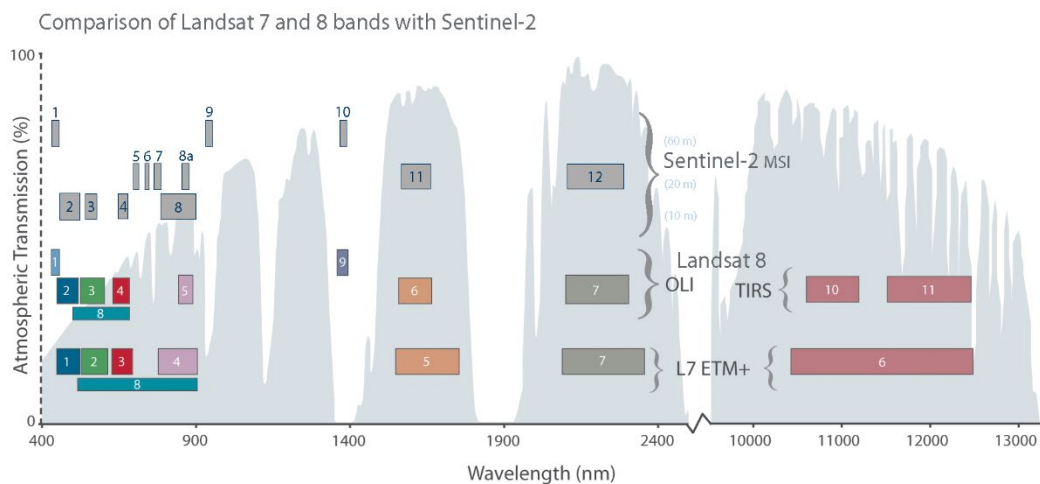
'The reflected electromagnetic radiation from each swath is registered as digital values from which images can be constructed. (a) SPOT; (b) LANDSAT' (Bernhardsen 2002, 190, after NOU 1983).



**Figure 6** Landsat Scene of West Nigeria (accessed by author of this thesis via U.S. Geological Survey on 01.05.2018).

The above image was acquired on the 29th of April 2018 by Landsat 8. The scene shows the Niger (river) in the North. Ile-Ife, as the major site of this research, is not on the image, but is located circa 50km south. The area covered by the scene is approximately 170km from north to south and 183 km from east to west. The location of the scene is path 190, row 054 (8° 41'N, 5° 14'E) (U.S. Geological Survey 2018b).

Combining different bands is an important step during the data analysis, such as in assessing the health of plants and biomass (Bakx, Tempfli, et al. 2012, 84-90, Teillet et al. 1997, 139). The radiance of the specific bands recorded is represented by Digital Numbers (corresponding to one grey value between 0 and 255). During the analysis each band might be assigned a colour to produce a false colour composite, where vegetation can stand out by appearing red-purple (Bakx, Gorte, et al. 2012, 167-173). If the red, green and blue bands are simply assigned RGB, a true colour image (composite) will be visible. Whilst also the Landsat 8 image of West Nigeria in Figure 6 does look natural, it is a composite of the red, near- and short wave-infrared bands 6, 5 and 4 with an emphasis on vegetation. Based on the assignment of colours, it is a false colour image that only looks ‘natural’ (U.S. Geological Survey 2018d, Liu et al. 2016). Figure 7 further illustrates how the bands of NASA’s EO satellites Landsat 7 and Landsat 8 as well as ESA’s Sentinel-2 are sensitive to regions of the electromagnetic spectrum that are of particular interest in GIScience. For example, the visible part is covered by bands 2 (blue), 3 (green) and 4 (red) onboard Landsat 8 (Bakx, Tempfli, et al. 2012, 72). Table 5 in the appendix displays the individual strength of Landsat 8’s eleven bands in relation to different features on the ground.



**Figure 7** Comparison of Landsat 7 and 8 bands with Sentinel-2 (NASA 2015).

### *Processing of remotes sensing data and limitations*

However, before any analysis can begin, corrections of remote sensing data are usually part of the daily work in GIScience, such as of atmospheric disturbances and differences in seasonal illumination. These are only a few of the many issues that need to be

considered when processing raw remote sensing data (Bakx, Gorte, et al. 2012, 174-189). Overall, information from EO satellites is prone to errors and should be complemented by in-situ research (Lein 2012, 12). Only fieldwork on ground can confirm whether a researcher's interpretation of remote sensing data does match a sampled ground-based 'reality' (Bakx, Janssen, et al. 2012, 205-220), and might be needed to draw any conclusions in the first place. Here, two aspects of fieldwork on ground become important. One relates to *visual interpretation* and *semi-automatic processing*, whilst the other one relates to the collection of primary data.

In the case of visual interpretation, our individual abilities of 'spontaneous recognition' and 'logical interference' play a role. In this case, existing knowledge about features on ground are a prerequisite for identifying them on satellite images. Relevant knowledge, such as in relation to patterns, shapes and size, either exists based on the researchers' experience in the field, their professional knowledge, such as in geology, or needs to be acquired by visiting the field. For example, based on my interest in aviation, I tried to find an unpaved airstrip near Bacita in North Central Nigeria. The result is not confirmed, but Figure 8 shows the structure that I identified as a landing strip through visual interpretation (Bakx, Janssen, et al. 2012, 205-212).

In the case of *digital* classification 'thematic data', such as soil types, is generated in a different way. This type of classification is particularly important in relation to studies of land cover and land use that spread over large areas. The acquired image is classified in relation to reference data that is collected on ground – a process that is also known as *ground-truthing*. For the classification of temporary landcover types, the so-called *supervised classification* needs timely 'direct in-field observations' or pre-existing knowledge of features on ground (Figure 9). Though the process is far more complex, it can be summarised as follows. Based on their field observations or knowledge, researchers can identify areas on the satellite image that represent a 'class of interest', such as cocoa (groups of pixels as so-called training sites). Researchers can then manually set the boundaries of similarity in terms of 'spectral reflectance characteristics' that still constitute one class. The satellite image (each pixel) is then further automatically classified. This process will identify sites of cocoa wherever the value of pixels reflects those of the sets of previously 'trained pixels'. In cases where the collection of ground truth data in the field proves challenging, the more 'objective' *unsupervised classification* can be applied. Here, pixels are in the first instance sorted into classes in relation to their remotely sensed 'spectral values' and not in relation to known ground-based features. However, the resultant 'statistical clusters' still lack knowledge about their content and hence will still require 'some knowledge of ground-truth' afterwards – though to a lesser extent. As both methods have their shortcomings, they are often combined (Bernhardsen 2002, 196-197, Liu et al. 2016, 77-102, Richards

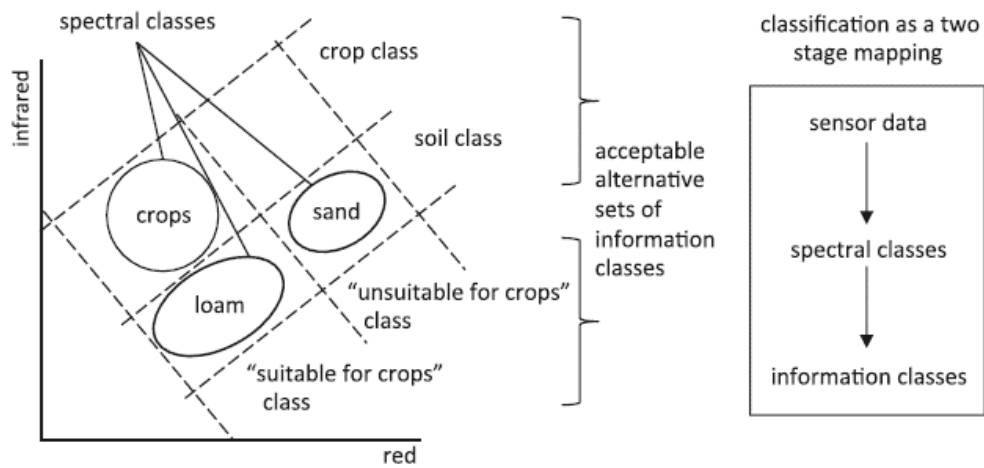
2013, 381-384, Bakx, Janssen, et al. 2012, de By et al. 2012, Van der Meer et al. 2001, 56, Awad 2017, Joyce 1978, Campbell et al. 2011). In the end, a trip to the field is always of advantage, regardless of the chosen method of interpretation, keeping in mind the only truth – that ground truth data ‘can never be 100% accurate’ (Liu et al. 2016, 421-422).

Furthermore, depending on a researcher’s individual discipline-related conventions and their actual research question, a trip to the field might also be required to collect primary data to support the production of end products, such as maps. De By et al. remind that for Earth science disciplines ‘specific survey techniques as ground-based approaches remain the most important source of reliable data in many cases’ (2012, 262). Researchers might, for example, use field surveys to in detail look at features, such as water bodies and questionnaires to collect socio-economic data (2012, 263-267).



**Figure 8** Visual Interpretation of satellite image, produced with ArcGIS Online map hosted by Esri (by author of thesis 2018).

Bacita Airstrip in North Central Nigeria (not confirmed), based on visual interpretation by author of this thesis.



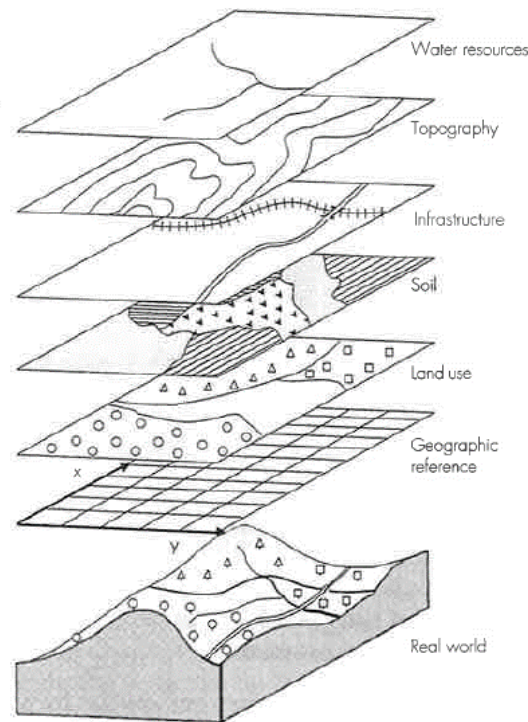
**Figure 9** Spectral and Information Classes by Richards (2013, 249).

This is a ‘simple illustration of the difference between spectral and information classes: in this case the spectral classes have identifiable names; in practice they are more likely to be groupings of data that match the characteristics of the classifier to be used’ (Richards 2013, 249).

### *Geographic Information System*

Processed remote sensing data and data from fieldwork eventually requires a system that can store and render data useful. The relevant Geographic Information System (GIS) comprises computer hardware and software (Goodchild 1995, 41-42, Bossler 2002) and helps to produce geospatial data as ‘[f]eatures shown on maps or those organized in a digital database that are tied to the surface of earth by co-ordinates, addresses, or other means’ (Bossler 2002, 3) (Figure 10). In GIS spatial data is then organised and made utilisable, such as for planning purposes (Bossler 2002, 6, de By et al. 2012, 237-238).





**Figure 10** Visualising layers in GIS by Bernhardsen (2002, 6).

‘One can visualize the data stored as theme layers in the computer, with each layer linked to a common georeferencing system’ (Bernhardsen 2002, 6).

### *GIScience in Nigeria*

In Nigeria, ‘geographical inquiry and spatial data handling’ by means of data from space-borne platforms coincides with developments in the rest of the world (Nkambwe 1986b, a, Areola 1986, 3). After Nigeria had already made use of aerial photographs, ‘modern remote sensing’ was used by Nigerian researchers, such as geographers, from the 1970s onwards. In the 1980s, remote sensing was further promoted by the then existing Nigerian Society of Remote Sensing (NISORS) that aimed at developing and using remote sensing technologies and science for developmental purposes in collaboration with the Nigerian Society of Photogrammetry and Remote Sensing (NSPRS) (Nkambwe 1986b, vii, Ajayi 1992). The integration of remote sensing and GIS in Nigeria will be addressed in more detail in the empirical chapters.

## Satellite Data Providers and Data Policies

The worldwide push for remote sensing-supported Earth science research began less than fifty years ago. Since then many actors that launch satellites and programmes that facilitate data sharing have entered the EO arena. Landsat, as the most long-standing series of EO satellites, began with the Earth Resource Technology Satellite ERTS-1 in 1972 (Morain 1998, 32). According to Morain, Landsat has not only promoted the production of ‘Landsat look-alike satellites’, but of various platforms, such as the non-governmental International Society for Photogrammetry and Remote Sensing (ISPRS) (1998, 39,43), ISPRS states that it is...

...devoted to the development of international cooperation for the advancement of photogrammetry and remote sensing and their applications. The Society operates without any discrimination on grounds of race, religion, nationality, or political philosophy. (ISPRS 2017)

Morain hence speaks of Landsat’s influence on a new global ‘remote sensing paradigm’ by broadening participation and contributing to the development of a unified community of users and suppliers of data, in which new technologies and application areas can fertilise (1998, 39). Meanwhile Landsat 8 has been launched (2013) and orbits at an altitude of 705km. Furthermore, since 2008 users worldwide can download all Landsat data free of charge through the U.S. Geological Survey (USGS) as the current custodian of Landsat data (U.S. Geological Survey 2016, Belward et al. 2015, 117; 126). At the same time, governments and businesses in more than thirty ‘sovereign states and geopolitical groups’ have likewise invested in EO missions (Belward et al. 2015, 115; 120). As of 2013, 879 space objects, that have a value for Earth science, had been launched globally since 1957. However, such figures are difficult to confirm, and will as of recently include various small-scale satellites, such as CubeSats (10cm x 10cm x 10cm, between 1-2kg) (NASA 2017, Belward et al. 2015, 116-117).

In addition to USGS, the European Space Agency (ESA) now likewise plays a significant role in providing free data. Their EO programme Copernicus has its origins in the Global Monitoring for Environment and Security (GMES) initiative and involves a series of Sentinel satellites in low Earth orbit (LEO). Three satellites with different sensors have already been launched and five more will follow (ESA 2017a, Aschbacher et al. 2012, 4-5, Schreier 2010, 2). The Sentinel satellites operate in addition to commercial and national missions, such as Germany’s radar satellite TerraSAR-X, that fill data gaps in relation to Copernicus’ mandate. Furthermore, there is an ‘in-situ’ component, ‘composed of airborne and ground-based monitoring networks’. Relevant products are made ‘available at

the European and global level in environment, climate and security domains’, as Aschbacher et al. further state (2012, 4).

### *Accessibility of data*

Whilst data of moderate resolution from Landsat and Sentinel satellites is available under ‘free-and-open data policies’, there are contributory missions to Copernicus, such as RapidEye, Ikonos (Space Imaging) and WorldView 1/2 (Digital Globe) that constitute commercial standalone missions outside Copernicus. Their high-resolution products are then often expensive (Aschbacher et al. 2012, 5, ESA 2017b, Belward et al. 2015, 116, Schreier 2010, 4). Here, access to the increasingly complex variety of satellite data and related policies is an issue of its own (Nativi et al. 2015, 1-2). Turner et al. ‘broadly’ consider access as ‘the ability of end users to discover, retrieve, and manipulate data and extract useful information from satellite imagery for implementation and monitoring of biodiversity goals’ (2015, 175).

The Group on Earth Observations (GEO) is one collective actor that works on more unified approaches in terms of data access, standards and products (Turner et al. 2015, 175). GEO has 103 governments as members, complemented by the European Commission as well as 106 participating organisations. The group aims at promoting collaboration to reduce duplication and identify gaps in research, such as by establishing a Global Earth Observation System of Systems (GEOSS). GEOSS shall comprise various autonomous ‘observing systems’ and shall address issues of standards and ‘open data policies’ to improve the applicability of EO data (GEO 2017, Nativi et al. 2015, 2). For example, GEOSS Common Infrastructure (GCI) shall help researchers to find and access data and services that are provided by participating agencies of member states and member organisations (Nativi et al. 2015, 2-3). This is a complex task and touches on many issues that Schreier points out in the context of Copernicus:<sup>12</sup>

Embedded in an international context of global programmes, such as GEO/GEOSS, GMES [now Copernicus] need also to find an answer on how to integrate the various data policies from its contributing entities. (...) Not an easy question in the ebb and flow of opinions concerning earth observation data as a public or private good in the recent years. (Schreier 2010, 9)

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<sup>12</sup> Schreier makes reference to the existing European spatial data infrastructure directive INSPIRE from 2007. INSPIRE aims at improving the compatible use of spatial data amongst EU member states.

### *Special attention to developing countries*

As now implemented, in 2010 Schreier emphasised that data from ESA's Sentinel satellites should live up to international open data movements and sharing principles, as promoted by GEOSS and the UN's Principles Relating to Remote Sensing of the Earth from Outer Space, that were adopted by the United Nations General Assembly in 1986 (Schreier 2010, 5, United Nations 1986). The relevant resolution (41/65) frequently refers to the responsibilities of states that '[carry] out remote sensing of the Earth from space'. In relation to non-observing developing countries, their responsibility includes 'non-discriminatory' access to data of a developing country's sensed territories, such as for disaster management and environmental protection (United Nations 1986).

### *Software*

Whilst open data still is a relatively new development in the EO arena, this likewise applies to remote sensing and GIS software. Remote sensing data is often processed with commercial software, such as Erdas Imagine, ENVI and ArcGIS. However, open source software is now widely promoted in GIScience. The open source software GRASS GIS, for example, 'provides extensive tools for a large range of spatial data processing', as Bunting et al. write (2014, 216).

## **Conclusion**

Nigeria is home to beautiful biodiversity and a large population, but many scholars in and outside Nigeria see both Nigeria's environment and any related socioeconomic development threatened. Socioeconomic tensions, post-independence politics, and environmental destruction go hand in hand. One form of environmental degradation is the oil production in the Niger Delta. Whilst the oil production and related pollution have only fully taken effect after Nigeria's independence from Britain in 1960 (Kadafa 2012, 38-43), Bassey relates the beginnings of destructive actions and a general environmental degradation in Nigeria to pre-colonial explorations, when the continent gradually 'became the storehouse, with inexhaustible minerals, plant life and animals, as well as people' (2013, 5).

Against the backdrop of continuous environmental destruction and declining oil revenues, Nigeria has now joined international agreements, partnerships and organisations that aim at mitigating environmental problems, such as deforestation (REDD+). Whilst Nigeria's environmental degradation continues, various researchers from different disciplines in Nigeria work on mitigating the consequences and future destruction, such as by

using data from EO satellites. Following the United States' push for remote sensing from space-borne platforms, also institutions in Nigeria had joined this space-based Earth observation practice in the 1970s by using data from foreign satellites.<sup>13</sup> The global EO arena now comprises various actors and discourses, such as on data policies (United Nations 1986). Whilst most developing countries are only sensed by foreign satellites, Nigeria meanwhile has a space agency that operates EO satellites. Nigeria also hosts UN-affiliated regional centres and other institutions that build capacity in GIScience. The next chapter will consider these developments in relation to the African continent and discuss how they might relate to the continent's and Nigeria's socioeconomic environment from a political, public and social scientific perspective.

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<sup>13</sup> This will be discussed in more detail in the empirical chapters.

# Chapter Two

## Earth Observation and other Space Activities on the African Continent – And their Representation

In conversations I often realised that it usually still comes as a surprise to people that any EO activities, under the abstract category of space science, and the developing world have a long-standing relationship. Before my engagement with this topic, I had no idea either that this relationship had already been under discussion more than thirty years ago. This chapter will discuss that an understanding of a ‘Third World Point of View’ on the ‘transfer of space science and technology’, as it was suggested at the National Autonomous University of Mexico in 1983 (Gall 1983), remains a challenging implicit idea in a wider public and academic context, where both media and literature often imply a comprehensive view on space science in developing countries – that cannot exist.

This chapter begins with a brief review of space/EO-related activities on the African continent. This will be followed by discussing how such activities are represented in media and academic literature. Without presuming that a comprehensive understanding of the implementation of space science in developing countries and Nigeria can be formulated, this literature review pays particular attention to space science with a focus on observations of Earth’s atmosphere, land and oceans (EO) (Okeke et al. 1994, 1226-1228). Overall, it sets the basis for empirical questions that should be answered in this respect. These will be further developed in relation to relevant theory in the next chapter.

### Africa’s and Nigeria’s Activities in the Space and EO Arena

#### Space/EO actors on the African continent

Only twenty-four years ago Okeke et al. (1994) considered serious space activities on the African continent improbable. In line with their pessimistic assessment, earlier in 1983, Gall had already referred to the ‘West African Experiment’ in the context of ‘sophisticated space technology’ and the related training of ‘Third World technicians’. This had ‘proved to be of little benefit to the developing countries’, as Gall remarks (1983, 7). Without prematurely assessing developments that have taken place over the last two decades, relevant literature suggests that by now various actors on the continent are actively or passively involved in space activities with a focus on Earth observation.

### *Defining 'space science in developing countries'*

Africa's space science activities are embodied in various institutions, organisations and private persons. For example, in 2015, the president of the French Space Agency (CNES) commended the 'rapid development in the use of space data' in Gabon. Gabon's agency for Space Studies and Observations (AGEOS) was established in 2010 and now operates a French-funded reception station to download data from foreign satellites, based on agreements with NASA and the Brazilian Space Agency (CNES 2015, MGAfrica 2015, AGEOS 2016). Even earlier than Gabon, Nigeria had founded their national space agency NASRDA that since 2003 operates EO satellites (Isoun 2008, 35, SSTL 2011).

Looking at developments in Gabon and Nigeria, there is a temptation to use Okeke et al.'s account from 1994 as a point of departure to observe the beginnings of EO-related space science on the continent. However, doing so might prematurely constrain what we count as 'space science in developing countries' (Okeke et al. 1994). For example, focusing on the African continent, we can acknowledge that an ESA/CNES 'Ariane launcher tracking station' was installed on Gabon's ground as early as 1986 (CNES 2015) and that Kenya is home to Italian EO activities since 1966. Italy's Broglio Space Centre in Kenya comprises an off-shore launch platform and an on-shore centre for data reception. Though the last launch took place in 1988, an agreement between Italy and Kenya (as of 1995) considers potential future activities and training of local staff (ASI 2009, OnuItalia 2016). This indicates that a history of space-related (EO) activities on the African continent is anything but straightforward. To better illustrate the complexity of pertinent actors, this section will introduce institutions and organisations that are mentioned in relevant literature or that present themselves in the context of EO activities and space science on the African continent.

### *Small-scale space actors*

Before introducing larger actors, it is important to mention that independent space initiatives exist all over the African continent. In South Africa, the Meta Economic Development Organisation (MEDO) runs a special 'space programme' to raise women's interest in STEM. The programme involves the design of 'Africa's first private satellite' (AARSE 2016d). Yet limited space activities on the continent are described as one motivation of encouraging female school graduates to pursue STEM careers:

Africa as a continent have launched but a handful of satellites with South Africa towering with a record of three successful launches into orbit. (...) We chose to enforce change with a space programme. Let's aim high and reach for the stars! (MEDO 2016)

Similar space-initiatives can be found at the individual level. In Kenya, Peter Waswa, a space system engineer, runs the blog ‘Kenya Space Sector Advocacy’, where he expresses his astonishment about Kenya’s hesitation in using space technologies for national development, despite being an advantageous launch site that hosts Italy’s Broglio Space Centre<sup>14</sup> (Waswa 2016a, 2016b, 2012).

#### *Large collective EO/GIScience actors*

At a larger scale, several organisations and initiatives with similar objectives and a specific focus on promoting space-based EO, have developed on the African continent since the late 1980s. For example, the African Association of Remote Sensing of the Environment (AARSE) was officially inaugurated in 1994 and immediately began to connect to international remote sensing organisations, such as ISPRS (Adeniyi 1994b). Twenty years later, the declaration of AARSE’s 2014 conference reiterates the importance of collaboration with the European Commission, the African Union, UNECA and other international bodies. The declaration further reasserts the importance of EO for national ‘development agendas’ and ‘societal benefits’ on the continent (AARSE 2014a). At the same time, AARSE states that in addition to their own work, a continent-wide strategy is needed to support these objectives through recognition in global space activities:

Recognising the need to establish an African space coordinating mechanism to ensure that Africa’s interests are represented in international space program collaborations; and to develop a coherent policy and strategy for utilising space technology for development; (...) (AARSE 2014a)

AARSE is not Africa’s only ‘facilitator’ of EO research (AARSE 2014a). Based on the United Nations Millennium Development Goals and the assumption that many decision makers in African countries are hardly aware of the role that space technologies can play in this respect, Nigerian delegates proposed the African Leadership Conference on Space Science and Technology for Sustainable Development (ALC) in 2004 (Martinez 2012, 33-34). Similar to AARSE, the ALC aims at improving communication of space activities amongst African countries. The ALC programme committee meets on the margins of the United Nations Committee on the Peaceful Uses of Outer Space (COPUOS) (ibid.), of which AARSE has become an observer organisation in 2014.

AARSE is not the only organisation with African member states that has observer status at COPUOS. The Inter Islamic Network on Space Sciences and Technology

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<sup>14</sup> A launch position close to the equator provides additional velocity to a launch vehicle (saving fuel). It further allows launched objects to enter any inclination orbit without expensive additional manoeuvres (ESA 2016a, Campbell et al. 1996, 67-69, Turner 2009, 24-25).



(ISNET) that has member states from Africa, enjoys observer status, as does the African Organization of Cartography and Remote Sensing (AOCRS) (UNOOSA 2016a, ISNET 2016). AOCRS was established as early as 1988, and as of 2007 has 24 member agencies, such as mapping organisations that represent national governments (COPUOS 2016). Their request for observer status with COPUOS, inter alia, states:

We deal in our organization with Remote Sensing and Space Science activity and do coordination between African principal mapping organizations/agencies in different African countries in these fields. (Anwar cited in COPUOS 2016, 3)

AOCRS emphasises the importance of harmonising and coordinating ‘remote sensing and space science’ activities for the benefit of Africa’s national economies (COPUOS 2016). There is yet another organisation that shares similar objectives. In their own words, EIS-Africa is ‘a pan-African membership organization working to improve use of geospatial and environmental information to enrich policy debate and support decision-making for the well-being of Africa’s people’ (EIS-Africa 2014a). The organisation has its origins in the Environmental Information Systems Programme for sub-Saharan Africa in the late 1980s. Their first conference AfricaGIS took place in 1993, and like AARSE, they aim at involving governments, academic institution, development agencies and the private sector to promote ‘the use of Geospatial Science and Technology’ for sustainable development on the African continent (Geospatial World 2014).

With AARSE, ALC, AOCRS and EIS-Africa,<sup>15</sup> we have four African organisations that despite their different organisational and legal structure, share many objectives and transnational networks, such as with GEO, ISPRS, GSDI, UNECA and COPUOS (AARSE 2016b, Geospatial World 2014, EIS-Africa 2014b). Furthermore, they all aim at creating awareness for remote sensing and GIS amongst African policymakers, which in AARSE’s case is formulated as follows:

The primary aim of AARSE is to increase the awareness of African governments and their institutions, the private sector and the society at large, about the empowering and enhancing benefits of developing, applying and utilizing responsibly, the products and services of Earth Observation Systems and Geo-information Technology. (AARSE 2016b)

#### *External collective actors (EU-African strategy)*

We also find similar arguments in the context of a ‘European - African partnership’, which despite all EO-related forums on the African continent, is based on many unknowns, as Giannopapa indicates:

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<sup>15</sup> This list of EO organisations and forums on the African continent must not be considered exhaustive.

There is little overview of how space applications are utilized by African actors and how cooperation between Africa and Europe is organized and conducted. (Giannopapa 2011, 99)

Giannopapa refers to the partnership's 'First Action Plan (2008 - 2010)' that also promotes development through space applications. One related platform is the programme 'Global Monitoring for Environment and Security (GMES) for Africa'<sup>16</sup> (EUMETSAT 2016b). The GMES and Africa initiative aims at strengthening space-based and in-situ Earth observation capabilities of 'African users' (Giannopapa 2011, 99-101). In addition to the African Union Commission (AUC) and the EU, both Europe's space agency ESA<sup>17</sup> and the European organisation EUMETSAT (meteorological satellites) are involved as data providers (EUMETSAT 2016c, Giannopapa 2011). The latter also contributes to the initiative Monitoring for Environment and Security in Africa (MESA). MESA is based on space-based and in-situ data, and in turn supports the mandate of GMES and Africa. Their objectives dovetail with those of aforementioned African EO organisations (EUMETSAT 2016b, MESA 2016a):

The purpose of the MESA programme is to increase the capacity in information management, decision making and planning of African continental, regional and national institutions mandated for environment, climate and food security. (...) MESA is exploiting Earth Observation (EO) data and technologies to promote socio-economic progress towards achieving the Millennium Development Goals. (MESA 2016a)<sup>18</sup>

Within the EO-related EU-Africa collaboration, relevant 'African actors' are regional economic communities (RECs),<sup>19</sup> technical organisations and Africa's space agencies. At the continental level, mandates are divided amongst the African Union (political), African Development Bank (financial) and UNECA (economic), with a joint secretary that coordinates initiatives. In this context, many UN organisations that work on the African continent, such as the Food and Agriculture Organisation (FAO), use data from EO satellites (UNOOSA 2015d, a, b, c, Giannopapa 2011). The technical institutions that are involved, are training centres on the continent. AARSE refers to them as 'institutions that provide skill development opportunities in remote sensing and GIS in Africa' (AARSE 2016c). One relevant UNECA-affiliated institution is the Regional Centre for Training in Aerospace Surveys (RECTAS) in Nigeria. Other relevant training centres on the continent,

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<sup>16</sup> The overall GMES is now known as the Copernicus programme (Copernicus 2017).

<sup>17</sup> ESA also runs the TIGER initiative in the context of satellite-based Water Resource Monitoring on the African continent (TIGERNET 2015).

<sup>18</sup> Under MESA's preceding programme 111 receiving stations for satellite data and environmental data products had been installed in sub-Saharan countries (MESA 2016b, a, EUMETSAT 2016a).

<sup>19</sup> RECs are 'regional blocs (...) which have been established by various African countries to facilitate mutual economic development', such as the Economic Community of West African States (ECOWAS) (Giannopapa 2011, 100).

amongst others, are the Regional Centre for Mapping of Resources for Development (RCMRD) in Kenya, the Federal School of Surveying (FSS) in Nigeria, and the African Regional Centre for Space Science and Technology Education (ARCSSTE-E) that is also located in Nigeria (Giannopapa 2011, 101, AARSE 2016c).

Furthermore, at least five African countries have an official space agency that together contribute to Africa's EO capacity. Most authors refer to Morocco's Centre Royal de Télédétection Spatiale (CRTS 2016), Algeria's Agence Spatiale Algerienne (ASAL 2009), Egypt's National Authority for Remote Sensing and Space Sciences (NARSS 2015), Nigeria's space agency NASRDA<sup>20</sup> and the South African National Space Agency (SANSA 2014) (Giannopapa 2011, 101, Harding 2013, 165). In 2018, also Zimbabwe established a space agency, the Zimbabwe National GeoSpatial and Space Agency (ZINGSA) (AARSE 2018). Other nations likewise host relevant institutions, such as the Ghana Space Science & Technology Institute (GSSTI 2014) and several African countries have institutions that function as National Focal Points<sup>21</sup> for the United Nations Platform for Space-based Information for Disaster Management and Emergency Response (UNSPIDER) (UNOOSA 2015a, 2015e). Furthermore, as of 2018, sixteen African countries are members of COPUOS (UNOOSA 2018) and various additional bilateral and multi-lateral EO collaborations exist amongst African countries and other states. For example, in 2006, Nigeria, South Africa, Algeria and Kenya initiated the African Resource Management (ARM) satellite constellation to operate 'space technologies in the areas of disaster management, resource identification, land use, and public health' (Harding 2013, 193, Mostert 2008, 56, Giannopapa 2011).

### *Many actors, many EO activities*

Overall, the identification of a region's space and EO activities depends on many variables, such as consulted sources and one's definition of space science. The United Nations Online Index of Objects Launched into Outer Space might suggest that with fifty-five member states the African Union lags far behind in terms of emerging space capacity. As of 2016 it indicates that five of only ten member states of the Association of Southeast Asian Nations (ASEAN) have a similar EO capacity (19 EO satellites launched) as Africa's ARM members plus Morocco and Egypt (15 satellites launched) (UNOOSA 2016b, ASEAN 2015, African Union 2018).<sup>22</sup> However, the relevant convention on Registration

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<sup>20</sup> Nigeria also operates a communication satellite (NIGCOMSAT 2015).

<sup>21</sup> UNOOSA (2015e) states that 'National Focal Points (NFP) are national institutions, nominated by the government of their respective countries, to represent the disaster management and space applications communities'.

<sup>22</sup> This includes any registered satellites with EO capacity.

of Objects Launched into Outer Space has not been ratified by all states and gives ample scope for interpretation (UNOOSA 2014, 2008b, 23).

With these limitations in mind, Africa can be considered home to various space activities. This section has skipped many projects and actors. For example, together with Australia, South Africa shall host the Square Kilometre Array (SKA) as the largest radio telescope on Earth (Bock et al. 2015). And despite AARSE's focus on EO, this project was frequently mentioned at AARSE 2014 in Johannesburg, which indicates the complexity of space science-related boundaries on the continent. Furthermore, only two years after AARSE's call for a representation of Africa's interests in international space collaborations, at AARSE 2016 China presented its aims of developing EO collaborations in the context of China's Digital Belt and Road (DBAR) initiative<sup>23</sup> to address common developmental challenges by means of remote sensing in countries of Asia, Europe and East-Africa (Song 2016, 104). In addition to these governmental initiatives, also non-governmental organisations keep an eye on Africa's space developments, such as the Geoscience and Remote Sensing Society (GRSS), the International Space University (ISU) and last but not least AfriGEOSS (Dowman 2006, AARSE 2016a, GSDI 2015, ISU 2012). As part of the Group on Earth Observations (GEO) that aims at facilitating global access to EO data, AfriGEOSS aims at building a 'coordination framework' that brings together all relevant EO 'stakeholders' (production, management and use) and provides the 'linkage country-region-continent' (AfriGEOSS 2018). The aim is to strengthen the role of existing EO institutions on the continent. In AfriGEOSS' own words, this should eventually help...

(...) African countries and organizations as well as international partners to access and leverage on-going local and international bilateral and multilateral EO-based initiatives across Africa, thereby creating synergies and minimizing duplication for the benefit of the continent. (AfriGEOSS 2018)

Overall, Africa's space-based EO activities comprise different independent yet often similar institutional agendas at various levels of regional and global collaboration that all aim at promoting EO for Africa's societal benefits (see Table 6 in the appendix for a non-exhaustive overview). One such agenda might also be an indigenous one, as the next section will discuss.

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<sup>23</sup> The 'Belt and Road initiative' is based on China's ancient trade network with the West (silk road) and involves 65 countries (Song 2016, 100).

## 'Indigenous' EO/space capabilities

In the literature, a discussion of space science for Africa's social and economic development is also often accompanied by the abstract attribute *indigenous*, whose essence has not been clearly articulated by any of the corresponding authors. It shall nevertheless become important in this research – both by virtue of the attribute's divisive nature in social sciences and based on its largely unexplored relationship with high-technologies and science in a postcolonial context. This will be discussed in detail in chapters three and four. The attribute can be discerned in relation to the following constituent parts of space-based GIScience (Table 1).

<b>Indigenous in relation to constituent parts of GIScience</b>	<b>Suggested focus of indigenous</b>
Indigenous as related to a local or national component/capability (most abstract use)	capability, national policy, location
Indigenous as related to understanding and using space technologies on the African continent	understanding, use, application
Indigenous as related to the researcher	individual actors, user
Indigenous as related to an arena of actions	collective actors, economy, development, policy
Indigenous as related to specific technological developments in EO	engineering, technology
Indigenous as related to research objectives	objectives, applications
Indigenous as related to contributory knowledge	knowledge, integration

**Table 1** Relation of the attribute indigenous to constituent parts of space-based GIScience.

*Indigenous as related to a local or national component/capability in space science and technologies (most abstract use)*

In 1994, Okeke et al. use the term indigenous when they point at China's and India's development of a 'reasonably strong indigenous component of space science research', as compared to other developing countries, but leave the term indigenous largely unexplained (1994, 1225-1226). In her paper on 'space agencies in low income countries', also John (2009b) frequently mentions 'indigenous space capabilities' and 'indigenous space activities' in relation to Nigeria's space programme. At first sight indigenous capabilities seem to be understood in relation to geographically and politically locatable competences

and ‘indigenous knowledge’ in developing relevant technologies. In other words, they seem to be appreciated as an alternative to capabilities in industrialised countries (ibid.). However, the adjective indigenous is nevertheless used in an almost tautological manner that does not further elucidate its essence in relation to EO/GIScience (why indigenous and not local or national?). This becomes more evident in the following.

*Indigenous as related to understanding and using space technologies on the African continent*

In 1994, AARSE’s newsletter introduces the reader to the component of ‘indigenous understanding’ of EO technologies as part of ‘scientific and technological capacity development’ that was needed on the African continent to in the long run contribute to regional and international environmental agendas and the related establishment of an EO infrastructure (Adeniyi 1994a, 13). An ‘indigenous understanding’ in relation to capacity building and the use of space technologies, however, remains abstract.

*Indigenous as related to researchers*

Potentially relevant references do usually not further explain the value of using the term. For example, in the context of a GIS technology transfer, the qualities of trained ‘indigenous researchers’ likewise remain abstract, when indigenous as an attribute is not further elaborated (Anonymous in Adeniyi 1994c, 10).

*Indigenous as related to an arena of actions*

Some authors use indigenous to frame a relevant arena of actions. For example, in the context of the African Union’s recently adopted African Space Strategy, space activities on the African continent shall culminate in an ‘indigenous space sector’ to support Africa’s many developmental goals (African Union 2017, 11):

Hence, overcoming Africa’s economic, political, environmental and social challenges is contingent upon a collective effort to formalise and sustain an indigenous space sector that is responsive to these challenges. (African Union 2017, 5)

In this context, indigenous is also used in relation to national space industries in developing countries (Esterhazy 2009, Jason et al. 2010, 581).

*Indigenous as related to specific technological developments in EO*

One such national space industry can be found in Nigeria. In 2010, the Nigerian government describes one of the roles of Nigeria’s space agency by linking the attribute

indigenous to technical aspects, such as the operationalisation of ‘indigenous space systems’ for the provision of ‘space services’. At first sight, they seem to provide a more concrete understanding of the term (Federal Republic of Nigeria 2010, A1252-1253). In the context of implementing mentioned systems, NASRDA has a partnership with the UK-based company Surrey Satellite Technology Ltd. (SSTL). SSTL has several customers in emerging economies, and the ‘indigenous’ aspect of space systems is emphasised in one of their brochures:

SSTL has delivered over 16 tailored training programmes as part of satellite contracts with its international customers, enabling the growth of indigenous space capability and associated industrial development. (SSTL 2013, 13)

Here, ‘indigenous space capability’ shall be achieved through the company’s Know-How Transfer and Training (KHTT) programme. Trained engineers shall eventually be able to build a micro satellite, as one staff at SSTL explains to me (SSTL 2006, Hawkins 2014)<sup>24</sup>. Other authors likewise seem to concretise indigenous capabilities in the context of building and operating EO satellites. For example, Wood and Weigel refer to emerging and developing economies<sup>25</sup> that ‘have already achieved indigenous capability to design, manufacture and operate satellites’ (2011, 1113). In this context, indigenous also appears as an adverb: ‘The South African satellite [SumbandilaSat] has been built with technology developed indigenously’, as Mostert writes (2008, 55, see also Arogun 2012, 120).<sup>26</sup> However, in any of these cases, the essence of indigenous, as related to the construction of EO technologies, eventually remains vague.

#### *Indigenous as related to research objectives in GIScience*

Looking at Gall’s thoughts on space programmes for developing countries in 1983, the term indigenous is also articulated in relation to relevant objectives. For example, Gall refers to the protection of ‘indigenous cultures’ by considering...

...the formation of local groups of high level space scientists and experts; instead of sophisticated transferred technology the use of space technologies appropriate to local economic and social status; services to the poorest fraction of the population and educational programs that protect the indigenous cultures. (Gall 1983, 5)

Gall’s statement is interesting in many respects. Gall links local space scientists, who could be understood as mentioned indigenous researchers, to the use of space technologies that

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<sup>24</sup> NigeriaSat-X was built by Nigerian engineers at SSTL (SSTL 2018).

<sup>25</sup> They refer to ‘India, China, Brazil, Argentina and South Korea’. South Korea is considered an advanced economy by the International Monetary Fund (IMF) (2011, 179-191).

<sup>26</sup> This list is non-exhaustive.

are appropriate, which can be preliminarily related to indigenous technological capacity building. She further includes the objective of protecting ‘indigenous cultures’ through related capacity and ‘educational programs’, which can be tentatively appreciated as above-mentioned indigenous understanding of the use of EO technologies.

*Indigenous as related to contributory knowledge*

In line with this, indigenous can also signify contributory knowledge to capacity in GIScience. When John looks at NASRDA’s impact on capacity building, she refers to three other authors who note that ‘the most effective way to develop indigenous capability is through the incorporation of external knowledge with indigenous knowledge and national priorities’ (Fukuda-Parr et al. 2002 in, John 2009b, 2). Similarly, the United Nations Institute for Disarmament Research speaks of fostering the ‘development and transfer of satellite technology’ in Africa by securing ‘indigenous knowledge’ (UNIDIR 2013a, 2).

*Indigenous – a notion fraught with ambiguity*

Even where a reference to indigenous knowledge seems to explain one component of EO/GIScience capabilities, indigenous as an adjective nevertheless remains ambiguous in terms of its contribution to knowledge and capabilities, as long as the attribute is not elaborated. Against this background, the essence of ‘indigenous skills, knowledge and capacity’ seems all but clear in Oladosu’s and Offiong’s following statement on the role of ARCSSTE-E:

The African Regional Centre for Space Science and Technology Education in English (ARCSSTE-E) was inaugurated in November 1998, with a mandate for the development of *indigenous skills, knowledge and capacity*, through rigorous theory, research, applications, field exercises and pilot projects that can enhance socioeconomic development. (Oladosu et al. 2013, 154; my emphasis)

In the new African Space Strategy, related indigenous space capabilities are mentioned as one anticipated development, but are not further explained:

An indigenous space capability, in both the private and the public sectors, for a coordinated, effective and innovative African-led space programme. (African Union 2017, 13)

Whilst ‘indigenous space capability’ has also been mentioned with reference to advanced economies<sup>27</sup> like South Korea (Schrogl et al. 2009, 84), the abstract notion seems prevalent in relation to the African continent for purposes of some kind of demarcation, whether conscious or not. At the same time, reducing the unexplained attribute to such

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<sup>27</sup> International Monetary Fund (2011, 179-191)



use, whilst ignoring the intricacies of the notion, is not an option as I will discuss in the next sections and chapters.

### **(Indigenous) space-based EO activities in Southwest Nigeria**

Suggested indigenous space and GIScience capabilities shall, *inter alia*, be realised in Southwest Nigeria. The relevance of focussing on GIScience in this geopolitical zone can be better understood with a brief introduction to Nigeria's National Space Research and Development Agency (space agency). In 2008, Nigeria's former Minister of Science and Technology recalls the beginnings of Nigeria's space programme:

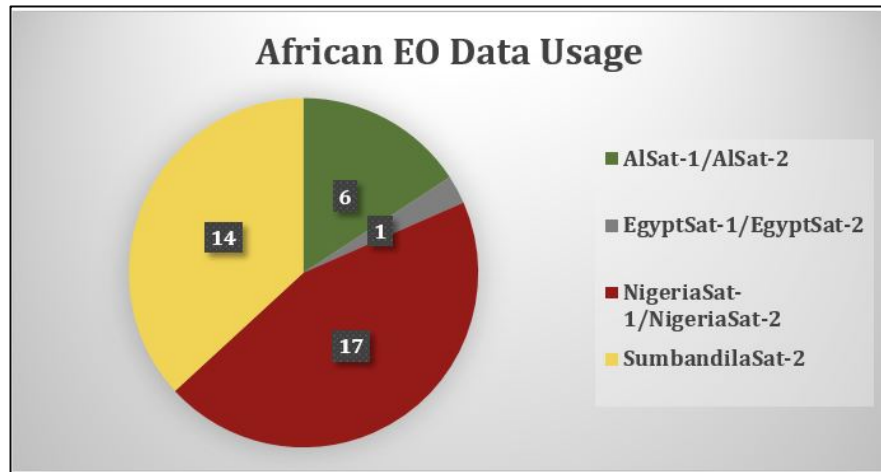
In 1999, Nigeria adopted a 30-year strategic space-policy agenda (...). The country's first venture into space took place in 2003 with the lift-off of NigeriaSat-1, a remote sensing satellite built in partnership with Surrey Satellite Technologies of the UK and launched from Plesetsk, Russia. (Isoun 2008, 35)

NASRDA has several areas of interest, such as 'atmospheric science and astronomy' and 'remote sensing' for environmental, economic and security-related reasons (Isoun et al. 2013, 45). These interests are organised in six activity centres: Centre for Satellite Technology Development, Centre for Space Transport and Propulsion, Centre for Basic Space Science and Astronomy, Centre for Geodesy and Geodynamics, National Centre for Remote Sensing, and ARCSSTE-E (Adetoro et al. 2009). Furthermore, ground receiving stations for satellite data can be found in Jos and Nigeria's capital Abuja (ESA 2016b). Meanwhile, NigeriaSat-2 was launched in 2011.<sup>28</sup> The 270kg EO satellite with medium and high resolution capacity was amongst others designed for 'mapping and security applications' (ESA 2016b). In consideration of this potential satellite-based EO capacity in Nigeria, that is complemented by satellites from three other African countries, AARSE is interested in learning about the sources of remote sensing data that their members from the African continent consult (Figure 11). 147 members replied to AARSE's survey in 2015. However, 'only 38 (25, 85%) have used satellite images produced by African countries' (AARSE 2015). AARSE consequently speaks of an 'unencouraging performance' that should be investigated (*ibid.*).<sup>29</sup>

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<sup>28</sup> It was launched from Russia, together with the 87kg satellite NigeriaSat-X and payloads of other countries (ESA 2016b).

<sup>29</sup> This issue will be addressed in chapter six.



**Figure 11** 'Reader Poll: EO Data Access & Availability in Africa' (AARSE 2015).

#### *Actors who use remote sensing data*

In consideration of AARSE's concerns over the yet limited use of EO satellites that are owned by African countries, it seems important to pay attention to those actors who focus on the downstream aspect of the so-called space economy by making use of remote sensing data. Related GIScience research takes place at various institutions and (Earth science) departments across Nigeria, such as geography and geoinformatics (Asiyanbola 2014, 116-117, Tronchetti 2013). Notwithstanding the little use of data from African satellites, a significant number of institutions and departments that make at least some use of NigeriaSat-1 and NigeriaSat-2 data are based in the geopolitical zone of Southwest Nigeria (Isoun et al. 2013, 14-19). Three of these institutions, RECTAS, ARCSSTE-E and the Federal School of Surveying (FSS), are introduced by AARSE (2016c) as regional centres that can serve Africa in terms of capacity development in remote sensing and GIS. Both RECTAS and ARCSSTE-E are located on the premises of the Obafemi Awolowo University (OAU) in Ile-Ife. In line with this, I will in the following introduce the relevance of Southwest Nigeria in the context of GIScience, as it is described in literature, and how both regional centres relate to the recurring call for indigenous capabilities.

#### *African Regional Centre for Space Science and Technology Education*

In 1990, the United Nations General Assembly endorsed a recommendation by COPUOS to set up UN-affiliated regional centres in developing countries that focus on education in space science and technology. Building related capacity and supporting regional 'socio-economic growth and development' are two interrelated aims (UNOOSA 2008a). All five

centres that have been established through the United Nations Office for Outer Space Affairs (UNOOSA) aim at achieving an ‘indigenous capability for research and applications’ in the following disciplines: remote sensing and GIS, satellite communication, satellite meteorology and global climate, and space and atmospheric sciences (ibid., 2). Two of these regional centres have been established on the African continent: the English-speaking centre ARCSSTE-E in Nigeria and a French speaking centre in Morocco (Chizea 2002, 303, Haubold 2003, UNOOSA 2008a).<sup>30</sup> ARCSSTE-E operates under Nigeria’s space agency NASRDA with funding from the Nigerian government, whilst UNOOSA provides travel grants. The supporting infrastructure is, in part, provided by the OAU. This is complemented by bilateral research programmes, support from foreign institutions as well as links to industries (UNOOSA 2008a, 12-15, Adeoye 2014, 4). The centre is also involved in research projects with departments at OAU (UNOOSA 2008a, 12-15) and aims at fostering international cooperation, such as by serving as a point of contact for the global University Space Engineering Consortium (UNISEC 2014). As of 2008, 120 students from 15 African countries had studied a nine-month postgraduate diploma at the centre, with most students focussing on remote sensing and GIS (Oladosu et al. 2013, 155-156, UNOOSA 2008a, 12).

#### *Regional Centre for Training in Aerospace Surveys*

RECTAS, as another regional centre, is likewise located on the premises of OAU. Under the auspices of UNECA, this bilingual institute<sup>31</sup> was established as early as 1972 by Benin, Ghana, Nigeria and Senegal (Ogunlami 1993, 1-2). RECTAS was likewise founded under the premise of promoting socioeconomic development by means of geoinformation and establishing relevant indigenous capabilities through foreign assistance (ibid.):

The objective was to provide long term training in both English and French languages in Photogrammetry, Photo-interpretation, Remote Sensing, Cartography and some other aspects of Geoinformation production for indigenous Africa manpower developments by Africans in an African environment, for the economic recovery of Africa and regional co-operation and integration among others, through appropriate technology transfer and technical assistances in these areas from developed countries (...). (Ogunlami 1993, 1)

In the case of RECTAS, Africa seems to become the essence of indigenous. However, even if one wanted to explain indigenous through ‘Africans in an African environment’,

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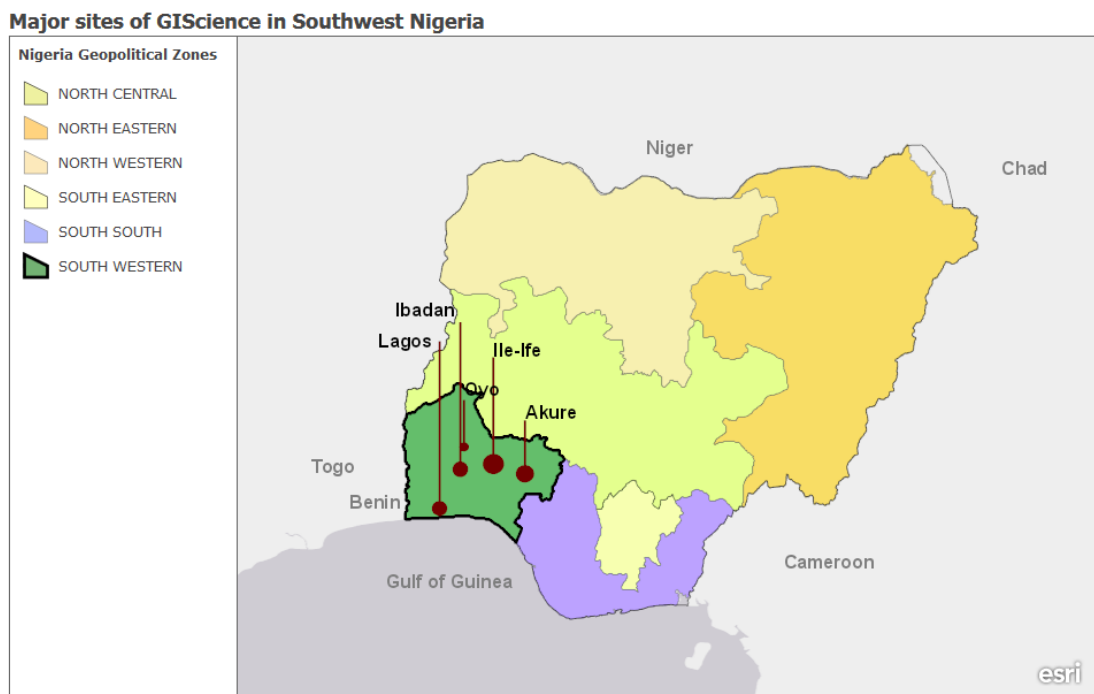
<sup>30</sup> Other UN ‘regional centres for space science and technology education’ can be found in Morocco, India, Brazil and Mexico (Haubold 2003, UNOOSA 2012).

<sup>31</sup> ‘The Centre is a (...) [UNECA] sponsored Institution with a diplomatic status of an International Inter-governmental Organisation fully accredited to the Federal Republic of Nigeria’ (Ogunlami 1993, 2).

this extended attribute remains vague. Today, RECTAS provides training in GIScience, including cartography, and in relevant applications, such as urban management. RECTAS is further involved in research and consulting (RECTAS 2012).

*Other institutions and departments*

Overall, OAU in Ile-Ife has a strong space science and GIScience focus by hosting two major UN-affiliated regional training and research institutions for remote sensing and GIS and by having Earth science departments that have integrated remote sensing and GIS into their curricula and research agendas. Isoun confirms this impression by listing OAU as one of the ‘core establishments for contributing to the development of Nigeria’s capabilities in space science and technology’ (2013, 50-51). In addition to OAU, Isoun lists the University of Lagos, the University of Ibadan and the Federal University of Technology in Akure (FUTA). According to Isoun’s list, the geopolitical zone Southwest hosts most relevant institutions. Ten additional institutions can be found in Nigeria’s other five geopolitical zones and the federal capital territory (ibid.). Furthermore, most researchers from Nigeria, whom I had met prior to my research at AARSE’s conference in 2014, work at institutions in Southwest Nigeria, with the majority from OAU. FUTA is not only geographically close to OAU, but another stronghold of GIScience. FUTA’s departments of



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**Figure 12** Major Sites of GIScience in Southwest Nigeria & Geopolitical Zones; produced with ArcGIS Online Map hosted by Esri (by author of thesis 2018).

Physics, Meteorology, Remote Sensing and GIS and its Centre for Space Research and Applications (CESRA) have degree-related collaborations with ARCSSTE-E and RECTAS (ARCSSTE-E n.d., RECTAS 2012, Oladosu et al. 2013). The major sites of GIScience in Southwest Nigeria and this research are shown in Figure 12.

## **‘Africa joins the space race’ – Representations of *African EO* and Space Activities**

The space science and EO-related actors, developments and policies that have so far been introduced are not simply met with approval. This section will further outline that a focus on GIScience in Southwest Nigeria is important as representations of space activities on the African continent include various unexplained undertones. Looking at media articles that were published between 2010 and 2016, many headlines and articles seem to suggest Africa’s almost *exotic* position with regard to space science. Academic literature discusses the prospects of EO activities on the African continent from different perspectives that will be introduced in the second sub-section.

### **Public writing about space activities *and Africa***

#### *Dreaming of space*

In 2013, a German newspaper article discussed how ‘The Third World wants to go to space’.<sup>32</sup> The reader is introduced to Ethiopia’s astronomical observatory on Mount Entoto. The author describes Mount Entoto as a breath-taking mountain site that probably has for generations served as a spot for stargazing. In addition to this brief reference to an astronomical past on Africa’s ground, the article introduces us to Ethiopia’s additional space-related ambitions, like a satellite in orbit – all despite Ethiopia being one of the world’s economically least developed countries, as the article’s summary suggests (Kaatz-Dubberke 2013).

Around the same time, many other headlines and articles by world’s major media outlets evoked the image of a deprived continent making its first dreamful steps towards outer space. Several articles repeated the story of Chris Nsamba from Uganda who, together with his friends, constructs a space shuttle-like aircraft in a backyard in Kampala. Cavell (2011) began her related article on ‘*African Space Research: Dreaming of a manned Shuttle*’ (BBC) with the words: ‘It would be easy to laugh at Chris Nsamba, founder of the African Space Research Programme’. Other media, such as CNN, were likewise

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<sup>32</sup> Original: ‘Die Dritte Welt will ins All’ (Kaatz-Dubberke 2013).

interested in Nsamba's project: 'One man's space mission to put Ugandans in Space' (Wither 2011). These recent headlines echo the headline of a Time magazine article from 1964: 'Zambia: Tomorrow the Moon' that introduced a Zambian school teacher, who since, has been mentioned in some articles<sup>33</sup> on Africa's current space ambitions:

During the independence festivities only one noted Zambian failed to share in all the harmony. He is Edward Mukuka Nkoloso, a grade-school science teacher and the director of Zambia's National Academy of Science, Space Research and Philosophy, who claimed the goings-on interfered with his space program to beat the U.S. and the Soviet Union to the *moon*. Already Nkoloso is training twelve Zambian astronauts, including a curvaceous 16-year-old girl, by spinning them around a tree in an oil drum and teaching them to walk on their hands, 'the only way humans can walk on the *moon*.' (Time 1964; emphasis in original)

Fifty-two years later, global media interest in space-related activities in Africa has not ceased. 'Orbiting over Nigeria' is the headline of a Time magazine article in 2006. Before, the article's author Robinson (Robinson 2006) described the application areas of NigeriaSat-1, he set the scene by pointing out Nigeria's fragile political past, the high level of poverty and Nigeria's surprising endeavour of operating EO satellites:

What does launching satellites have to do with lifting Africans out of poverty? Just ask Robert Boroffice. He's the head of the space agency of Nigeria – yes, Nigeria (...). (Robinson 2006)

Baker (2012) (BBC) joined in with the article 'Wanting Space: Africa's Journey to Space begins on the Ground' and concludes: 'As Nigeria continues to capitalise on its current satellite technology and Ghana begins to tap into its potential, the sky appears to be the limit for these two West African space programmes'. In The Guardian, Smith (2010) began his article 'Africa prepares to join the big boys in the space race' by quoting science fiction author Larry Niven: 'The dinosaurs became extinct because they didn't have a space programme'. Smith added: 'Africa, the cradle of mankind, has been slow to heed the warning, but that could be about to change'. Reading this, Aron (2013) from New Scientist did eventually cry out: 'Yes, Nigeria has a space programme'. Finally, BBC's (2016) World Service has broadcasted two episodes on 'Dreaming the wrong dream? – We shall fly' – introducing Africa's 'future as a space-going continent'. The recurring narrative of a continent that, to the surprise of the rest of the world, is dreaming of space is also reflected in art projects. For example, in his newspaper article 'Afronauten auf dem Weg ins All' (Afronauts journey to outer space), Neshitov (2012) introduced the reader to a photographic art project by Christina de Middel (2012) – inspired by the Zambian teacher's space initiative in the 1960s.

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<sup>33</sup> For example Kalan (2013).

### *Feasibility of realising the dream*

A limited number of articles seem less interested in capturing their readers' imagination. They are more technical in that they address a specific aspect, such as Africa's science education (Joy 2013) or directly refer to questions over the economic reasonability of space activities in developing countries. The Economist (2013) asks: 'How can poor countries afford space programmes?', whilst Kalan (BBC) states:

To Western eyes, it may seem rather inappropriate to launch space programmes in sub-Saharan Africa, where nearly *70% of the population still lives on less \$2 a day*. (Kalan 2013; emphasis in original bold)

Similarly, a German newspaper titles: 'Nigeria – a country between ambition and reality' and argues that in 2003, 'the then-government even had the presumption to establish a space programme to catapult Nigeria from stagnation to modernity' (Drechsler 2016).<sup>34</sup> Overall, most media articles remain abstract and indeed carry an undertone that appears 'half patronizingly, half cynically', as one blogger comments with regard to Cavell's article on the backyard space project in Uganda (Nielsen 2011).

### *A divisive public image of space activities and Africa*

This abstract public representations of space and Africa seems reflected in a governmental dispute over UK's development aid to Nigeria, as described in a Telegraph article in 2013:

Tory MPs have criticised [Greening's] department for allocating more than £900 million in government funds for social and educational projects in Nigeria when the country is spending its own money on training an astronaut. (Ross 2013)

Regardless of whether these are the actual allegations from Members of Parliament or not, this passage suggests that (mis)understandings are constructed at various levels, based on potentially flawed information. For example, in a relevant press release by Nigeria's space agency, this debate is eventually directed towards the agency's EO satellite-related partnership with SSTL in the UK (NASRDA 2013). The UK's former International Development Secretary Justine Greening, who was questioned about Nigeria's space activities, likewise refers to Nigeria's EO satellites (though described as weather satellites). On BBC Radio 4's Today programme Greening publicly defended their value for Nigeria's social and economic development, such as in relation to agriculture (Today 2013, Ross 2013). It is important to mention that this brief controversy about Nigeria's engagement

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<sup>34</sup> Translated from German by the author of this thesis.

with space, is also joined by Nigerian citizens, such as by Nkemji[pseud.] (2011), who refers to another ‘white elephant’ project below a relevant article about Nigeria’s second EO satellite (Amos 2011). In the end, many different truths about space activities on the African continent seem to circulate. The next section will complement discourses in media by introducing an academic perspective. It will assess whether available literature can provide a more in-depth understanding of alleged indigenous space science ambitions on the continent.

## **Scientists on Africa’s space science and EO research**

Scholars from different disciplines have brought in frameworks of analysis to understand the implementation of space science in developing countries and draft policy recommendations. The central frameworks and general positions towards space science and EO in developing countries will be discussed in this section.

### *The comparative and linear understanding*

One approach is of comparative nature. Some researchers use frameworks that allow for the mapping and comparing of policy decisions in implementing space science and technologies across different countries. Wood and Weigel, for example, analyse the ‘evolution of satellite programs in developing countries’ by using a framework that they introduce as the ‘Space Technology Ladder’ (STL). The STL describes a linear path to a nation’s full space capability in a global space economy, comprising various developmental stages. The first step is the establishment of a space agency, whilst the last stage of the ladder is only reached through national autonomous launch capability. The ladder proves to be a taxonomy of space activities, where Nigeria has at least reached the second stage, thanks to its EO satellites (2012, 17-19). Whilst mapping a country’s space capability based on available information about space programmes allows to see differences in policies and strategies across countries, Wood and Weigel nevertheless focus on a linear understanding of ever-complex ‘national space technology capability’ (ibid., 20-22). In this context, the STL reminds one of comparative developmental models, such as Rostow’s five stages of growth that each economy shall pass, from a traditional society that relies on ‘pre-Newtonian science and technology’ to a society of ‘high mass-consumption’ (1990 [1960], 4-16). Wood and Weigel emphasise that understanding space capabilities through a comparative framework allowed to cover various countries by means of key data. They, however, acknowledge that understanding mapped strategies usually requires a more detailed focus (2012, 23).



Other authors have a similar comparative and linear approach. Instead of a ladder, Leloglu and Kocaoglan introduce a ‘space technology pyramid’ that describes different stages. It includes a wide stage at the bottom that comprises users of space technologies and a narrow stage at the top, which a country can only reach through manned missions in space (2008, 1879-1882). A similar linear comparative perspective on national space-related investments is also visible in Harding’s (2013) book *Space Policy in Developing Countries*. Harding speaks of tiers that allow to describe and compare a developing country’s space capacity in terms of their capabilities and formalisation of space policies. His first chapter describes related processes as ‘part of a logical progression’ in the context of national economies, and shall contribute to the development of a theoretical framework for the new academic interest in ‘space power’ (ibid., 12-14, 78-79, 145-146).

### *The linear developmental narrative*

Most authors who look at the implementation of space science in developing countries express their optimism in terms of the potential impact that space technologies can have on socioeconomic developments, provided that sensible decisions accompany a nation’s climbing of the space ladder. For example, Esterhazy from the company Thales Alenia Space argues that a domestic space sector allows developing countries to leave the position of being a provider of raw materials to a higher position in the ‘value chain’, and that it helps to address ‘key societal challenges’ on condition that relevant provisions, such as human capital, are made (2009, 1056-1057). In this context, Jason and colleagues discuss experiences of Nigeria, Algeria and Turkey with Surrey Satellite Technology’s (SSTL) ‘know-how and technology transfer programme’ that comprises training in engineering of satellites, EO applications, policy-related issues and eventually collaboration in a Disaster Monitoring Constellation (DMC). The first constellation included NigeriaSat-1, that was built at SSTL, and satellites from Algeria, Turkey, China and the UK (Jason et al. 2010). It is described as belonging to an ‘affordable’ package of technology and knowledge transfer that also allows to collaboratively share data for disaster relief. Whilst Jason et al. identify several structural challenges in climbing the ladder of space capabilities, such as qualifications of engineers and financial issues, they eventually share common optimistic narratives, as they can be found in many relevant articles, such as regarding economic growth, environmental protection and mitigation of brain drain (ibid.). Regarding Nigeria’s and Algeria’s DMC experience they conclude:

(...) [The governments] have been able to support national capacity building gaining their own guaranteed source of Earth observation data, with control over where, what and when this is taken. (...) Having a guaranteed influx of satellite data, local user groups

have flourished supporting diverse areas of national interest, resource management and environmental sciences. (Jason et al. 2010, 576)

Notwithstanding this positive assessment, their colleagues Leloglu et al. acknowledge that at many space conferences the general attitude towards space capability in developing countries was rather sceptical. Many participants would argue that developing countries should focus on making use of data, as outer space would already host ‘enough earth observation and communication satellites’ (2008, 1881). Whilst Leloglu et al. counter this argument by referring to the long-term developmental impact of related technology and knowledge transfer, they do acknowledge challenges, including the possibility of ‘complete failure of maintaining’ transferred technologies, and suggest to have a wider discussion in this respect (ibid., 1883-1886).

*A limited perspective – the methodological issue*

The need for a wider discussion on space science and technologies in developing countries is also expressed by other authors. Giannopapa refers to a flawed understanding of space applications on the African continent and Europe’s role in this respect (2011). At the same time, by suggesting three user types, Giannopapa supports an analytical unit that many relevant articles share – the nation state in a comparative manner:

Passive users are African countries that do not have any space capabilities. They only receive information already processed by others. Active users are African countries that have the capacity to process the information offered. Active developers are those African countries that themselves have capacity in space activities and typically have a space agency and more advanced space policy components, either self-standing or as parts of other policies. (Giannopapa 2011, 102)

John (2009a) not only confirms that the ‘effect of space agencies in developing nations is not well understood’, but also emphasises that most relevant studies remain static and repetitive, such as by either highlighting ‘economic growth’ through space science-related knowledge and innovation or by considering such investments inappropriate in a developing country context. John hence suggests that a focus on the actual impact of national space agencies in developing countries is needed. In her related study, John leaves the macro-comparative perspective and focusses on relations (knowledge flows) between Nigeria’s space agency and other institutions to understand the agency’s impact. Based on this new methodological approach, John ‘preliminary’ argues ‘that space activities within Nigeria have been beneficial to development’ (2009b, 9101-9109). Whilst John points at the meso- and micro-level, she acknowledges that her use of data from the website of NASRDA, newspapers and other sources that provide information on the agency’s

activities, does entail certain restrictions, such as in identifying knowledge flows between NASRDA and industries (2009b).

*Need for a qualitative, micro-level perspective*

Overall, a macro-comparative approach towards capacity development in space sectors in developing countries prevails in social and political sciences, and in the policy arena. Relevant research is so far primarily based on policy documents, databases and secondary literature. Whilst most articles outline requirements, they usually encourage developing countries to climb the space ladder, especially in the context of EO. Common supporting arguments are reiterated in continent-wide space declarations, such as the Mombasa Declaration on Space and Africa's Development (2012), AARSE's Johannesburg Declaration (2014) and the African Space Strategy as a complementary document to an African Space Policy (African Union 2017).<sup>35</sup> For example, looking at plans for an African space agency, Martinez (2012) discerns recurring comparisons to multilateral space agencies in other parts of the world, like ESA. However, most recurring arguments relate to remote sensing capabilities for socio-economic development, health, resource management and environmental protection. The Mombasa Declaration includes Africa's right to participate in the space arena, '[r]ecognizing that space science responds to the universal human urge to explore the unknown, thereby enhancing our knowledge of the natural world and providing a powerful source of inspiration for the youth to embrace science and technology' (Mombasa Declaration 2012).

At the same time, a qualitative ethnographic micro level perspective that might provide a more in-depth understanding of related space applications and accompanying ideas of indigenous capabilities in GIScience, is yet largely missing.<sup>36</sup> In declarations and relevant academic literature, space science usually appears as an all-encompassing category that ranges from Earth observation to planetary exploration, whilst national space programmes remain the analytical focus in a linear comparative framework of space capability. I have summarised this approach in Figure 13. However, though policy-focussed, we find literature from within Nigeria's space science arena, where researchers and policy-makers have written personal accounts about Nigeria's investment in space science. For example, Nigeria's former Minister of Science and Technology (Isoun et al. 2013) argues for Nigeria's operation of EO satellites in his work *Why Run before Learning to Walk?* Other

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<sup>35</sup> An African Space Policy and Strategy was adopted in January 2016 (African Union 2016): 'The African Space Strategy hinges on the African Space Policy, which provides the main tenets and guiding principles for the establishment of a formal African space programme' (African Union 2017, 25).

<sup>36</sup> There for a long time has been a general lack of ethnographic studies on space science. Recent ethnographies include Zabusky's (1995) 'Ethnography of European Cooperation in Space Science' and Olson's (2010) 'Ethnography of Astronautical Visions and Ecologies'.

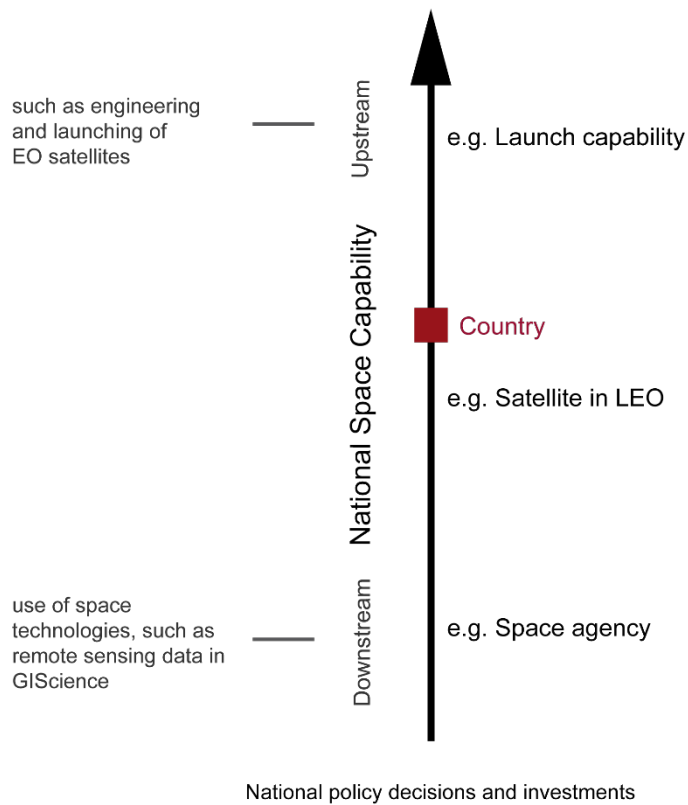
Nigerian scholars discuss agendas, benefits and prospects of having EO satellites: Abidoun (2013) has written about *Space in the Revitalization of Nigeria's Economy*, Oduntan discussed a *Progressive Technological, Policy and Legal Regime for the Utilization of Space Solution for Effective Peace, Human Safety and National Security*, and Akinyede and Boroffice (2011) look at *Nigeria's Quest in Space*.

## Conclusion

Space activities on the African continent are not only many and varied but are accompanied by the unexplained attribute 'indigenous'. At the same time, their representation in media and academic and policy-related literature is abstract. This includes a limited empirical understanding of relevant actors. As Harding himself indicates, in most studies, space science in developing countries currently means anything from...

...the Chinese juggernaut that has in a generation literally gone from empty rice bowls to launching satellites and manned orbital missions, down to a small Zimbabwean software company that writes satellite programming language. (Harding 2013, x)

Whilst all studies are valuable in that they discuss potential developmental impacts of space technologies, a better understanding of accompanying social processes is needed. Skewed perspectives on space science and technologies on the African continent seem to develop in the public and policy arena, ranging from optimism to scepticism in an atmosphere in which space activities in Africa still often seem far-fetched. This atmosphere is based on persistent stereotypes about sub-Saharan Africa's relationship with technologies, as Giannopapa suggests (2011). The next chapter will discuss this relationship in relation to theoretical perspectives on technology and knowledge transfer in a postcolonial world as both supporters and sceptics of space capabilities in developing countries often implicitly refer to perspectives of modernisation and dependency (development theory). In line with this, the next chapter will argue that it is time to disentangle space science by providing qualitative ethnographic data on GIScience, as one element of space science.



**Figure 13** Prevalent academic approach towards space science/EO activities in emerging economies/developing countries; based on literature review by author of this thesis.

# Chapter Three

## From Modernisation to Alternative Development – Technologies and Knowledge in a Developing World

The previous chapter outlined how EO technologies like satellites, GIS and relevant knowledge have become part of global development strategies. Related technology and knowledge transfers are supported by various academics and global environmental and developmental initiatives. This chapter will shed more light on both the positions of supporters and critics by looking at academic perspectives on technology and knowledge transfers to developing countries. In this theoretical context, this chapter will further outline the significance of scrutinising the term indigenous with its different abstract connotations in relation to GIScience.

In 1960, five years after a large part of the ‘Third World’ had met in Bandung to form a Non-Aligned Movement (Burke 2006), countries were already largely classified on basis of certain indicators, such as ‘income per capita’ (Stamp 1960, 178). The related idea of the necessity of development in the Third World has been critically examined by several authors (Jasanoff 2002, Escobar 1991). Here, Hilty and Hercheui refer to two perspectives that are relevant to ‘development’, as it will be discussed in this chapter, and that eventually relate to the current theoretical perspective on space science in developing countries. Looking at the case of ICT, Hilty and Hercheui discern an ‘optimistic view’ that describes positive structural change in economies through the world-wide ‘diffusion’ of ICT, and they refer to a ‘pessimistic view’ that considers resource consumption and unsustainable structural change (2010, 227-229). The ‘ICT-revolution’ on the African continent is linked to many hopes, such as the internet as a means for an improved representation of the continent (Graham et al. 2013, 3-4). A simple determinist dichotomy of optimistic and pessimistic views does, however, not leave sufficient space for reflecting on ‘human choice’ in ‘the development and application of technologies’ (Hilty et al. 2010, 228), where, for example, a wave of scam emails from Nigeria was followed by a governmental project to rehabilitate Nigeria’s image (Graham et al. 2013).

The literature review so far suggests that the implementation of GIScience in developing countries is largely treated with optimism, provided that certain aspects, such as national policies, can be further developed. At the same time, few scholars, policymakers and journalists are sceptical about the sustainability of EO and other space activities in developing countries. In the context of an optimistic view, also the largely unexplained notion of indigenous capabilities has entered the space science arena in developing

countries and Africa in particular. This divisive attribute might in the first place appear as blackboxed developmental jargon. A better understanding of the attribute's relation to GIScience hence requires a more nuanced view.

Various theories and perspectives describe technology transfer-related relationships between a presumed developed and a developing world. Pieterse describes the overarching development theory as being part of 'broad explanatory frameworks' (2001, 2). It can embody anything from 'classical economic and social thoughts' to ideologies, policies, practices and other theories. Furthermore, various models and schools of thought are rather linked to development than originating from the developmental arena itself. The term 'development' eventually becomes a mirror of changing intellectual paradigms and societal structures (ibid., 2-9, 38-39, 150). Whilst 'development is multidimensional' and methodologically and politically challenging, two theories – modernisation and dependency theory – constitute major signposts in developmental thinking. Underlying perspectives will be at the heart of this chapter to gain a better understanding of optimism and pessimism in relation to science and technologies in a postcolonial world (ibid., 150).

Modernisation theory and dependency theory will be discussed in the first section. In relation to dependency theory, the second section discusses alternative developmental concepts, which includes ideas of indigenous and appropriate elements in the context of global technology and knowledge transfers. Overall, this will constitute a discussion of whether developmental theories can be useful in elucidating what indigenous capabilities in GIScience might describe, and whether it is worth scrutinising the attribute in this context. This also means to identify potential theoretical gaps that can be addressed through a qualitative case study. This discussion will be extended by looking at technopolitics and politics in outer space, as they affect GIScience. This chapter eventually articulates my research question and prepares a discussion of my analytical perspective in the next chapter.

## Technology and Knowledge Transfer Agendas

### Technologies for a modern world

According to Smith, a straightforward idea of linearity, 'from pre-technological to technological, from traditional to modern, from indigenous to scientific' is still often present in 'mainstream development thinking' (2009, 12). It can be traced back to the era of Enlightenment, when knowledge was increasingly considered accumulative in terms of generational progress (Cherlet 2014). This understanding, as it manifested during the eighteenth century, is still visible in, for example, the United Nations Millennium Project Task

Force on Science, Technology and Innovation (Smith 2009, 12-16). Cherlet relates the ongoing ‘unconditional trust in the power of Western scientific knowledge and technology’ to the perspective of ‘technological determinism’<sup>37</sup> that is yet ever-present in public discourses (2014, 774). In the 1940s, the growing promotion of ‘scientific knowledge and industrial technology’ in a presumed ‘underdeveloped’ world became known as Technical Assistance, supported by the UN’s post-war Development Programme. Since the 1970s financial capital increasingly frames development and promotes the World Bank as a key player in this respect. However, with more and more actors joining the development arena, it is now full of negotiations over failed and successful policies, the essence of development and related priorities (Pieterse 2001, 9-10, 41).

The notion of modernisation plays a key role in this discourse. One of the exogenous projects that relates to modernisation theory is the worldwide diffusion of technologies to promote industrialisation (Pieterse 2001, 43). For example, in postcolonial Indonesia, an early sociotechnical imaginary was largely based on how development had been theorised in the context of modernisation theory, with foreign investors at the heart of promoting an industry-oriented economy (Moon 2015, 182). Nowadays, high-technologies are still associated with ‘economic and cultural uplift’ (Aslinger 2012, 194-196), such as in the case of Rwanda, where ICT became a central element in the country’s recent ‘sociotechnical imaginary of modernization and development’ (Bowman 2015, 82-83, Pieterse 2001, Heeks 2010). Related technology transfer, as the cross-border ‘movement of artefact and/or knowledge’, must of course not be reduced to a relationship between industrialised countries and a developing world (Shrum et al. 1995, 633). Various economic paradigms and industrial policies in industrialised countries can be linked to an ‘overarching development rhetoric’ that eventually has ‘made its imprint on developing economies’, as Pieterse (2001, 40) argues. In 1982 Arghiri Emmanuel describes this global imprint in the context of technology transfer by stating that...

...at all periods and independently from the socio-political leanings of their countries (...), the import of the most modern technology from the advanced capitalist countries is unquestioningly the permanent objective of development strategy [in ‘the Third World’]. (Emmanuel 1982, 31)

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<sup>37</sup> For a detailed discussion see Smith et al. (1994). In relation to technology, Smith describes two forms of determinism: ‘a “soft view”, which holds that technological change drives social change but at the same time responds discriminately to social pressures, and a “hard view”, which perceives technological development as an autonomous force (...)’ (1994, 2).



However, this ‘macro-economic drive towards modernity’, as Smith describes it with reference to Rostow’s famous five stage model of development<sup>38</sup> (2009, 14), is in a crisis since its very beginnings.

## The dependent periphery of a modern world

Early post-war criticism by individuals, who expressed concerns over a perhaps inappropriate duplication of Western institutions in economically and socially different environments in developing countries, increasingly gained prominence from the mid-1960s onwards. This criticism is now known as dependency theory, where the often improvident transfer of technology is blamed for having entrenched the position of developing countries as an exploited periphery (Pieterse 2001, 39, Cherlet 2014, 780-781). Scholars like Ya’u (2004) go as far as speaking of a new form of imperialism in which developing countries now depend on knowledge from the industrialised world. According to Ya’u, ICT is one example for an initially promising technology transfer that in the end has led to dependence on international infrastructure providers and control mechanisms of more and more standard setting organisations.

In the context of dependency theory neoliberalism has been problematised in light of an uneven globalisation (Pieterse 2001, 151-152), where governments eventually support the World Trade Organisation as the prime facilitator of international trade with ‘international trade as an end in itself’ (Ya’u 2004, 17-21, 24), accompanied by the WTO’s multilateral intellectual property rights agreement (TRIPS) that works in favour of developed countries and limits a developing country’s access to new scientific knowledge and technologies (Ya’u 2004, 18). This market-oriented development has so far only under specific circumstances proven beneficial for few developing countries, such as India that has developed significant capacity in the ICT sector (Joseph 2009).

However, in the case of ICT, most developing countries are yet treated as consumers. For example, the required infrastructure on the African continent largely depends on loans and foreign direct investment (Ya’u 2004). A debate in the House of Commons in 2012 indicates how despite some developing countries’ ICT capacity (like India), industrialised states still often discern a ‘competitive advantage’ in some areas and might approve a potentially dependency-creating relationship for the sake of trade interests. In consideration of India’s dynamic yet ‘fragmented mobile technology market’, member of parliament Stephen Hammond referred to an economically important ‘opportunity for the UK telecoms industry’ (Hansard HC Deb 2012).

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<sup>38</sup> The model describes a linear transition from a ‘traditional society’ to a nation that is characterised by ‘mass consumption’ (Smith 2009, 14, Rostow 1990 [1960]).

Whilst technologies are often more directly linked to dependency theory than scientific knowledge (Shrum et al. 1995), scholars like Hwang do also look at a 'core-periphery relationship in the scientific world system' (2008, 101-105). Hwang argues that science laboratories in parts of Europe and North-America are usually considered the centres of knowledge production, whilst most other parts of the world are largely understood as applying scientific knowledge. Furthermore, the periphery's dependence on core science from the self-referential centres, with their 'heritage of basic research', can grow when local knowledge becomes marginalised, as Hwang further argues (*ibid.*, 103-108).

Overall, the transfer of technologies like ICT has been considered both in relation to development and trade (Ya'u 2004, 22). However, without further research it will be difficult to understand whether organisations and scholars that encourage developing countries to invest in space technologies, are consciously or unconsciously driven by wider modernisation theory or – by introducing the idea of indigenous capabilities – perhaps have alternative post-dependency perspectives in mind. These will be discussed in the following.

### **Alternative (modernisation)**

The new awareness of dependency-creating technology and knowledge transfer and ever-stronger calls for cultural diversity have led to post-development discourses (Pieterse 2001, Moyo 2010, Sillitoe 2002b). Simplistic ideas of unidirectional knowledge and technology transfer had dangerously reduced the African continent's developmental challenges to a technological and knowledge (science) issue (Smith 2009, 19-20, Juma et al. 2002). For example, in some ICT projects, requirements as assumed in the North, 'mismatched local realities in the average developing country village', such as in the context of rural telecentres (Heeks 2010, 629). Already in the 1980s, it was acknowledged that development economists had weakened their position by overlooking local social aspects. Economists like Amartya Sen subsequently shifted the focus towards 'capabilities and freedoms as indicators of development', stressing that technologies might only be useful if the economic, social and technological environment encourages their use (Lundvall et al. 2009, 13-14).

In the meantime evolutionary economists have suggested that instead of treating the economies of developed countries as the end-goal on a linear path, developing economies could focus on developing scientific and technological *niches* in relation to local issues (Smith 2009, 16-17, Juma et al. 2002, 4-7). India's ICT sector, for example, has developed a strong global presence and competitiveness in this context (Joseph 2009). Whilst this suggested path does yet seem to dovetail with modernisation theory, it is less determinist

and represents a new era in development theory. In line with this, contemporary innovation literature, such as on sectoral innovation systems in developing countries, emphasises the co-evolution of technologies, industrial structures and institutions that develop in society and not external to it (Altenburg 2009, 33). The following section will look at additional post-development perspectives that emphasise local social environments and their knowledge.

## Indigenous & Appropriate Post-Modernisation Alternatives

The new awareness for a local context is reflected in discourses on ‘alternative development’ (Pieterse 2001, 152-153, Cherlet 2014, 781, Sillitoe 2002b, 3). The following discussion brings back the notion of indigenous and scrutinises whether perspectives on alternative development can shed further light on this attribute in relation to GIScience. The attribute so far seems to awkwardly sit between modernisation theory, dependency theory, niche-development and potentially alternative developments.<sup>39</sup>

### Indigenous – a divisive notion

Dibua, who had studied in Nigeria, is critical of how most policymakers and scholars from African countries have been following a purportedly universal ‘model of industrial modernity’, with the transfer of technologies as a priority (Dibua 2006, 143, Morgan State University 2015). He argues that ‘it is not possible to talk of technology transfer in isolation of the cultural process to which it is intimately bound’, and hence suggests that the transfer of ‘Western technology’ inevitably entails a form of ‘cultural imperialism’ that leaves no space for local ‘indigenous technology and culture’ (2006, 144).

Before, discussing Dibua’s use of the attribute indigenous in relation to yet unexplained *indigenous* capabilities in GIScience, the attribute should be considered part of a divisive developmental and ‘terminological debate’ (Ellen 2002, 236). Ellen argues that indigenous ‘knowledge has been, by turns, muted, actively rejected and subsequently re-discovered and celebrated’ during the last century (2002, 236-237). Since the 1980s, when postmodern discourses gained momentum, local people’s knowledge-based choices about their use of local resources, were increasingly considered in a wider context. During the 1990s indigenous knowledge finally became part of a wider discourse amongst

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<sup>39</sup> Indigenous in relation to 1) a local or national EO component/capability, 2) understanding and using space technologies, 3) the researcher, 4) an arena of actions, 5) specific technological developments, 6) research objectives and 7) contributory knowledge.

development practitioners and later anthropologists (beyond ethnographic description). Whilst indigenous knowledge has been increasingly considered important in complementing *Western* science, and countering a ‘top-down transfer of technology’, a more ‘ideologically driven’ proclamation of indigenous knowledge has rather been questioned (Ellen 2002, 237-238, Sillitoe 2002b, 2). Some anthropologists have highlighted a problematic understanding of the term, such as in the context of indigenous rights movements, where the putative ‘descendants of the original inhabitants of a country’ are considered enjoying ‘privileged rights, perhaps even exclusive rights, to its resources’ (Kuper 2003, 390). Kuper suggests that such a politically dangerous essentialist understanding of indigenous (especially in a European context), which is tied to rigid understandings of ‘culture and identity’, might be supported by outdated ‘romantic and false ethnographic vision’ (2003, 395). In response, other social anthropologists caution against reducing the term to essentialism and suggest a relational approach to indigenous (Kenrick et al. 2004, 4-6, 9). Kenrick and Lewis ask us to not lose sight of political concerns by those people, who refer to indigenous, and argue that in the context of Africa...

...Africans view themselves as indigenous relative to colonial and post-colonial powers. Additionally, Africans who live in the same regions as African hunter-gatherers and former hunter-gatherers recognize these groups as being indigenous relative to themselves. (Kenrick et al. 2004, 6)

They emphasise the use of indigenous in relation to ‘issues of power and dispossession’ and people’s ‘enduring social, economic and religious practices that constitute their relationships with land, resources and other peoples’ (ibid., 9). Notwithstanding these two perspectives on indigenous in relation to place and culture, from a development perspective, Ellen eventually sees a danger of ‘indigenous knowledge becoming either everything or nothing’, and suggests that some anthropologists point at reasons for failed development projects but shy away from providing concrete solutions in relation to their understanding of indigenous knowledge in the field (2002, 254-255). Sillitoe argues that anthropologists could help to implement and promote ‘culturally appropriate and environmentally sustainable interventions’ beyond ‘postmodern mindgames [sic]’ (2002b, 1).

At this juncture, it is important to underline that this discourse is not confined to Western social scientific or developmental arenas. In the early 1990s, when indigenous knowledge entered developmental discourses among anthropologists (Ellen 2002), African scholars discussed the relationship between technological development and ‘indigenous institutions and practices’, examining how local knowledge can be incorporated into Western knowledge and technologies. Emeagwali’s (1993) publication *African Systems of art, science and technology: the Nigerian experience* covers historic and present technologies, such as textile, traditional medicine (Yoruba) and metal technology in pre-colonial Nigeria, and

argues that these technologies have always been ‘appropriate’ as related to ‘whatever circumstances [‘Africans’] found themselves in’ (Bell-Gam et al. 1999).

## Indigenous and appropriate technology between Africa and the West

When Dibua refers to indigenous technology, he means technology that is grounded in ‘artisan technology as well as arts and crafts’ that shall not pass unheeded in Nigeria’s industrialisation process (2006, 146). What if Dibua and other scholars would then relate GIScience to the modernisation paradigm that, according to Dibua, considers ‘indigenous Nigerian technology’ as ‘backward and irrational’ and rather focusses on ‘large-scale, centralized and capital-intensive technology’ (ibid., 144, 146). One pitfall in following Dibua’s criticism lies in transferring Dibua’s notion of indigenous to an understanding of the attribute’s theoretical use in the context of GIScience, and to hence focus on looking out for artisan elements. When Dibua himself reminds that technology can mean ‘a body of knowledge (...) about techniques of production’ (ibid., 146)<sup>40</sup>, technology becomes a complex term in this context of post-development theory. Furthermore, any understanding of small-scale technologies is further complicated by the concept of ‘appropriate technology’, which is ‘likely to be older technology from advanced countries, traditional technology from the Third World, or recent technology that has been designed with local conditions in mind’, as Shrum et al. suggest (1995, 645). This definition entails another analytical trap in understanding local capabilities and technology transfer in GIScience. Both attributes imply location. In the case of indigenous technology, technology seems to be inherently local, whereas appropriate technology comprises indigenous technology, simpler (older) imported technologies and technologies that include ‘local conditions’ in their design, but do not originate from the *local*. Ellen further explains what local solutions might involve in relation to the ‘indigenous knowledge option’:

This requires serious engagement with peoples’ knowledge systems, understanding the interconnectedness of the technical and the symbolic, and the provision of sufficient social and cultural context. (Ellen 2002, 255)

Whilst both attributes, indigenous and appropriate, take social and cultural context in developing countries into account, their relation to GIScience seems more ambiguous than ever before as the local context is yet abstract and might entail essentialist readings. This becomes clearer by considering the new focus on the user of technologies in a Western

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<sup>40</sup> This understanding is in line with other social scientists like Bijker, who defines technologies as comprising ‘different layers of meaning’, such as ‘*artefacts*’, ‘*human activities*’ and ‘*knowledge*’ (Bijker 1995, 230; italics in original, Kumwenda et al. 2003).

STS context, where due attention to the social construction of technologies<sup>41</sup>, respectively the co-evolution of technology and society, shall promote appropriate innovation processes (Geels 2004) in which various groups become relevant:

Each social group has its distinctive features. Members share particular perceptions, problem-agendas, norms, preferences, etc. They share a particular language ('jargon'), tell similar stories of their past and future, meet each other at particular fora, often read the same journals etc. In short, there is coordination *within* groups. (Geels 2004, 900)

Several relevant studies focus on how users in a Western context not simply acquire technologies, but how 'cultural appropriation' plays a central role in this process. Technologies are integrated into local and domestic practices and institutions (Geels 2004, 902). Already in the 1990s, Silverstone et al. focussed on how technologies enter the 'moral economy of the household' as a 'transactional system of economic and social relations' (1992). One of my concerns is that, looking at the emphasis on indigenous knowledge in relation to Africa, we face a similar yet different emphasis on the local context with reference to industrialised countries. In line with this, the next section will ask whether we deal with a particular narrative towards Africa *and* technologies, and whether this might finally shed more light on the relevant local context and its explanatory value in relation to GIScience in Southwest Nigeria.

### **A particular narrative of technologies *and* Africa?**

Various scholars refer to the persistent stereotypes that exist about sub-Saharan Africa in relation to technologies, as they have also surfaced in public representations of Africa's EO activities in the last chapter (Redfield 2016, 176, Giannopapa 2011, 106, Graham et al. 2013, 4). Dibua and others, who call for more attention to the local and indigenous context, counteract what Mavhunga describes as Africa being the 'antithesis' of technology in a 'Western imaginary', where all developments from architecture to astronomy are considered as originating from outside the continent (2014, 9-10). Mavhunga, who grew up in Zimbabwe and is associate professor in STS (MIT 2017) rhetorically states:

How could one expect to find technology and innovation (by Africans) amid all this 'chaos' (...)? A sick continent whose signatures of technology are the begging bowl, the Red Cross symbol, and SUVs belonging to non-governmental organizations and corrupt local elites? (Mavhunga 2014, 10)

Mavhunga illustrates a widely-held stereotyped understanding of Africa in relation to technologies. Against this backdrop, he critically contemplates on related academic

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<sup>41</sup> As formulated in the Social Construction of Technology (SCOT) perspective (Pinch et al. 1984).

perspectives by rhetorically asking whether ‘historians, anthropologists, political scientists, engineers, and scientists’, would not be keen to write about ‘Africa’s contribution’ to technologies that constitute our ‘modern’ societies, if such a contribution ‘mattered or existed’ (2014, 10-11):

They have not, and we can safely assume they have nothing to write about Africa that resides in the domain of technology and innovation except how the technological innovations of others have victimized them. That, or how Africans are ‘reacting’ to incoming technologies, or how such technologies are impacting them, is all they write about. (Mavhunga 2014, 11)

This is a rhetorical perspective that reminds of obsolete determinist views of technology and science in relation to society, where a society has been considered ‘the passive recipient of innovation, by which it is “determined”’ (Macola 2016, 8). Macola confirms that no other part of the world has been more extensively considered in relation to notions of technological determinism than Africa (ibid.). Whilst Macola and Mavhunga have not overlooked recent research on *appropriation* of technologies (Mavhunga 2014, 11-12), the literature indeed is limited in terms of both scale of technologies and historical context (Macola 2016, 8-17).<sup>42</sup> Here, Macola acknowledges that studies which consider a ‘co-construction of technology and society in Africa’, such as in the case of mobile phones and media consumption, are not ‘completely absent’ (ibid., 8-9). More and more studies indeed aim at confronting the longstanding ‘dominant discourse’ that depicts Africa as the backward part of the world in terms of technology and innovation (Gewald et al. 2012a).<sup>43</sup> In their publication on the transformation of ‘innovations in Africa’ and ‘appropriation in African societies’, Gewald et al. (2012b) hence suggest a more careful definition of innovation, which at first sight again is in line with relevant STS perspectives in a *Western* context:

It is a process that encompasses the acts of numerous individuals, not only the original inventors but also the producers, consumers and middlemen that transmit and operationalize the innovations, making them acceptable to society. Innovation here thus refers to processes of invention, adoption, adaptation, appropriation and transformation. (Gewald et al. 2012a, 3)

At the same time, the spell of a particular narrative towards Africa seems maintained. Gewald et al. refer to technologies that also other authors recognise in relation to studies that look at how technologies are ‘innovatively transformed’ in African societies with regard to ‘local conditions, expectations and demands’, such as motor vehicles, mobile

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<sup>42</sup> In his book about the appropriation and domestication of the gun in Central Africa, Macola also points at ‘the *rejection* of a given exogenous technology’ that ‘is no less socioculturally motivated than its adoption’ (Macola 2016, 119).

<sup>43</sup> Rankings, such as the Global Innovation Index, might still promote this image (Gewald et al. 2012a).

phones and bicycles (Gewald et al. 2012a, 3-5, Redfield 2016, Macola 2016). The unique perspective on the user of everyday technologies in an African context, amongst others, becomes visible in Bellucci's and Zaccaria's 'social history of the car-mechanics sector in the Horn of Africa' (2012). They, in their own words, have been able to 'move away from the simplistic view of a contraposition between "tradition" (indigenous) and "modernity" (endogenous)' by focussing on how transferred automobile technology has been 'absorbed, transformed and adapted to meet local conditions' (2012, 237-238). Bellucci et al. provide a historical account of how Eritreans have become artisans with regard to Italian automobile technology under Italian colonial rule. Spare parts often had to be developed locally (especially during World War Two). Furthermore, local conditions, such as terrain, put a different strain on automobiles than in the far-away Italian landscape, which led to the development of innovative maintenance solutions. Up to the present day, spare parts are modified and copied, which allows several FIAT 682 trucks from the 1950s to still be operated in the Horn of Africa. Based on the long-standing development of local solutions, 'individual parts' of automobiles can be adapted with whatever is available, such as by Dante Vaccari from Asmara (ibid., 254-255):

The springs of the shock absorber tend to break as a result of wear and tear and, in the absence of a proper replacement spring, a used spring has to be adapted, often by shortening and tightening it. Generally speaking, the tools needed for these mechanical procedures are simple but mechanics then have to fashion a series of finely tuned tools to supplement their basic instruments for more intricate repairs. (Bellucci et al. 2012, 254)

In this case, appropriation is studied under the premise that the relevant technology had not originally been constructed in the social and environmental contexts of the African continent, that is then understood as a distinct entity in cultural and environmental terms. In comparison to Western appropriation studies, appropriation on the African continent *prima facie* seems to be related to a separate 'sociotechnical landscape'. I borrow this term from Geels' discussion of sociotechnical systems, where landscape comprises 'the material aspects of society', such as infrastructure and spatial arrangements as well as entrenched 'cultural beliefs' (Geels 2004, 913).

## GIScience and the new focus on Africa's appropriation

One may appreciate an overdue yet unique focus on Africa in relation to science and technology.<sup>44</sup> This relationship is increasingly well-researched in the context of everyday

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<sup>44</sup> Some studies specifically relate to *knowledge*. As early as the 1970s, scholars had aimed at freeing the African continent of a skewed Western imagination by focussing on alternative perspectives on knowledge. In her book *Africa counts: Number and Pattern in African Culture*, Zaslavsky addresses 'the application of mathematics in the lives of African people, and, conversely, the influence that African



technologies (Macola 2016, 8). However, what if we add GIScience to it? To understand this challenge, I recall the apparent complexity of relevant actors and technologies (chapters one and two) and refer to Isoun who in 1987 wrote about the *Evolution of Science and Technology in Nigeria*. In 1980, Nigeria's Rivers State University was opened, and Isoun gave an inauguration speech in which he explained the rationale behind the university. Isoun, and in his eyes the public, believed that local socio-environmental issues and the governing of 'modern societies' can be 'controlled by the hard cutting edge of science and technology, as institutionalised in a University' (1987, 31, 65-68).

This does not only sound like a modernist approach, but with post-development discourses, including soft-modernisation perspectives (such as niche-development), and unexplained indigenous aspects of GIScience, we face a paradox. We can look at Africa through the lens of 'cutting edge' science and technology, which to a certain extent seems carefully promoted in innovation studies and macro-comparative studies that look at the potential of space science on the African continent. Alternatively, we can focus on Africa's hybridity with *modernity* by focussing on appropriation that is specifically embedded in discourses on local and indigenous knowledge as well as local materials, that jointly and 'innovatively' transform transferred technologies in relation to a local cultural environment (Bellucci et al. 2012, Gewald et al. 2012a). This appropriation perspective seems to suggest that it is applicable in any technology transfer context on the African continent and must indeed not be ignored for its critical approach to determinist modernisation theory. At the same time, it might be misleading in relation to GIScience, as the following section shall further exemplify by discussing the tangibility and spatial complexity of GIScience technologies in terms of a spatial (geopolitical) context.

## Technopolitics and Politics in Outer Space

With *technopolitics*, Hecht refers to 'a concept that captures the hybrid forms of power embedded in technological artifacts, systems, and practices', which can comprise 'strategic practice of designing or using technology to enact political goals' (2011, 3). A number of STS scholars have provided relevant case studies on how artifacts have politics in various forms (Hecht 2011, 3, Winner 1980). Perhaps as early as 1963, Goldsen had anticipated such social constructivist discourses in *Outer Space in World Politics*, arguing that the Cold War political environment will have had a substantial impact on the transformation of 'dozens of branches of science and engineering' (Goldsen 1963, v), such as the United States post-war investments in Europe's science to counter communism. Here, Krige

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institutions had upon the evolution of their mathematics' before 'Africans' engaged with 'pure mathematics' (1973, 7).

assumes that ‘informal’ empires can exist based on a country’s capability of shaping the politics of other states, such as through dependency (Judt 2004, Gaddis 1997, 27, cited in Krige 2006, 2-4). The idea of informal postcolonial empires is provoking. However, in consideration of many global EO initiatives on the African continent, it will be valuable to look at potential geopolitical and thus spatial intricacies of GIScience with a focus on its space components (EO satellites and data). Leaving the African continent for a moment, I shift attention to MacDonald’s call for ‘a critical geography of outer space’ (2007, 592). MacDonald reminds us that also...

...[t]he sea is being reconceptualized in geography not as an undifferentiated emptiness between the land, but as a culturally configured site of knowledge and power where philosophical, scientific and aesthetic discourses intersect with socio-economic, technological and political forces. (MacDonald 2007, 594)

MacDonald’s statement is of particular relevance with regard to international space law. Related discourses highlight the importance of keeping an eye on the spatial component in relation to the preceding discussion of technology transfer; especially in cases where space technologies and related knowledge(s) are supposed to be appropriate or indigenous in relation to location on ground.

Stuart reminds us that unlike solid ground, the high seas and airspaces do challenge the ‘legal and theoretical language’ and asks how related territorial sovereignty can be reconceptualised regarding outer space. She refers to Westphalian sovereignty as the historic foundation of current nation states, which in 1648 declared that a ‘territory’ may be administered by a ‘nation-state’ without interference from outside (2009, 8-10). Three centuries later, and now in the context of outer space, the important legal clause ‘res communis’ has been incorporated in the Outer Space Treaty (OST)<sup>45</sup> of 1967. This basically means that the use of outer space is not restricted to certain groups, but that it is a space that belongs to all of humanity (MacDonald 2007, 607-608, 612, Stuart 2009, 10). Accordingly, what is the current state of affairs with regard to developing countries?

Forums for negotiating space law, such as the United Nations Committee on the Peaceful Use of Outer Space (COPUOS), include developing countries that since the 1980s call for a fair distribution of spacefaring-related benefits (Danilenko 1990, 224-226), including access to remote sensing data of their own national territories (Williams 2005, 284-285). However, that much more is at stake became visible in the Bogota Declaration of 1976, when eight equatorial developing countries proposed to extend their sovereignty to the geostationary orbit. In this orbit at an altitude of approximately 36.000 kilometres, satellites appear to have a fixed position above an equatorial national territory in relation

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<sup>45</sup> In full: The Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies (UNOOSA 2008b, v).

to Earth's rotation and gravitation (Oduntan 2003, 75, JAXA 2017, Silva et al. 1978, Ospina 2005). The declaration amongst others is a response to the OST, stating that developing countries had not been capable of understanding the political implications in 1967 (Silva et al. 1978, 195). It furthermore is a response to the International Telecommunication Convention of 1973, which includes statements about the efficient use of an already crowded geostationary orbit, which might exclude most developing countries (Oduntan 2003, 75-76, Gorbil 1978, 171, Finch 1998, 389). Overall, access to orbits in space has become a major issue.

Related legal discourses have already been directly linked to the African continent. In 2013, the conference 'The Role of Norms of Behaviour in African Outer Space Activities', organised by the United Nations Institute for Disarmament Research (UNIDIR), was held to support an 'International Code of Conduct for Outer Space Activities' (UNIDIR 2013a, 1). New norms shall facilitate decisions about appropriate space activities in light of urgent issues, such as space debris (2013b, 5). Space debris, or in MacDonald's words 'pressing "environmental" questions about the pollution of Earth's orbit' (2007, 611), became an important topic at the conference. It was introduced by Mathieu from the European Space Agency (UNIDIR 2013a, 2). Taking Mathieu's institutional affiliation into account, one might be inclined to extend this issue to discourses on global environmental responsibilities. The conference participant Akinyede from Nigeria draws this parallel and stresses that African countries might again be in danger of not having enough time to understand the 'implications' of yet another exogenous policy framework – only that this time the framework is related to a common outer space that has largely been polluted by European countries and North-America.<sup>46</sup> Here, 'Africa's contribution to this problem so far is less than one percent', as Akinyede states, wondering why 'outer space' has 'become an African outer space' in the context of UNIDIR's proposal:

I hope we will be given, the Africans will be given sufficient time to understand its implications, to our determination to harness the benefits of space for our own societal transformation. (Akinyede 2013)

In line with this, the conference organisers conclude that international law and national policies are yet to contain a 'space domain' that 'is becoming both congested and an environment where power projection and terrestrial instabilities are being expressed' (UNIDIR 2013b, 1). Overall, space, respectively low Earth orbit, has become an additional social and political geography of concern to which GIScience technologies are linked. This spatial dimension adds another challenging layer to understanding *indigenous* as related to GIScience. It demands considering the micro level, where relevant actors can

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<sup>46</sup> The conference presentations have been recorded (UNIDIR 2014).

be found, that according to UNIDIR shall at least be involved ‘throughout the consultation and development process’ of suggested norms, as they will indeed be ‘affected’ by them (2013b, 5).

## Conclusion

This chapter has outlined that an understanding of technology and knowledge transfers in a postcolonial world is all but straightforward. Existing studies on EO in developing countries often implicitly suggest that an understanding of the transfer of EO technologies and knowledge might be found in modernisation theory. However, with unexplained indigenous capabilities in GIScience in mind, the latest theoretical and empirical focus on local agency suggests that it will be deficient to simply regard related technology transfer as a linear leapfrogging<sup>47</sup> process that can be explained through narrowly articulated developmental imperatives. At the same time, the complex spatial context in which GIScience technologies and related actors are involved, indicates challenges for a new constructivist perspective, as it has been discussed in relation to indigenous and appropriate technologies, and eventually appropriation as an analytical perspective towards *Africa’s* engagement with technologies. The more important it is to appreciate the unexplained attribute indigenous. It seems to implicitly suggest a need to better understand GIScience and high-technologies in a postcolonial world. Based on its conceptual uncertainty, yet clear indication of something that can be localised, the attribute can guide us towards a better understanding, provided that the attribute is taken seriously. In other words, what does GIScience in Southwest Nigeria teach us about its location in a (post)-development context and what can we learn from it?

Locating GIScience in such a theoretical context seems important. On the one hand we have a *Western* academic perspective on the social construction of science and technologies, including innovation and related appropriation studies in a Western environment. Innovation literature in particular emphasises the wider local context in relation to developing countries and their national systems of innovation. On the other hand, we find those studies on appropriation that at first sight seem more valuable for an improved understanding of indigenous capabilities in GIScience. However, when an empirical focus on the integration of local knowledge and materials into technological and scientific processes is embedded in narratives towards Africa as a distinct cultural entity, this discourse seems confined in relation to the complex geographies in which GIScience takes place.

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<sup>47</sup> This means to omit different preceding developmental stages of transferred technologies (Waswa et al. 2012, 167, Dibua 2006, 147).

The importance of acknowledging such a postcolonial discourse is further grounded in more precise yet divisive understandings of the attribute indigenous in other contexts of technology and knowledge production. Mavhunga, for example, uses indigenous in relation to 'African' and means 'things derived from within and by African societies' (2014, 16). At the same time, Tihamiyu reminds of the 'necessity to match and integrate *foreign and local* technological components, standards and conditions toward ensuring sustainable technology transfer and organizational learning and innovation' (2003, 188; my emphasis). Mavhunga's and Tihamiyu's statement in combination can seem overly essentialist at a second glance. This is particularly visible when Mavhunga refers to the principle of symmetry as proposed within the Empirical Programme of Relativism and later the Social Construction of Technology (SCOT) approach (Pinch et al. 1984, Williams et al. 1996). He argues for a 'hermeneutic and epistemological' move that acknowledges that...

...the same concepts we use to analyse northern-made technology and science must be the same ones we extend to an analysis of African thought and practices. (...) Instead of being a mere user, the African becomes a designer who makes technology, not just someone who appropriates or (mis)uses incoming technology. (Mavhunga 2014, 16)

Whereas Mavhunga makes an important point by criticising that Africa needs more than appropriation studies, he sets *science and technology* from the North apart from 'African thought and practices', whilst suggesting universal underlying principles in an epistemological sense to underline their equal essence. So far, the local context is not explained in a way that could provide guidance in any technological and knowledge-related context. At the same time, technology transfer in relation to Africa seems always implicitly expected to be at least in parts substituted by something local. Dibua distinguishes between 'borrowed technologies' that need to be adapted and those technologies that are only sustainable and useful if they 'originate from the cultural and ecological realities of that society' (2006, 164). Considering that in GIScience, discourses relate to various spaces, any understanding of specific 'cultural and ecological realities' seems challenging. In other words: how can we approach the social construction of GIScience in Southwest Nigeria beyond modernisation narratives, whilst not restricting any potential analytical perspective to an emerging bounded locale. Related pitfalls become further evident when Dibua argues that based on presumed culture-bound developments in industrialised countries, Africa and Nigeria should likewise develop their own paths in terms of technological developments and innovation:

It thus follows that indigenous knowledge and practice should constitute the basis of technological development and innovation in Nigeria and other African countries. Indigenous knowledge, which is the product of indigenous peoples' direct experience of the workings of nature and its relationship with the social world, includes the cultural traditions, values, belief systems and worldviews of local peoples. (Dibua 2006, 165)

The conception of a culture-bound basis for technological development in relation to a distinct African geography, renders indigenous as related to GIScience increasingly ambiguous. In line with this, Sillitoe contemplates on a meanwhile obscure use of terms like indigenous and local:

But they all share a certain common semantic load and address the same broad issues. Some writers contrast this knowledge with scientific knowledge, even implying that it applies only to non-Western knowledge, prompting others to query the status of 'non-scientific' Western beliefs and the implications of contemporary accelerating globalizing trends. (Sillitoe 2002b, 8-9)

In summary, the controversial nature of these attributes between an essentialist and relational understanding, their unarticulated relation to GIScience and a new post-development focus with a distinct narrative towards Africa, constitute a mandate to unbundle indigenous in relation to GIScience in Southwest Nigeria to better understand this space science in relation to (post)-development discourses about technology and knowledge transfer. Borrowing the words (not the argument) of Zeleza, Africa either seems related to 'the capacity to transform itself into the breadbasket of the world through modern technological leap-frogging and good political and scientific leadership' or shall ideally realise 'its own modernities in a world of multiple, often conflicting, modernities' (2003, 30). This implies a complex spatial rigidity that is perhaps best summarised by looking at Jasanoff's following argument. Referring to developmental discourses, Jasanoff argues that the similarly existing plurality of science and technology-related positions in 'western societies', often takes a back seat (2002, 269). Whilst this is a valuable argument in this context, we nevertheless go round in circles: The *West* remains a challenging point of reference. Furthermore, technology transfer is not solely a process between nation states, but also between various smaller national and transnational entities. Accordingly, one should aim at integrating a macro into a micro perspective (Lundvall 2007, 112).

I argue that inductive qualitative research helps to answer some questions in apparently heavy seas. Static ideas of geography and culture do eventually obscure our full understanding of transfers of different technologies and accompanying concepts. We do not know whether any reference to indigenous capabilities in GIScience is linked to a 'particular local, sectoral, professional or national policy context', indicates 'ideological and moral loads', is used to circumnavigate the 'real problems', or has become 'everything' and 'nothing' (Ellen 2002, 236-237, 255). A closer look at postcolonial science and technology studies (PCSTS) in the next chapter sheds further light on this issue and indicates an adequate methodology to understand the social construction of GIScience in Southwest Nigeria beyond macro-comparative perspectives. Whilst I follow Jasanoff's additional reminder to acknowledge 'alternative visions' of developmental modernity (2002,

271-272), we must not overlook the complex reality of postcolonial and post-Cold War ‘technopolitical entanglements’ as we seem to encounter them in the context of GIScience (Hecht 2011, 11). This, however, can only be adequately understood by considering relevant actors that shape the implementation of GIScience.

# Chapter Four

## Research Problem and Research Design

This chapter begins by formulating preceding empirical and theoretical considerations in relation to GIScience in Southwest Nigeria as a research question. It will subsequently look at analytical perspectives in relation to knowledge, technology, geography and culture that have been useful in formulating my methodological approach. This includes both a discussion of ethnography's relation to knowledge, geography and culture as well as a critical review of postcolonial science and technology studies (PCSTS), which has led to additional theoretical questions that need to be addressed by answering the research question. Based on this discussion, I will in a second step introduce the research design that covers the methodological approach of this research, methods of data collection and ethical issues.

### Research Problem

This research has scrutinised the following research question: How is GIScience in Southwest Nigeria socially constructed and – related to this – how do relevant actors/social worlds construct the recurring notion of indigenous space science capabilities, and how does this construction reflect the development of the GIScience community in Southwest Nigeria?

This objective is based on the preceding literature review that indicates the following empirical, theoretical and policy-related gaps:

- 1) Space science/EO/GIScience in developing countries has so far been overlooked at the micro-level. Nation states and national space programmes remain the main level of analysis.
- 2) Most EO organisation that act on the African continent, and macro-comparative literature on space science in developing countries (and Africa), provide an optimistic developmental outlook. In literature, any concerns usually lead to policy recommendations, recalling modernisation theory. At the same time, considering Nigeria's and other developing countries' socioeconomic and political situation,



some policymakers and media in industrialised countries viewed their investments in space science with scepticism. This, in part, relates to dependency theory.

- 3) The recurring attribute 'indigenous' in relation to space science/GIScience, that in this context shall bring about 'societal benefits', remains unexplained, but seems to dovetail with post-development theory.
- 4) Without qualitative micro-level research, GIScience cannot be adequately understood in relation to (post)-development theory as related theoretical perspectives on technology and knowledge transfers still seem static in their approach to history, culture and geography.

The research problem has then been addressed by considering the following subsidiary questions (a sample of interview questions can be found in appendix IV):

1. How do those actors (researchers/students), who relate to GIScience, situate themselves against other scientists, policymakers and their immediate social environment, and how do they describe their area of work/studies (how has this changed over time)?
2. How do those actors that are involved in GIScience conceive their work and themselves in relation to society?
3. How do those actors that are involved in GIScience address their practices and material as well as immaterial resources that they use and that they have at their disposal to support and promote their policy position/objectives?

### **Ethnography, geography, knowledge and the local**

Ethnography is a prominent methodology in social anthropology and other social sciences that seems particularly appropriate for describing social processes in unfamiliar *places*. At the same time, the concern that I introduced in the last chapter relates to the often circular and static manner in which *local place* is used to describe the transfer and essence of technologies and knowledges. Looking at outer space, Redfield uses its indeterminacy to highlight issues with the local on ground. Redfield is surprised at the neglect of outer space

with regard to social theory, and sees one reason in most social scientists' contemporary emphasis on the local, where 'locality in human affairs' is put in moral 'opposition to the proliferation of global metaphors and transcendent claims made on behalf of capital and science' (2002, 791-792). Local, as Redfield further argues, becomes a conflicting 'article of faith' (ibid., 792), where the practice of knowledge production is considered a 'local phenomenon in the first instance' (Kuukkanen 2012, 477). This leads Redfield to ask: 'All knowledges, practices and objects may indeed be local, but are they *equally* local' (2002, 792; emphasis in original)? Kuukkanen sees a particular issue with the often vague definition of 'locally existing factors' by which scientific knowledge shall be explained (2012, 478). This can be better understood by looking at relevant perspectives that have followed the 'spatial turn' in the 1970s, which for historians and sociologists of science had ruled out an a priori 'disembodied' understanding of science through a new empirical focus on aspects of time, space and social context, respectively situated practices of constructing sciences (ibid., 479-480).

A sociology of knowledge primarily focusses on 'social locations' in which intellectual positions are to be understood. Social relations are in the first instance more important than their geographic location. Historians of science (including some sociologists) further pay attention to mapping spatial relations between places, such as libraries, coffeehouses and other places, where science has been practised and debated (Dear 2005, 31-34, Kuukkanen 2012, 480-482). In this context, Kuukkanen asks whether *locality* actually has an irreversible impact in the form of a 'cognitive factor' on science or whether location is not more than a setting for practices, irrelevant for a natural 'harmonization' of science (2012, 480-481). Whilst place as a 'geographical location' where science is produced, is not questioned by those who have a universalist understanding, it gains a more complex essence when place is considered as 'locale' (ibid., 484-485), where place is not just part of a geographic grid, but it is essentially human through interaction and becomes part of the essence of science. In contrast to the universalist, the 'localeist' does then perceive place in which science is produced as something that is inwrought with humans and their actions (Livingstone 2003 in Kuukkanen 2012, 484-485).

If we now take the localeist's view as a potential analytical lens to approach social dimensions that accompany GIScience in Southwest Nigeria, with its unarticulated notions of indigenous and spatially extended web of technologies and actors, we still need to address one important question. Kuukkanen formulates this question as follows: 'Now we need to ask more precisely what kinds of objects are taken as "local" or "universal"' (2012, 485). Furthermore, do those researchers, who follow 'strong localism', limit

their understanding to ever-smaller social units in relation to location and time, where, in Livingstone's words, 'science is always an ancient Chinese, a medieval Islamic, an early modern English, a Renaissance French, a Jeffersonian American, an Enlightenment Scottish thing' and where science in Edinburgh is much more Edinburgh science? Livingstone, for example, describes how early nineteenth century scientific institutions in different parts of Britain had individual interactions with society and politics, producing a 'cultural geography of science' (Livingstone 2003, 13, 107-108, Kuukkanen 2012, 486).

Livingstone's call for a 'geography of science' reminds us of essential questions: above all the question of whether *location* has an imprint on the content of science, on its credibility (as perceived by others) and on its acceptability (Moore 2005, Dear 2005, Livingstone 2003, 1-16). Livingstone basically argues that for an understanding of the 'appearance of universality'<sup>48</sup> it is not sufficient to limit the aspect of geography to a mapping of how scientific discoveries and technologies have been introduced in different places. Looking at Darwinism, one would only need to consider different locations in the same city to understand that the perception of what Darwinism means will change in relation to social context (Livingstone 2003, 1-5, 14). Kuukkanen concretely asks whether in a postmodern sense one should reduce scientific activities to social activities. Will it be valuable to follow such 'radical localist particularism' for what one might be inclined to call *Nigerian* science (Kuukkanen 2012, 486)? Whilst from a social-constructivist perspective this is a valuable approach, I should be cautious in light of unexplained indigenous aspects of GIScience that can be either understood in an essentialist (location and ethnicity as one unit) or relational way.

I have to backpedal at this stage. My research has taken place in a former colony and the deficiencies in our understanding of science, nature and culture, are usually articulated by referring to an a priori entity – the *West* (see Latour 1993, 91-129). Lagos in Nigeria, on the same longitude as the eastern surroundings of Paris (Île-de-France), is often perceived as not counting to *this* West. Here, Livingstone reminds us of the complexity of spatial terms, where physical proximity might not match the social and cultural arenas in which we move (2003, 6). Might a solution be to 'detach' the ethnographic field that emerges as a methodological opportunity 'from the concepts of space and place' to 'rescue the possibilities of comparison across theoretically relevant boundaries in space', as Cook et al. discuss (2009, 48)?

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<sup>48</sup> 'Universality' in the sense of scientific realism is to be understood as universal nature, as the object of science. Here, sociologists of science do not aim at denying regularities or laws of nature, but at scrutinising how they are understood and represented as such (Kuukkanen 2012, 487).

In this context, a central element that should be considered between the poles of particularism and universalism, is movement (what, how, where and when) of local 'products and practices of science' ('delocalization'). If we look at space as abstract and the local as geographically bounded within space, an analysis of the movement of 'materials and techniques' between locations can be imagined ('spatialization') (Kuukkanen 2012, 489-490). With reference to Livingstone (2003) and other geographers and historians of science, Kuukkanen to a certain extent addresses the localist's dilemma: the local and the general are reduced to a common denominator through 'standardization'<sup>49</sup>, such as by using charts to make the local 'commensurable'. This has promoted the suppression of local practices of knowledge creation during colonialism and the apparent universality of science from Europe, as scholars point out (Kuukkanen 2012, 489-492).

This discussion of how 'formal global scientific knowledge' spatially relates to 'local scientific knowledge' might, however, also be a practical one in the first place, such as in the context of development theory (Cleveland et al. 2009). We could for example use Sillitoe's argument that we need a 'working definition' of indigenous knowledge, which 'may relate to any knowledge held more or less collectively by a population' (Sillitoe 2002b, 9). As Sillitoe further states it...

...is culturally informed understanding inculcated into individuals from birth onwards, structuring how they interface with their environments. It is also informed continually by outside intelligence. Its distribution is fragmentary. (Sillitoe 2002b, 9)

With a working definition, one looks at the universalist and localist perspective from a different angle. This brings us back to the question of radical particularism, where we need to ask how we refer to social activity in relation to a geographically identifiable spatial and political context, such as Southwest Nigeria. This issue becomes more apparent when Kuukkanen refers to the warnings of some historians of science, who are concerned about a narrow view of Western science as an 'expanding culture'. Their concerns lead to some questions regarding an analytical perspective on knowledge flows (technology transfer) in a postcolonial world, where social scientific research takes place somewhere and in relation to relevant actors that can be found in places:

Also local cultures have contributed [to the integration and production of knowledge].  
Second, it has been suggested that the idea of static centres of scientific knowledge

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<sup>49</sup> For universalists these processes of standardisation are understood in terms of a pre-existing universality of relevant properties (Kuukkanen 2012, 489-492).

production may distort the picture, and it would be better to see knowledge continually moving and flowing, or ‘circulating’ between localities. (Kuukkanen 2012, 491)

In line with this warning, this research has been aware of many pitfalls in relation to how knowledge, ethnicity and culture relate to locality. This research has aimed from the outset at neither reducing GIScience in Southwest Nigeria to immutable technologies and knowledge (universalism), nor to being *Nigerian* (radical localism). When Redfield contemplates on how colonial history became part of the space age (ESA’s launch site in French Guiana), he sees spatial and temporal components as one of the great challenges in studying the local in relation to apparently universal science and technologies:

At stake in this example for science studies, I believe, is a recognition that any effort to deflate universal claims into local knowledge practices must not lose sight of the different spatial and temporal frames within which ‘the local’ takes shape. (Redfield 2002, 792-793)

In line with this, Appadurai argues that time and movement need more attention in ethnographic research: Whilst ‘[r]ecent work in anthropology has done much to free us of the shackles of highly localized, boundary-oriented, holistic, primordialist images of cultural form and substance (...) not very much has been put in their place’ (2002, 60). To illustrate this gap, Appadurai uses the idea of *scapes* ‘as the dimensions of global cultural flow’ (ibid., 50). In technoscapes, we might then discern parts of Surrey-constructed, Ukraine/Russia-launched and Nigeria-operated *Nigerian* EO satellites. These scapes are ‘navigated’ by various actors, from the individual to the nation-state (ibid., 51-54).

## Postcolonial Science and Technology Studies

Spatial and cultural considerations in relation to science are also addressed through a post-colonial lens in STS. A related discussion in this section has helped to find an adequate ethnographic methodology without restricting an understanding of the *local* from the outset. The postcolonial lens in STS (PCSTS) has gained momentum since the 1980s, and is amongst others interested in understanding the relationship between colonialism and the development of science in Europe (Watson Verran et al. 1995, Harding 2008, 130-133). This relatively new focus also relates to shifts in development theory after confidence in development programmes declined in both the developing and industrialised world (Escobar 2011) (chapter three).

Whilst Harding argues that in STS micro-level studies on the social construction of ‘Western sciences’ and technologies still prevail, she acknowledges that these studies have

implicitly questioned ‘the conventional contrast between purportedly value-free Northern science and value-laden knowledge systems of other cultures’ (2008, 23, 133-134). However, what is the global South that is considered in relation to Northern science in PCSTS? Harding calls for attention to the standpoints<sup>50</sup> of ‘peoples and cultures at the peripheries of Northern modernity’, their ‘scientific and technological achievements’ and how they have been affected by science and technologies from the global North (ibid., 7-8, 134). According to Harding, one promising PCSTS perspective would be to look at a world of interacting ‘sciences, each serving the economic, political, cultural, and psychic needs of its peoples’ (2011, 9-10). This perspective further suggests that local sciences should ideally not be assimilated into ‘modern Western sciences’ to preserve the diversity in ‘knowledge systems’ (ibid.). Also in the case of Watson-Verran and Turnbull, ‘localness’ becomes the basis of various knowledge systems with their different characteristics, such as epistemologies, of which ‘Western contemporary technosciences’ is no exemption (1995, 116). For example, in the publication *African Cosmos: Stellar Arts*, the whole African continent seems constructed as a multifaceted yet distinct knowledge system, when Kreamer points at a yet limited appreciation of ‘African concepts about the cosmos’ and related astronomy, which she relates to the Western tendency to ‘view Africans as cultural, but not scientific, beings’ (2012, 13-14). Notwithstanding the importance of counteracting such a narrow view, that is also criticised by scholars like Mavhunga (2017), African concepts and an African cosmos suggest an intricate epistemological essence of Africa.

On the one hand, any standpoint perspective that reflects particularism should be supported for its urgent political commitment. However, recalling the previous discussion, the *local* is in danger of being prematurely tied to geography, culture and knowledge in contrast to a not less restrictive universalist approach. Anderson and Adams suggest that Harding’s perspective looks for ‘epistemological pluralism’ (2008, 186-187). Such a multicultural approach, however, is contested amongst various postcolonial scholars, as it would not live up to the ‘heterogeneity and messiness of technosciences’, including a modern scientist’s potential ‘multiple subjectivities and sensitivities’ (Anderson 2002, 650, Anderson et al. 2008, 187). In this context, Anderson also questions older science studies perspectives for their missing potential in ‘explaining the co-production of identities, technologies and cultural formations’ in relation to an ‘emerging global order’ (2002, 643).

A pluralist and relativist PCSTS perspective that builds on bounded communities so far seems confined in relation to GIScience and its unresolved relationship to

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<sup>50</sup> Such as expressed ‘science and technology concerns’ by people in the South, through which Northern policies and practices can be understood (Harding 2008, 134-135).

particularism and universalism. The concept of culture remains a strong reference point in relation to places of knowledge and technology production. However, since the 1980s social anthropologists increasingly argue for a constructivist understanding of culture (Clifford 1986) and Abu-Lughod (1991) even suggests to write ‘against culture’ with reference to the problematic dichotomy of ‘selves and others’, which might prematurely tie an understanding of how GIScience in Southwest Nigeria is constructed to certain pre-conceptions, such as geographically bound knowledge.

At this juncture I have a particular feeling of unease. I, for long, have wondered whether I should relate this research to the field of PCSTS only because I look at the construction of a research community in a former colony. Would I refer to the post-imperial if I intended to focus on GIScience in Europe? One of my original concerns (for my research) is that we, on the one hand, aim at looking at the ‘multiple vectors of technoscience’ and at the same time handle unarticulated notions of ‘places’, ‘cultures’ and ‘sites of technoscience outside Europe and North America’ as the points of those vectors (Anderson et al. 2008, 184-190, 191-193). In other words, what can a postcolonial STS lens contribute in addition to STS in a *Western* context and anthropology that increasingly looks at global sciences (Anderson et al. 2008, 185, Crate et al. 2016)?

Western STS and related scholarly work has revealed that Europe has never been less heterogeneous in terms of norms and values than other places (Livingstone et al. 2005, 12, see also Gieryn 1999). At the same time as this is praised in PCSTS literature, science and the West are as much deconstructed as they remain points of reference. This becomes more visible by looking at Gieryn’s thoughts on boundary-work – how ‘science becomes local and episodic rather than universal’ (1999, 27). In Gieryn’s non-PCSTS perspective spatial references to culture (and the West) do not enter deductively, but are rather constructed through different knowledge claims about nature, where...

...those serving up discrepant realities can draw discrepant cultural maps to legitimate their claims as uniquely credible and useful. (Gieryn 1999, 17)

Properties attributed to science on any occasion depend largely on the specifics of its ‘other’, on who or what is being excluded from the cultural space of ‘science.’ (Gieryn 1999, 22)

This leaves the postcolonial lens quite ambiguous, which becomes further visible when Ellen critiques unhelpful characterisations of ‘indigenous knowledge as local’ (such as socially constrained and practical) in contrast to science, and questions whether *any* knowledge is then indigenous and whether any reference to the West, or indeed a

postcolonial lens, becomes obsolete (2002, 247, 250). So far social and spatial references to knowledge remain ambiguous and circular.

When Gieryn asks ‘who really has the epistemic authority to map science’ (1999, 28), this question can also be translated into the postcolonial lens – to the owners of knowledge and to PCSTS researchers who seem to know where they are: ‘In what organizational and institutional arenas does the boundary-work occur’ (Gieryn 1999, 29)? In other words, who from a PCSTS perspective, is actually considered a *Western* scholar (both in social sciences and natural sciences)? Here, one central PCSTS provocation is to demarcate where the local begins in a geographical and social sense. Are the institutions in GIScience that I have visited a priori part of culture-bound Nigerian institutions and practices of knowledge production (Harding 2008, 16)? What is GIScience in Nigeria with scientists, who according to a Southern standpoint perspective belong to ‘peoples of other cultures’ (Harding 2008, 144)? What if I only did STS in Nigeria? Would I oppose post-colonial arrogance for some scholars and support it in the eyes of others?<sup>51</sup> Would that be a ‘fascination with globalization theory’ instead of ‘postcolonial issues’ (Harding 2011, 4)? Should my focus be on ‘processes of integrating Northern sciences and technologies into non-Western societies’ by looking for Nigerian and Yoruba ‘legacies, meanings, and practices’ (Harding 2008, 150)? In summary, though PCSTS counters determinist developmental narratives (chapter three), some PCSTS standpoints face a similar ‘paradox’:

Modernity symbolically constructs indigeneity, otherness and the idea of fundamental difference between Western and non-Western societies even as it promotes the social and material dismantling of whatever divide may once have existed through the mixing and hybridisation of elements that lie on either side of it. (Dove et al. 2009, 130-131)

Ellen further speaks of the tension of a focus on ‘cultural diversity’ and the ‘assumption of common human responses in problem solving’ (2002, 241). These tensions eventually relate to the ‘universalist/relativist debate’ and (ethical) dilemmas in relation to how ‘local knowledge’ is distributed in complex social realities (ibid., 241-242). My unease with blindly relating my research to PCSTS, where a favourable localist perspective often seems restricted and embedded in paradoxes (especially for my research question), is not only best articulated by Itty Abraham from the National University of Singapore (NUS 2017); he has also rescued PCSTS for this research:

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<sup>51</sup> See also Mavhunga’s (2014) partitioned call for a Western epistemological approach to *African* knowledge and technology. In his case, a Western STS perspective covers the epistemological aspect (SSK and SCOT), but not an Africa-bound essence of knowledge and technology.



Is it possible that postcolonial techno-science can be an alternative mode of analysis at the same time as the postcolonial indexes a locational site for alternative, i.e. non-western, knowledges? One line of thinking appears to do away with the nation-scale, while the other seeks to reinforce it. (Abraham 2006, 210)

In line with the previous discussion about the knowledge-related locale, Abraham contemplates on the analytical use-value of a postcolonial lens that ‘articulates an ontology that ties knowledge to location as a singular and essential quality of place’ (2006, 210). Like Anderson (2002), Abraham seems to look for a compromise between a Southern standpoint approach and understanding the messiness of technoscience – the ‘travels and circuits of scientists, knowledges, machines, and techniques’ (Abraham 2006, 210). Abraham sees value in the postcolonial lens if we do not isolate the South from the West (2006, 217). Instead of ‘either endless discussions of the authenticity and origins of western and eastern ontologies and epistemologies or assertions of the inherently liberatory potential of a “scientific temper”’, that eventually maintain ‘reified notions of the west and western science’, one should consider an ‘empirical response’, as Abraham suggests (ibid.). This, inter alia, includes more social research on scientific practices ‘in relation to (...) [the] geophysical location’ of scientists (ibid., 211). Such a focus can then reveal the ‘uneven circuits of global science’ (knowledge flows) whilst ‘location no longer offer a one-dimensional and stable reference to knowledge’ (ibid., 217). Only then can science possibly be identified as a culture- and politics-related discourse (such as *Nigerian* science). This is in opposition to treating indigenous GIScience capabilities as something inherently alternative from the outset. I will return to PCSTS in the last chapter to respond to some of the questions that have emerged in this section, such as: what can PCSTS look at and on behalf of whom? With this objective in mind, the next section will introduce the methodology that has allowed to focus on practices of GIScience in Southwest Nigeria, whilst keeping postcolonial discourses in mind.

## Research Design

### Research paradigm

Overall, this research understands ‘scientific truths’ and technologies as being socially constructed (Williams et al. 1996, 868-869). This includes ‘a critical understanding of our systems of formal knowledge with an equally deep appreciation of the institutions, practices, cultural beliefs and material resources that sustain particular ways of knowing’, as Jasanoff formulates it (1996, 409-410). This acknowledgment, however, must be

understood in the context of my previous discussion of locality and PCSTS. For example, I do not follow an ontology that treats knowledge and place (culture) as an essentialist entity (Abraham 2006, 210). Whilst this research overall can be located within an interpretivist/constructivist paradigm (Schwandt 1994, Guba et al. 1994), Rabinow suggests that epistemology itself should be understood as a ‘historical event’, respectively a ‘distinctive social practice’ (1986, 241, 236). This chapter has discussed how the postcolonial lens is not only constructed in a postcolonial era, but how it includes and excludes different actors, discourses and localities. Science and Technology Studies has primarily been established in few Northern countries with a focus in Western Europe and North America. At the same time, postcolonial STS has been influenced by several theories (such as feminist) and disciplines like Western anthropology that have their own long-term, and often national, debates over epistemologies and disciplinary futures, especially in the context of an engagement with development (Escobar 2011, 282, Ellen 2002, Sillitoe 2002b, Harding 2008).

Discourses on development as a postcolonial research practice are of particular relevance for this research. Ellen, for example, argues that ‘anthropologists increasingly inhabit an analytic space with political scientists, political economists and sociologists’ (2002, 250-251). His colleague Sillitoe sees opportunities ‘to take anthropology in exciting new directions’, but acknowledges that some anthropological traditions might oppose any ‘threat’ to their ‘intellectual integrity’ (2002b, 10). In European anthropology, epistemological discourses usually take place at the national level. Recalling the postcolonial challenges of understanding societies in relation to knowledge, Fox and Gingrich see this national disciplinary attitude as a dangerous drawback:

Even after the critical debates of the 1980s and 1990s, most anthropological approaches in use today are still deeply entrenched in their respective linguistic or national boundaries (...). In a global world, however, referring to only one anthropological tradition is a serious – and dangerous – impediment to moving ahead. (Fox et al. 2002, 7)

PCSTS is daringly tapping at this (national) intellectual integrity. In line with Sillitoe’s hopes, this research aims at contributing to a broadening of social research as related to developing countries. Whilst some PCSTS scholars argue that STS until recently has largely focussed on the global North, only two decades ago anthropologists like Lemonnier found themselves quite alone when it comes to an anthropology of technology (from acting with our bodies to ‘making jumbo jets’) that aimed at studying technologies (material culture) in the same way as ‘kinship and religion’ (Schiffer 1994, 202-203, Lemonnier 1992, 1). Around the same time, Redfield saw in anthropology a focus on the

‘geographically bounded group’ and suggested it should consider spaces between the local and universal as places, where modernity and tradition are negotiated, and where science and technology studies could hence come in as ‘new ethnographers of the world of modern knowledge’; who themselves had so far hardly left the laboratory (1996, 254-256).<sup>52</sup> Redfield suggested that...

...an anthropology that remembered technology beyond the study of material culture and its diffusion, and a social study of science that remembered anthropology beyond ethnographic technique, would find and describe place beyond villages and space beyond laboratories. (Redfield 1996, 268)

Today, anthropology, such as an anthropology of climate change (Crate et al. 2016) already intersects with STS, whilst STS increasingly participates in postcolonial discourses. With my aim of ‘locating and describing the sites and subjects’ that relate to GIScience in Southwest Nigeria (Marshall et al. 1989, 55) between the local and universal, this research has required a methodology that indeed considers ethnography beyond the laboratory and the village.

## Methodology

### *Multi-sited ethnography*

To describe relevant actors, their policy positions and agency in GIScience, a twofold methodology has been applied. Remembering Abraham’s suggestion to understand the construction of any potential cultural traits of scientific communities by looking at their practices in those postcolonial geographies that we are concerned with, George Marcus provides valuable additional thoughts. In 1995, Marcus describes a multi-sited ethnographic approach that focusses on ‘the circulation of cultural meanings, objects, and identities in diffuse time-space’ (1995, 96). The postmodern mode of multi-sited ethnography resonates with my tentative approach to locality and development theory:

This mode defines for itself an object of study that cannot be accounted for ethnographically by remaining focused on a single site of intensive investigation. It develops instead a strategy or design of research that acknowledges macrotheoretical concepts and narratives of the world system but does not rely on them for the contextual architecture framing a set of subjects. (...) Just as this mode investigates and ethnographically constructs the lifeworlds of variously situated subjects, it also ethnographically

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<sup>52</sup> Redfield acknowledges that some historians of science had already pointed at the wider ‘imperial scope of the scientific enterprise’ and ‘the material and symbolic effects of specific technologies’ (Redfield 1996, 256).

constructs aspects of the system itself through the associations and connections it suggests among sites. (Marcus 1995, 96)

Recalling my concerns with locality and PCSTS, Cook et al. further suggest to move away from the idea of holism. They extend Marcus' approach that already questions culture as a homogenous layer of 'space, place and field' that could be studied as one unit at a specific point in time (2009, 59-65). With reference to human geography, they suggest to draw a more precise distinction between space (abstract) and place (experienced and subjective) (ibid., 59). They describe 'places' as '*imagined* spaces', which are not necessarily bound to a specific location (ibid.). Cook et al. thus call for an un-sited understanding of the field that acknowledges how places can be imagined from the village to the nation state<sup>53</sup> (ibid., 59-60, 64). The empirical chapters will show how important Cook's et al.'s considerations are.

In line with Marcus and Cook et al., also Abu-Lughod's (1991) contemplations on 'ethnographies of the particular' have been helpful. Abu-Lughod intends to avoid othering and generalisation. Her suggestion is to tell 'stories about particular individuals in time and place', which includes their various standpoints and connections. This has eventually led me to follow a multi-sited ethnography approach that is mindful of how my dialogue partners indicate relevant places and people in space and time (Cook et al. 2009). This nevertheless implies challenges, such as deciding where 'multi-sited' actually begins (Falzon 2009, 13). In my case it began within the gated campus of the OAU in Ile-Ife that I have introduced as a major centre for GIScience. With regard to Marcus' original account the mode of 'following' has then been helpful in constructing a multi-sited field, such as by 'following' people, 'signs, symbols, and metaphors' (I acknowledge the negative connotation of following people) (Marcus 1995, 106-110).

### *Situational Analysis*

Referring to ethnographers' forms of analysis that often seem tacit, LeCompte and Schensul (1999, 45-46) remind us that 'a number of strategies useful in thinking about, organizing, and coding material in a study' have been suggested. Hammersley and Atkinson likewise emphasise that '[i]deally, every period of observation should result in both processed notes, and reflexive monitoring of the research process' (1983, 165). These 'preliminary analyses' can then function as 'guidelines through the corpus of data' (ibid.). Whilst the ethnographic process in this research will be introduced in the next sections, this section

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<sup>53</sup> Cook et al. refer to Benedict Anderson's (1983) *Imagined Communities*.

will already discuss how *situational analysis* has helped in guiding this process. It will focus on the relevant relation between codifying the collected data and producing maps.

Having looked at what other scholars offer with a focus on describing and exploring places, actors and ideas (multi-sited ethnography), Adele Clarke provides *situational analysis* as a helpful analytical approach that is in line with my PCSTS perspective. It is based on grounded theory (Strauss et al. 1997, vii), but has been freed from a related positivist touch (Clarke 2005, xxi-xxii, xxiv). In line with Marcus' idea of ethnographically constructing lifeworlds (1995, 96), Clarke suggests that '[t]hrough mapping the data, the analyst constructs the situation of inquiry empirically', which can be considered a supplementary tool to the collection and analysis of ethnographic data in complex situations (2005, xxii-xxiii). Referring to ethnographic experience in STS, Hess suggests to not only 'interpret complexity' but to generate new sensitizing concepts (2001, 239). This is in line with situational analysis. Unlike grounded theory, situational analysis is no longer interested in theory generation but 'grounded *theorizing*' with the help of 'sensitizing concepts' (Clarke 2005, 28). My research question already involves the explanation of a sensitizing concept – indigenous as related to GIScience. During my research the latter has turned out to be 'thin', but can in parts be explained through a different sensitizing concept (Faulkner 2009, 84-85).

#### *Mapping in situational analysis*

In line with my soft-particularist multi- to un-sited approach to GIScience in Southwest Nigeria, Clarke suggests to observe collective action and understand *social worlds* empirically at the meso-level, 'where individuals become social beings again and again through their actions of commitment to social worlds and their participation in those worlds' activities' (2005, 110). Clarke et al. define a social world as 'a group of people who come together through a shared interest on which they are prepared to act and who use similar technologies and discourses in pursuing their mutual concerns' (2015, 174). These worlds are part of larger arenas of 'sustained interest and concern' in which they come together as allies or opponents (ibid.). Answering my research question and its sub-questions has then been guided by also asking: 'What are the patterns of collective commitment and what are the salient social worlds operating' in the GIScience arena (Clarke 2005, 110).

I have looked at relevant policy positions by integrating two concepts for guidance (Blumer 1954, 7). The first concept, 'frames', is formulated by Schön and Rein. They define 'frames' as the underlying structures of policy positions that are made up of 'belief, perception, and appreciation' (1994, 23). They acknowledge the dilemma of becoming

aware of the often tacit ‘frames’ (for example ‘autonomy’) and of deciding which frame is important for which policy position, and how far this is consistent with people’s action. The ‘frames’ have been constructed from speeches, texts and routines and with ‘carefully nuanced observations’, which is in line with both multi-sited ethnography and situational analysis (ibid., 34-36, 73). A second concept has then helped me to address the action frames in more detail. Jenkins (1983) discussed the theory of resource mobilisation. Here, I have paid attention to how ‘a group secures collective control over the resources needed for collective action’, and the different meanings that resources in the GIScience situation can have (ibid., 532-533).

This has accompanied the central method in situational analysis: I have mapped the social worlds in GIScience in Southwest Nigeria for matters of guidance in collecting and interpreting data by using three maps that are at the heart of situational analysis (Clarke 2005, 83-85). The maps include a *situational map* that encourages to ‘lay out’ various elements that can be found in the ‘messy complexities of the situation’ that is studied, with an additional focus on discursively important nonhuman elements.<sup>54</sup> It has helped me to find direction in multi-sited ethnography and data analysis during my stay in Nigeria and post-fieldwork (Clarke 2015, 133-135). Likewise, producing a draft ‘meso-level’ *social worlds/arenas map* during fieldwork has helped me to understand the organisation of actors, overlapping relevant social worlds and their ‘arenas of commitment’.<sup>55</sup> Finally, drafting a *positional map* has highlighted controversial issues (sub-positions) in this respect (ibid.).<sup>56</sup> Before introducing the three maps in situational analysis in more detail, I will describe how my data analysis relates to these maps.

#### *Maps in situational analysis in relation to the data analysis*

Across an analytical ‘spectrum’ that ranges from using ‘uncodified’ to codified data (Schatzman et al. 1973, 109), I focussed on beginning to codify data during my research stay in Southwest Nigeria (Clarke 2005, 83-84), and have also used this approach for my post-fieldwork analysis. In line with situational analysis as an ‘extension’ of grounded theory (Clarke 2015, 133), I have used ‘open coding’ for my data analysis to also allow for ‘theoretical sampling’ where, in accordance with multi-sited ethnography, ‘what is to be studied *emerges* from the analytic process over time’, as Clarke suggests (ibid., 122-123; emphasis in original). The three maps in situational analysis should then be considered an

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<sup>54</sup> See Table 7 in the appendix

<sup>55</sup> See Figure 34 in the appendix

<sup>56</sup> See Figure 20.

add-on in combination with conventional coding of data (such as in grounded theory) (Clarke 2005, Clarke 2015). They do not need to constitute ‘final analytic products’ (2005, 83). During my fieldwork, all maps in this thesis have only been used to “‘opening up” the data’ with as much coded or ‘carefully read’ data and related memos as possible (looking for what needs further attention) (ibid., 83-84).

In line with this, I have read my transcripts of interviews to identify ‘particular phenomena’ (Clarke 2015, 122). Here, Hammersley’s and Atkinson’s hope in 1983 that IT solutions for ‘filing, sorting, and retrieving ethnographic data’ would become more available and reliable, has been fulfilled (1983, 172). After every interview I imported the related audio file<sup>57</sup> into the qualitative data analysis software NVivo (versions 10 and 11) and, as soon as possible, transcribed my handwritten memos and fieldnotes in the same software environment. I further began to transcribe the interview audio files whenever the field situation allowed (usually in the evening). This included a preliminary analysis of the transcripts. Upon identification of phenomena, I labelled (coded) them in relation to descriptions and themes (nodes), such as ‘USGS as a saviour’ and ‘USGS as a model’. Different codes became ‘robust’ in various interviews and in relation to my observations. Together with other relevant codes, I ‘densified’ them into bigger substantial analytical ‘categories’, such as ‘appreciation of foreign collective actors for capacity maintenance’. This process also sensitised me to look for other relevant aspects. In combination with related memos, this has become an abductive way of generating categories as part of ‘theorizing’ (Clarke 2015, 121-123). Schatzman and Strauss<sup>58</sup> refer to this process as ‘discovering classes’ in relation to ‘things, persons and events and the *properties* which characterize them’, as well as relevant ‘linkages’ (1973, 110; emphasis in original).

Here, LeCompte and Schensul argue that ‘ethnographers actually use both induction and deduction throughout their analysis’ (1999, 46). Although not in relation to established theories, looking at the three maps, this is also the case in situational analysis, such as regarding *situational maps* as the first suggested map. In mutual relation to the constructed codes, Clarke offers basic categories to produce an ordered situational map. Clarke suggests to first list all important elements, as they appear in the research situation, in a messy situational map. This map has then helped me to also discern implicated ‘silent’ (collective) actors that are important for GIScience. The second step is an ordered map

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<sup>57</sup> I recorded interviews after consent by using an Olympus digital voice recorder (Hammersley et al. 1983, 144-145).

<sup>58</sup> Anselm Strauss *initially* developed grounded theory together with Barney Glaser. Strauss taught Clarke who, inspired by certain principles of grounded theory and their limitations, developed situational analysis (Clarke 2005, Richards et al. 2007, 62-65).

that has helped to classify the elements according to, for example, individual/collective human elements, nonhuman elements, 'political/economic elements', 'sociocultural/symbolic elements', 'temporal elements', 'spatial elements' and 'major issues/debates' (Clarke 2005, 86-90, 115).<sup>59</sup>

Based on some ordered codes, the second type of maps (*social worlds/arenas maps*) has helped to further theorise social relations in my research situation (Clarke 2005). Actors in GIScience are at the centre of the map with various relevant social worlds surrounding them. When visualising these social worlds, they can overlap and can be scaled in relation to their relevance. With regard to my research question, this has also helped me to understand which part of the research situation is an arena and which a social world (Clarke et al. 2015, 175). The provisional map of early 2015 (before the research) can be found below in Figure 14, whereas the map that I drafted during fieldwork can be found in the appendix (Figure 34). According to Clarke, the situational map and the social worlds/arenas maps can be followed by the construction of *positional maps* (2005, 115-116) to better understand different policy positions within the research situation that can exist amongst 'individuals, groups, and institutions' (Clarke et al. 2015, 178-179). In this research, different sub-positions towards Nigeria's EO programme have become visible amongst my dialogue partners and have been plotted along the axes of 'importance for data independence' and 'degree of future orientation' (ibid., 177-178). This map will be introduced in chapter six, whilst a template can likewise be found in the following (Figure 15).

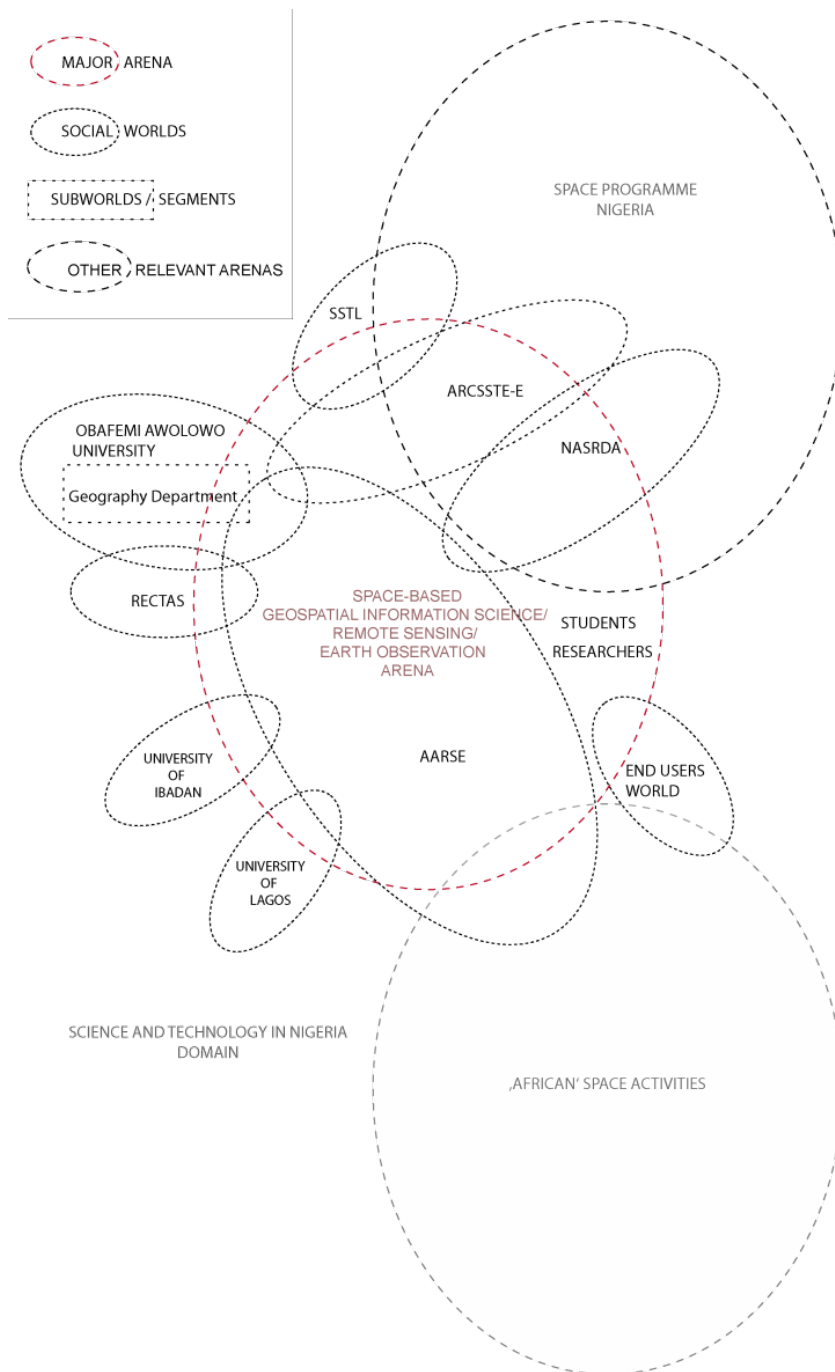
Overall, based on this combination of initial coding and map-based 'theorizing', 'theoretical sampling', as part of grounded theory's legacy in situational analysis, has also sensitised me to new instances, dialogue partners and institutions in relation to the mode of 'following' in multi-sited ethnography (Clarke 2015, 122-123, Clarke 2005, Marcus 1995). At the same time, my capacity to transcribe and analyse data in the field was often limited to relevant passages in accordance with my notes and memos (Clarke 2015, 122).

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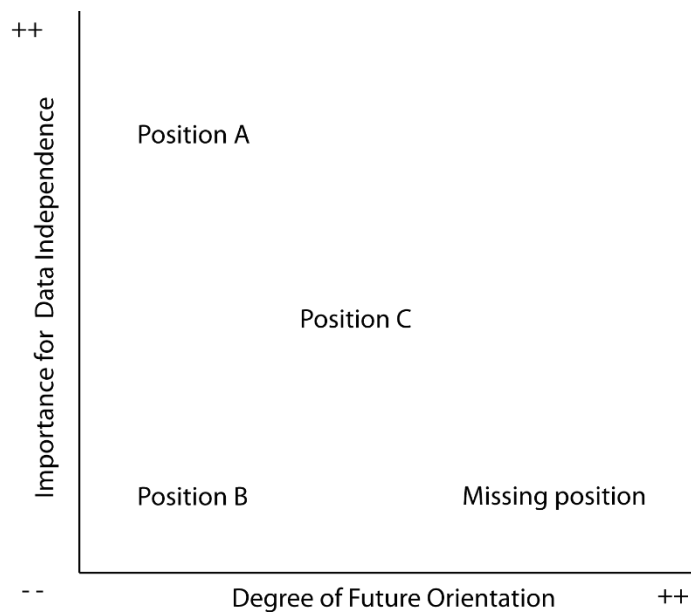
<sup>59</sup> See Table 7 in appendix.



*Social Worlds/Arenas Maps and Positional Maps*



**Figure 14** Provisional 'Abstract Map of Social Worlds in Arenas' (prior to fieldwork in 2015) by author, adapted from Clarke (2005).



Template of Positional Map on Nigeria's EO satellites

**Figure 15** Template of Positional Map, based on Clarke (2005).

*Final remarks*

In combination with multi-sited ethnography, situational analysis has allowed to better understand the elements that empirically constitute the ‘situation of inquiry’ – GIScience in Southwest Nigeria. Whilst the focus of this research is on ethnographic descriptions, coding (interview data), memoing and mapping have helped me to observe collective action and empirically understand relevant social worlds at the meso-level (Clarke 2005, xxii, 110). Clarke suggests that related maps, such as Figure 34 in the appendix, do not need to constitute final analytical products but can be used for guidance, which was the case in this research (ibid., 83-85). However, the production of these maps during fieldwork proved more challenging than expected. The physical challenges that I faced in this respect reflect nothing less than my research situation and have hence been revealing in relation to those ‘implicated actants’, such as air conditioning, that eventually also belong to GIScience capacity in Southwest Nigeria (ibid., 47-48). In her original work, Clarke acknowledges general challenges of data analysis and suggests to map along with coded

data during research or at least with as much ‘carefully read’ data as possible (ibid., 83-85). Here, the use-value of situational analysis eventually depends on the situation that is researched if the situation of data analysis cannot be transferred to a researcher’s personal office. Situational analysis is time-consuming. As a guest in a multi-sited ethnographic setting, such an analysis was hence handled with much care.

Ten years after Clarke’s original publication, Clarke et al. appreciate that people have adapted their mapping strategies to their personal research situations (2015, 178-179). In line with this, Figure 31 in chapter seven is loosely based on social worlds/arenas maps, as originally suggested by Clarke, as is Figure 34 in the appendix.

### Methods of data collection

I have conducted the multi-sited fieldwork in Southwest Nigeria between October 2015 and April 2016. An additional two weeks’ research stay in the Netherlands and my attendance at both AARSE conferences in 2014 and in 2016 frame this research (Table 2). During this period, I have accompanied researchers and students to different sites, such as their places of work, conferences, meetings, field sites, and other places of social activities. I have observed daily practices and routines of researches and have participated in them as often as the situation allowed.

Time	Country	Sites	Fieldwork
October 2014	Johannesburg, South Africa	AARSE conference	Introduction to the field
October 2015 - April 2016	Osun State, Oyo State, Ondo State and Lagos State (Nigeria)	Diverse institutions (Table 3, appendix I)	Major research phase
September 2016	Enschede, Netherlands	ITC	Additional research
October 2016	Kampala, Uganda	AARSE conference	Research and Member checking

**Table 2** Major sites of research.

My chosen methodology has guided me to several university departments across Southwest Nigeria, such as surveying and geoinformatics, geography, remote sensing & GIS, forestry, veterinary science and ecology. These sites include the OAU with RECTAS and ARCSSTE-E as my primary sites of research, the University of Lagos, the University of Ibadan and FUTA in Akure. Furthermore, I have visited research institutions like the

Forestry Research Institute of Nigeria (FRIN), the International Institute for Tropical Agriculture (IITA) in Ibadan as well as the Federal School of Surveying in Oyo (Figure 12 in chapter two). Finally, instead of Abuja, as first expected, my research has led me to the Faculty of Geo-Information Science and Earth Observation (ITC) at the University of Twente in the Netherlands. My research has comprised the following methods at all these different sites.

*(Multi-sited) ethnographic methods*

Ethnography, as a flexible methodology, that has largely been developing in social anthropology and sociology since the early twentieth century, has contributed valuable methods to this study of the everyday experiences in geospatial information science in Southwest Nigeria. Ethnography, which is also often used synonymously with ‘fieldwork’ has further been integrated and adapted in many other fields as an important alternative to using quantitative methods. Here, the common understanding is that ethnography, amongst others, builds on different sources of data, such as observations. Related objectives can range from describing a group’s everyday life to building theory in relation to observed behaviour (such as by following grounded theory) (McNeill 1990, 64-65, Hammersley et al. 1983, 1-3, 8-14). However, in combination with situational analysis, with its implicit postmodern and feminist character, the development of theories is eclipsed by a focus on ‘sensitizing concepts’ and ‘theoretically integrated analytics’, if appropriate (Clarke 2005, 4, 18-19, Clarke 2015).

As part of my multi-sited ethnographic approach, I have participated in and ‘overtly’ observed researchers’ day-to-day routine in different places to understand relevant practices in the GIScience situation. To this end, I have also conducted semi-structured interviews with GIScience researchers in preference to more positivist-tinted structured interviews and questionnaires (McNeill 1990, 64-71, Hammersley et al. 1983, 1-26). Here, participant observation is a central element of anthropological and sociological ethnographic enquiry (Wolcott 2005, 88). Whilst the history of this method is complex, the following definition by Jorgensen shall illustrate its key essence: ‘The methodology of participant observation requires that the researcher becomes directly involved as a participant in peoples’ daily lives. (...) Through participation, the researcher is able to observe and experience the meanings and interactions of people from the role of an insider’ (1989, 20-21).

Looking at three relevant modes that McNeill suggests with reference to Gold (1958)<sup>60</sup>, I primarily was a ‘participant-as-observer’ (1990, 81-83). Here, I was ‘not really

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<sup>60</sup> See also Hammersley et al. (1983, 88-97) with reference to Junker (1960) and Gold (1958).

one of them [GIScience researchers]' (ibid.) in terms of their roles in the 'situation [that I was] studying' (Gans 1962, 399, cited in McNeill 1990, 82). In line with this, I always informed researchers and students about my background (which would be concealed in a 'complete participant' mode). I accompanied them in their offices, GIS laboratories, seminar rooms, on corridors and in other places, where I observed and/or participated in their interactions and activities that belong to their daily routines, such as the acquisition of data and research-related communication (Hammersley et al. 1983, 92-97). Though I occasionally seemed to adopt the role of a member of a GIScience-related discipline, such as during conferences, I did not 'become over-involved' (McNeill 1990, 82). As my visits to some institutions were 'brief', I also was an 'observer-as-participant' (ibid.). Here, my focus was on what Gold, in his original article, calls 'one-visit interviews' and 'more formal observation' (1958, 221). Overall, in line with McNeill's (1990, 90) reference to Gans (1962, 397-398), I used local facilities and 'observe[d] my own and other people's behaviour' in the situation. Furthermore, in an unplanned manner, I also observed outside the immediate research situation, where I usually became a 'complete observer' whenever I was not in direct contact with the observed 'social interaction' (Hammersley et al. 1983, 51-52, 94-97).

All this required sampling 'across time and people' (Hammersley et al. 1983, 51). For example, I regularly retreated to GIS laboratories and offices, where I was able to briefly work, such as taking notes. At the same time, I continued paying attention to knowledge-related interactions around me, connected nonhuman actors (present and absent), and began following relevant paths (multi-sited ethnography in relation to situational analysis). This further included my hosts' (informants) and dialogue partners' advice on whom I should also meet – as part of their comprehensive response to interview questions, and accordingly as 'member-identified categories' (ibid., 45-53).

Overall, I did most focussed observations ('watching what happens' and 'listening to what is said'), semi-structured interviews and informal conversations ('asking questions') (ibid., 2) in my dialogue partners' places of work. Interviews were either scheduled or took place spontaneously while hanging around. In this situation, frequent power outages constituted a prevailing event, which I also observed by 'listening, smelling, touching, and tasting' – as additionally important sensory perceptions in ethnographic research (Bailey 1996, 65-67). Here, I not only often observed turned-off workstations and other devices, but whilst usually feeling some sweat on my skin, when air conditioning units were not working, I also listened to the noise of generators that provide basic power supply to some facilities, and occasionally smelled their exhaust fumes. This included observations

of ‘the social implications of the physical surroundings’ and of my own reactions in relation to situational behaviour (ibid., 65-67, 71). In line with situational analysis, a focus on semi-structured interviews, became an activity in relation to my observations of pertinent activities during power outages. This situation not only comprises the activity of getting fresh air, but relevant discourses and a demanding impact in relation to capacity, that will be discussed in the empirical chapters. At the same time, it also provided implicit space for in-depth interviews in which researchers, amongst others, shared their personal tacit experiences, explanations and views in this respect (Hammersley et al. 1983, 107-109).

In the following, I will not only briefly refer to the interview method, but also introduce other methods that I have used. As Hammersley et al. (1983, 24) emphasise, participant observation and interviews are only two methods in ethnographic research. Here, one of the analytical strengths of ethnography is the use of ‘multiple data sources’ (data triangulation whenever feasible).

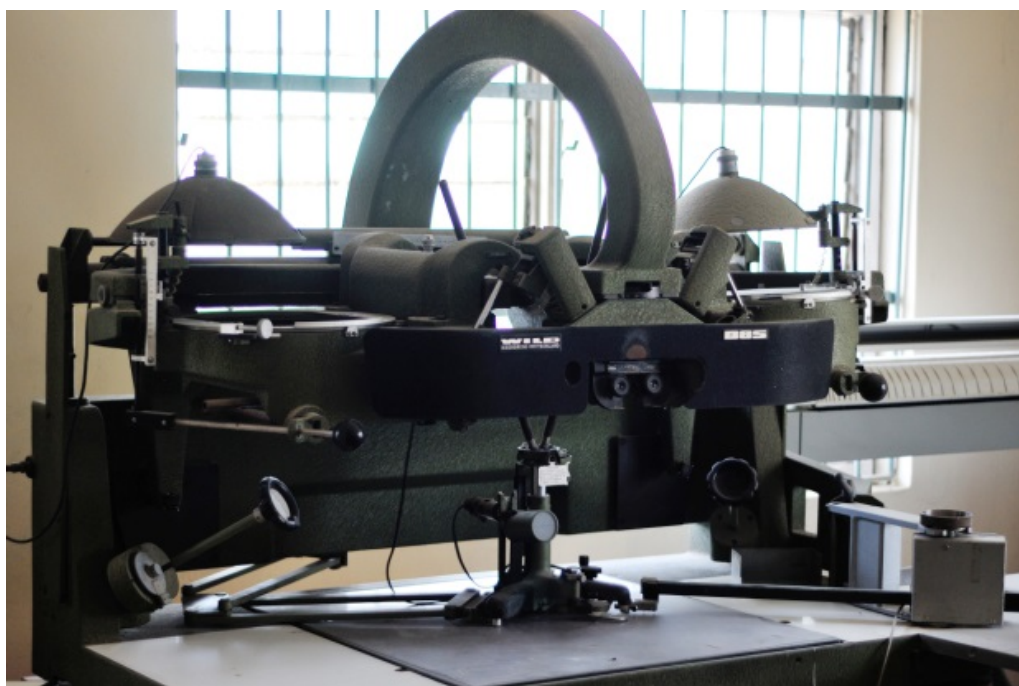
#### *Semi-structured/non-directive interviews and focus groups*

The prime method of data collection has been semi-structured/non-directive interviews and focus groups with researchers and students, who relate themselves to GIScience through their intellectual and practical activities (see Table 3 in appendix). Non-directive phases during semi-structured interviews have been important as rigidly controlled interviews can obscure important narratives (Cortazzi 2007, 390). Although to a limited extent, I have also organised formal focus groups. In this case, participating students or departmental staff first briefly introduced themselves individually, and subsequently discussed relevant issues for up to two hours. Focus groups have been helpful as participants usually use detailed narratives to ‘define an issue or a collective stance’ (Cortazzi 2007, 387, Morgan 1997). This has compensated some multi-sited ethnography-related shortcomings (such as time constraints) (Horst 2009, 126).

#### *Documents and visual research*

I also focussed on reading GIScience-related documents, and other relevant documents, that had been produced and/or been published in Nigeria, and hence constitute important ‘social products’ in relation to my analysis (memos) (Hammersley et al. 1983, 127-135, 137, 163). The consulted documents comprise theses, lectures, research publications, syllabi, legal texts, teaching materials (textbooks) and newspapers (media in general) (Clarke

2005, 148). Furthermore, my dialogue partners and I have talked about the denotative and connotative meanings of objects, such as of analogue satellite images that I had found in one of the GIS laboratories and stereoplotters at RECTAS that had been used in photogrammetry (to produce topographic maps) before satellite data came into use (Figure 16). This has improved an understanding of the historical context of GIScience in my research situation (Mitchell 2011, 41-43, Plummer 2001, 140).



**Figure 16** Stereoplottor (WILD Heerbrugg) at RECTAS (Thorpe 2016).

### *Life histories*

In line with relevant methods in ethnography (Bailey 1996, 78), and as part of situational analysis, I have also introduced a focus on life histories (life stories/narratives) in some interviews (McNeill 1990, 85-87, Plummer 2001, 19, Pascale 2011). According to Plummer, they can be both illuminating and helpful in constructing new sensitising concepts (2001, 30, 130-143). A related narrative analysis has then allowed me to pay additional attention to my dialogue partners' experiences and their evaluation of events (Cortazzi 2007, 385, 389, Clarke 2005, 154-156).<sup>61</sup> For example, with a focus on 'events from the

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<sup>61</sup> Tools for narrative analysis have been provided by, for example, Labov and Waletzky (1997). Here, the focus has been on stories about 'the major events of life'.

past' (Bailey 1996, 78), some of my dialogue partners have in more detail reflected on their path towards Earth science. In this case, a focus on short, 'more focused' life stories in interviews (usually the first half hour) became a 'complementing' method that allowed for an additional subsequent focus in semi-structured interviews, conversations and observations (Plummer 2001, 19-25, 130-131).

In line with Atkinson's suggestion, I usually had the feeling that my dialogue partners appreciated sharing their stories from the past, such as about the 'meaning' of places that they had visited and that have an impact on their life (Atkinson 1998, 25, 59, 62-66). I have only introduced an initial focus on life histories in those interview situations that allowed for additional questions. Here, Atkinson suggests to think of relevant individual questions that 'facilitate' the dialogue partner's 'story' without constraining it (ibid., 41). I hence integrated 'broad, open-ended questions' about my dialogue partners' childhood and education, but most often I simply told my dialogue partners that I was interested in learning about what they would like to share about their life. Most researchers and students began by describing where they had grown up. Others immediately focussed on a later stage in their life. In most cases, my interest or an additional question, such as about what mentioned people mean, also made my dialogue partners think about other events ('meaning making') and, pertaining to this, already their role in relation to GIScience (ibid., 41-53, 62-66). In some cases, my dialogue partners talked for more than half an hour before I asked the next question. Here, Atkinson further reminds us that 'a life story interview is a highly personal encounter' (ibid., 59), that the stories told 'are themselves interpretations' (ibid., 65) and that, considering the 'many ways of analysing narrative data', an analysis is 'highly subjective' (ibid., 59). In line with this, paying attention to 'metaphors' and 'comparisons' has helped me to understand what might be 'meaningful' (ibid., 64), such as in relation to experiences with the environment. Chapter five in particular is relevant in this respect. In its first section, I will thus briefly refer to an exemplary project: *An Oral History of British Science* (British Library 2018a).

### *Fieldnotes and Memos*

Finally, as Hammersley and Atkinson remind us, our 'memory can play tricks' (1983, 145-156). In line with multi-sited ethnography and situational analysis, I hence took fieldnotes and also took photographs as 'visual aids' (after consent) to support my memory (ibid., 145-150, Bailey 1996, 82). As 'part of the analytic process' (Bailey 1996, 80), I usually produced more detailed memos about my thoughts (analysis) and notes of my observation and 'emotional reactions' in the evenings, but also as much as possible during and after



interviews. However, I refrained from taking notes during informal conversations, and wrote down what I remembered afterwards ('mental notes') (Bailey 1996, 80-85, McNeill 1990, 77-78, Hammersley et al. 1983, 178). Overall, borrowing Emerson et al.'s words, I took fieldnotes 'day-by-day, open-endedly, with changing and new directions' (2007, 355).

## Positionality, validity and ethical considerations

Standing on shifting ground makes it clear that every view is a view from somewhere and every act of speaking is speaking from somewhere. (Abu-Lughod 1991, 141)

This section adds to the discussion of PCSTS, which has already helped me to articulate a few personal dilemmas, such as methodological preconceptions when doing research in a non-European/North-American environment. I will in the following address aspects of research integrity and for a start recall my concern about whether I could have ignored development theory and PCSTS. Would I then, in Anderson's and Adam's words, be in danger of ignoring 'hidden geographical notations and power relations' (2008, 183-184)?<sup>62</sup> This is a rhetorical question in the first place. Being from Europe and looking at science and technology in a former colony, I must of course not ignore colonial history, power relations and hence my site of research in relation to development theory and related criticism. In line with my discussion of PCSTS and Anderson's and Adam's suggestion, this research has been conducted with a 'heightened sensitivity to the ways that not only geography, race, and class but also gender hierarchies are (re)constituted through the relations of travelling sciences' (ibid., 188).

### *Positionality*

During my research I have moved in spheres with different degrees of privacy and formality in which my dialogue partners and I will implicitly have contextualised each other and our knowledge in a complex web of mutual expectations.

In practice, multi-sited fieldwork is thus always conducted with a keen awareness of being within the landscape, and as the landscape changes across sites, the identity of the ethnographer requires renegotiation. (Marcus 1995, 112)

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<sup>62</sup> Anderson and Adams actually criticise any resistance against PCSTS. Here, they also address those social scientists, who argue that their research (such as in 'Euro-American laboratories') is not connected to 'science in temporally postcolonial locations' (2008, 184).

Reflecting upon my relation to people in different settings has indeed been important. One particular danger would have been to reduce my relationships in the field to a researcher/researched dichotomy as promoted through rigid regulations, such as informed consent (Murphy et al. 2007, 2229). Dialogue partners in the field are not necessarily 'passive, vulnerable and in need of protection' as Murphy et al. argue (ibid.). This is an important statement in the context of STS studies, including my research. My dialogue partners had different positions, from students to senior scientists and directors. None of them must be reduced to a developing or subaltern context, as the next chapters will show in more detail. Social researchers (me) should be aware that they are often more dependent on their hosts in the field than the other way around (ibid.). Indeed, without the support of my hosts in Nigeria this research would from the very beginning not have been possible. Innumerable aspects, such as introductions, transport, visa extensions and actually *being* in the field, would not have been possible without my hosts.

Overall, I constantly occupied different positions in the field. Beyond doing research, I was encouraged to publicly talk about my research, such as briefly in front of a group of ECOWAS delegates, who met in Ile-Ife, and at the 2016 conference of the Association of Nigerian Geographers in Lagos (Hammersley et al. 1983, Hess 2001). At the same time, I have also participated in social worlds that only marginally intersect with the GIScience arena but nevertheless constitute a significant part of daily routines in my research situation. This ranged from religious sites and a wedding to staff clubs – with different roles and expectations in each place. Here, Abu-Lughod's contemplations on 'people whose national or cultural identity is mixed by virtue of migration, overseas education, or parentage' (halfies) becomes important (1991, 137). She speaks of halfies in relation to researchers, who to some extent research their own society. Though I do not fall into Abu-Lughod's definition of a halfie with regard to Nigeria, I through a problematic historical and political context, never completely stood outside (Abu-Lughod 1991). Sometimes related societal developments have located me in shared social worlds in the eyes of my dialogue partners or in my own eyes. First and foremost, as a male researcher I of course had a different partial viewpoint in relation to my largely male dialogue partners. Furthermore, whilst I *prima facie* was either the European or North-American, for many of my Christian dialogue partners I was likewise *prima facie* a fellow Christian. At the same time, at RECTAS, Mali (as a largely Muslim West African country) became a central element in my relationships with researchers and students from francophone West Africa, as I had spent three months in Bamako. For others, I was another space enthusiast, who eventually became one of the co-organisers of an astronomy barbeque, and an environmentalist,

who was invited to talk about environmental issues, such as during FUTA's Earth Day event in 2016. However, in the end I had the feeling that I was most often considered a fellow researcher. Every single interaction has eventually unsettled the 'boundary between self and other' (Abu-Lughod 1991, 138) and has required me to renegotiate my 'changing identities' throughout my research (Marcus 1995, 112).

#### *Quality control (data collection and analysis)*

I do further acknowledge the political nature of my research, which includes issues of representation and authority. Whilst I have avoided to overindulge in what Janesick calls an 'obsession with the trinity of validity, reliability and generalizability' (1998, 48), valuable tools exist to support the analysis of qualitative data. In line with Mauthner's and Doucet's 'voice-centred relational method of data analysis', I have read my interview transcripts against my personal (emotional) reactions (2003, 419) and in line with Labov's suggestions, I have paid attention to the reactions of audiences (1997, 1) at conferences. A third method in this context has been member checking. For example, some of my dialogue partners have provided feedback on my presentation at the conference of the Association of Nigerian Geographers during the final week of my stay in Nigeria. Furthermore, whenever time allowed, data source triangulation was carried out (e.g. interviews, participation and document analysis) to improve confidence in observations and explanations (Bechhofer et al. 2000, 57-58, Hammersley et al. 1983, 198, Falzon 2009, 7, Blaikie 2010, Kaiser 2009).

#### *Partisanship and applied social research*

Though I do have a symmetrical approach towards my dialogue partners' policy positions and activities, I acknowledge that I commit myself to aspects that relate to society and academia. Marcus reminds that multi-sited research is steady 'circumstantial activism' and that researchers cannot solve the problem of 'contradictory personal commitments' by being 'detached' researchers. I have hence immersed myself in the different roles that I have experienced as a researcher and have renegotiated and analysed them in relation to different actors and discourses in different places (Marcus 1995, 113, see also Hagberg et al. 2012, 4-5). This relates to often divisive questions regarding purposeful active commitment in social research. Concerns over the 'neutral analyst's stance', that Watson-Verran and Turnbull discerned in 1995, are still debated amongst social scientists researching in developing countries:

The strength of social studies of science is its claim to show that what we accept as science and technology could be other than it is; its great weakness is the general failure to grasp the political nature of the enterprise and to work toward change. (Watson Verran et al. 1995, 138)

In the context of studying knowledge transfer, Cozzens et al. do actually see an ‘excellent vantage point for analyzing knowledge confrontations that matter’ and argue that more active engagement is desirable (2008, 802-803). Accordingly, it is important to further reflect on my hybrid position when doing STS research in a country that is part of global development efforts and much social anthropological research. In STS, discourses on extramural engagement still largely focus on Europe and North America. Hackett et al. describe STS as an interdisciplinary field that ‘is not a narrowly academic endeavour’ (2008, 1). Instead STS scholars increasingly ‘strive for change in the service of justice, equity, and freedom’ (ibid., 1-6). In anthropology, discussions of applied anthropology date back to the era of Evans-Pritchard (Hagberg et al. 2012, 5-6, Schönhuth 2002). Anthropologists in the UK have a lively debate about contributions to development and society. Ellen, for example, argues that anthropologists should not only identify problems but contribute to solutions by acknowledging that ‘development, planned and unplanned social change’ will happen anyway (2002, 254-255). Also Sillitoe discerns locally-informed developmental commitment as a pressing issue (2002b, 9-10). Whilst the UK academic system and related funding bodies (like ESRC) actually directly ask researchers to outline any potential academic impact on policy and ‘practical applications’ (ESRC 2013),<sup>63</sup> academic systems in other countries might from time to time oppose involvement in development work or policy making. Referring to a relevant analysis by his German colleague Schönhuth, Sillitoe acknowledges potential issues of ‘intellectual integrity’ (2002b, 10). Schönhuth (2002) explains that as of 2002, calls for applied and participatory research have still been opposed by many social anthropologists in Germany. He discusses different contentious issues, such as the discipline’s<sup>64</sup> position towards NGOs and the protection of yet understudied cultures (Schönhuth 2002).

If we further distinguish between applied anthropology (working for NGOs) and action anthropology (personal commitment to practical implications during research), I to some extent might have done action (PC)STS, which involves a ‘commitment to justice or politics’ (Hagberg et al. 2012, 6, 9-11). Keeping in mind the ethical challenges (what common interest and whose agenda), one should perhaps at least aim at being a mindful

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<sup>63</sup> See also a study by Tang et al. (2014) on *The Relationship between Interdisciplinarity and Impact*.

<sup>64</sup> Germany’s academic environment (social sciences and humanities) is largely characterised by disciplines that for a long time have been promoting their intellectual independence. However, calls for more interdisciplinarity exist (WZB 2017, ESSA 2007, Fricke 2014).

mediator between academic and practical perspectives, and between decision makers and those who have limited opportunities to communicate their positions (Schönhuth 2002, 145-155). For example, I linked up researchers from Ile-Ife with a project on the conservation of fruit bats at the Max Planck Institute for Ornithology. Accordingly, my research is normative in the sense of a...

...commitment to understanding the ethics and values implicit in science and technology and to using that understanding to guide the transformative powers of science and technology in ways that are more generally beneficial and less potentially harmful (Hackett et al. 2008, 6).

#### *Practical implications (research ethics)*

Relevant research consent has been negotiated with institutions and individual dialogue partners throughout the research (Tomlinson 2011, 164). Whilst I have always disclosed my research aims, I have not promised anything regarding any potential impact. Murphy and Dingwall treat 'fully informed advance consent' with caution and criticise regulatory regimes that tend to rather constrain ethical ethnographic research in this respect. They hence appeal to a researcher's 'ethical sensitivity' (2007, 2228-2230). Also the UK Data Service (2015) refers to a possible 'over-bureaucratisation and confusion for the participant' in some cases. Accordingly, a consent form has allowed my dialogue partners to add their own views regarding the use of data (Kaiser 2009, 1639) (see appendix III).<sup>65</sup> Finally, all security-related requirements by the University of Edinburgh had been addressed prior to my research. Most of the potential limitations that I had listed in the risk assessment form have not occurred. Though this is only my personal appreciation, I have not directly encountered any of the following risks, as listed in Lee-Treweek's and Linkogle's (2000) framework: physical, ethical and professional risks. I acknowledge that these risks have nevertheless been present. At the same time, I always had the full support of my hosts.

## Conclusion

This chapter has revealed the importance of finding a methodology that does not constrain an understanding of the social construction of GIScience in Southwest Nigeria from the outset. The attribute indigenous has sensitised this research towards a discussion of ethnography in relation to knowledge, geography and locality, and relevant perspectives

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<sup>65</sup> This research is in compliance with the University of Edinburgh's Self-Audit Checklists for Ethical Review.

in PCSTS. This has revealed potential pitfalls and questions that need to be answered in relation to how we (can) look at different sciences and technologies in a postcolonial world. PCSTS scholars aim at both understanding the global postcolonial legacy of Western science and technology as well as the construction of technologies and knowledge in non-*Western* places. At the same time, culture and the West remain challenging, if not paradoxical, static points of reference in this respect and confine any understanding of the implementation of GIScience in Southwest Nigeria from the outset. In line with Abraham's (2006) thoughts, I have suggested to look at the construction of potential cultural traits of science communities by understanding their everyday practices in those postcolonial space and places that we are concerned with. In Southwest Nigeria, this has been supported by the twofold methodology of multi-sited to un-sited ethnography and situational analysis. The empirical insights will be introduced in the following chapters. The next chapter will illustrate the importance of not confining a postcolonial understanding of place and social entities. It will challenge a pluralist understanding of science and technology in relation to culture by paying attention to 'multiple subjectivities and sensitivities' in a specific science and technology context – GIScience (Anderson et al. 2008, 187).



# Chapter Five

## Carrying Satellite Images to ‘the Bush’ – Researchers and their Relationships to the Field and Technologies of Sensing

In terms of contemporary world, the main thing is the issue of climate change. It is not because I am in the field of climatology. But the issue of climate change has no boundary. It doesn't know your colour (laughs), nor your background. So, it is a general issue that actually has given me concern. (Interview 3, 15.10.2015)

### Introduction

The African continent has become a focus of transnational, bilateral and multilateral Earth observation initiatives and it is increasingly considered ready for its own national EO programmes to promote social and economic development. Relevant social processes, however, still largely flourish in obscurity, as do recurring ideas of relevant indigenous capabilities. With the aim to contribute to this understanding, this chapter will look at how remote sensing from EO satellites relates to the environment by focussing on people on the ground that bring both together. In Southwest Nigeria, the encounters of Earth science researches with technologies of remote sensing and analysis (GIS) have in the first place much more to do with personal experiences than with global policies. Remote sensing data is not simply analysed as a transferred product. People with their own stories form the basis for any sustained integration of remote sensing in Earth sciences in Southwest Nigeria.

The first part of this chapter will discuss how researchers, who now use remote sensing and GIS as an integral part of their work, have encountered these technologies as part of complex social and material relationships, where both temporal and spatial elements play a key role. In line with this, remote sensing and GIS have been gradually appreciated and promoted as a choice. This chapter will in a second step look at the wider historical and contemporary foundations of this choice. I will discuss how researchers have integrated EO satellites into Earth science disciplines as a distinct ‘liberatory technology’ (Hollick 1982) to address their collective experiences with their social and natural environments in Nigeria.



## Encountering Remote Sensing

Researchers, working at institutions across Southwest Nigeria and investigating Nigeria's environment(s) on the basis of data from remote EO satellites have, in the first instance, an intimate relationship to these environments. Throughout their lives, they have directly sensed and experienced on ground the physical features that they are now researching. They have learned to appreciate what the environment provides, but also what seems worth further investigation. For many researchers this relationship will, with varying degree, legitimise that remote sensing, as another means of sensing, now constitutes a significant part of their daily lives.

By looking at how researchers have gradually encountered remote sensing and GIS, this section will begin to discuss this experience in relation to (post)-development theory. As discussed in chapter three, we can find perspectives that consider any 'direct experience of the workings of nature' as the experience of 'indigenous people', that shall constitute the prime basis of 'technological development and innovation' on the African continent (Dibua 2006, 165). This has raised questions about whether it can accommodate the experiences of those who now use remote space-based technologies towards the 'workings of nature'. This issue can at least be partially addressed by looking at relations that researchers have with both nature and remote sensing.

With the aim of understanding the social place of remote sensing in the lives of my dialogue partners, this section will take the form of life stories as they can also be found in the recordings for an 'oral history of British science' that has been promoted since 2009. Here, the voices of 'scientists, engineers and technologists' from different fields and social backgrounds can be accessed through the British Library. They 'reflect on their early life and background, their career and their involvement in the course of UK science', such as in climate change research and physics. The botanist and geologist Richard West, for example, reflects on how he 'got hooked on biology' through his 'invigorating' biology teacher (British Library 2018c, b, a).

### Memories of the environment

One early career researcher from Ile-Ife describes his relation to nature in detail as he had experienced it before EO satellites entered his life. He grew up in the small village of Ndemili in the local government area of Ndokwa West of Nigeria's Delta state. The

environmental consequences of the nearby oil production<sup>66</sup> had not yet been visible to him during his childhood. The village's name, Ndemili, can be translated as 'People of Water', and his memories illustrate what water means to the village. The 'crystal clear' water of a nearby stream not only caters for the physical needs of the villagers but brings great joy to children:

I wake up early in the morning, we go to the stream. There is nothing like borehole, there is nothing like tap water. So, you go to the stream and the stream is just a very wonderful one because I remembered it's so clean, let me use the word (relatively) clean, that if you throw/there is something called (shelly), is a fruit we call (shelly) or something like that (...) or a cover a cork of coke. So, when we throw it inside the water you will be seeing it. You will see it. It's so crystal clear that you can see it. So, what we normally do is that we'll have that (shelly) or a mango and throw it inside the water, all of us will go outside, then we will run into the water and dive who and go and get it first, like a game. (Interview 26, 16.12.2015)

In his memories the stream is the artery of a remote village in 'the heart of the rainforest' that supported a specific awareness for the value of his immediate environment. Though I stayed in more urbanised areas of Nigeria's rainforest, I immediately felt a personal connection to these memories. Apart from my stays in Lagos and Ibadan, the rainforest was visible to me every day. I listened to animal sounds emanating from its depths, I witnessed how it provides bushmeat that is sold by the roadside and how it isolates cities and villages from each other, where a stream can mean *life* and nothing less:

So, what bringing the story is that is the water that we drink, that is the water we bath, we wash and everything. (...) And the place is actually located in the depth, in the heart of the rainforest. So, you see. Is in the heart of the rainforest. So, growing up there enabled me to start appreciate nature and appreciating my ecosystem, my small biological and or let's say biotic and abiotic components of my environment. (Interview 26, 16.12.2015)

The environmental awareness of my dialogue partner further developed when he left Ndemili for Jos in early 1984/1985. He suddenly found himself in a region that shows different geographic and geological features, where his stream was replaced by a railway – a manmade artery that wound its ways through the mountains near his home. He now began posing questions about the interaction of the elements that he encountered in different geographic places:

Where I came from [Ndemili] that was plain and with (sweet) streams and more of vegetation. So, it is a totally different. :: Now I remember growing up [in Jos], there is a railway/railway line across my house and there are mountains. So, when the railway is

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<sup>66</sup> See chapter one.

coming, when the train is coming, we will rush to the mountain and climb and watch it from that distance. Now that environment motivated again the quest to understand more of environment. (Interview 26, 16.12.2015)

Not all GIScience researchers have this experience of rural environments, where the physical features of the immediate geography are most prominent. Others grew up in urban centres and had their own observations. One researcher describes how his interest in urban dynamics in West Africa is grounded in his observations of urban structures since his childhood in Dakar – the capital of Senegal that stands in stark contrast to rural areas, as he observed:

(...) [O]nce you leave the capital, you go inside : inside the country, villages, there you will know that you are in a Third World country (chuckles). The difference [to the capital] is so high. (Interview 48, 06.02.2016)

For other researchers, their early appreciation of structures and features in their environment, emanates from interpersonal communication. One researcher at the Federal School of Surveying explains that his father was a civil engineer, who directly introduced him to the physical structures of the built environment and made him ask questions about his observations:

He told me that that is what urban and regional planning is all about, you build environmental stuff, houses, structures (...). (Focus Group 9, 07.03.2016)

Specific observations at a later stage in life have likewise influenced interests in the environment. One geographer, for example, recalls how he began wondering about the physical features of a reservoir on the premises of OAU, when he was a student:

As a student I noticed that the water gets polluted at a particular/despite the treatment they give to it. Now I wanted to see what happens to the water. Why will the colour of the water change at a particular (time). (Interview 13, 29.10.2015)

For my dialogue partners, their early memorable experiences with nature are neither bound to one place, timeframe, nor to a particular social environment. Unlike an essentialist understanding of the ‘direct experience of the workings of nature’ (Dibua 2006, 165), these have been made in different geographical and social places.

### **Being gradually exposed to remote sensing**

Observations regarding the environment can support a sustained interest in remote sensing as this chapter will argue, but they usually do not directly relate to a researcher’s first

encounter with remote sensing as a technology. My dialogue partner, whose childhood experiences with natural and manmade physical features in Ndemili and Jos have raised his environmental appreciation, makes clear that this has neither marked the beginning of his Earth-science-related studies, nor of his current GIScience research. Instead, my dialogue partners describe how particular events, technologies as well as people have gradually introduced them to remote sensing and GIS.

*Arriving at the appropriate degree*

For many researchers studying a subject that at some point introduced them to remote sensing and GIS had been an unexpected development in the first place, and usually depended on individual encounters. My dialogue partner from Ile-Ife, who first grew up in the depths of the rainforest and later in Jos, describes how his transfer to a secondary school eventually also brought him to the ‘fascinating environment’ of the Shere hills, with the ‘largest massifs in Nigeria, in terms of clusters of mountains and rocks’, as he explains. Despite his continuous appreciation of his ‘environment’, his interests in school were rather related to engineering. One day, however, a young geologist, who taught geography at his school, reminded him of the many questions that he had developed during his childhood observations:

The way he actually taught the geography and the way he explained it and I was so amazed, because just like I am now receiving explanation of my youthful imagination. (...) At that point in time the geography was able to explain to me the things I see, how these mountains were formed, the stream I was bathing when I was a child (...). (Interview 26, 16.12.2015)

Instead of further developing his interest in engineering, he shifted his attention and began studying geography and regional planning at the University of Benin. His studies then ‘exposed’ him to different subjects, such as ecology, human and physical geography, and mathematics, and extended his understanding of his childhood observations:

Then also I was able to get good information on this whole nature of things, the phenomena I see when I was growing up, how they interrelate to make up the environment and how man has also related to it. (Interview 26, 16.12.2015)

This shift from engineering to geography has been a gradual process in which memories, interests, individuals and learning experiences have played a role. Notwithstanding their individual paths to Earth sciences, researchers often share an early interest in science and

engineering-related topics as well as environmental observations. That is the case of one of my dialogue partners, who works in ecology and environmental studies:

[I like] asking so many questions about nature, about why things are the way they are, and I also like biographies, and I have read biographies of people like Isaac Newton, about Einstein and quite a lot of others. (...) So, it is not really like a coincidence that I find myself in science, doing research and trying to make my own little contribution in the way/and I personally loved astronomy. (Interview 22, 27.11.2015)

Another Senegalese researcher at RECTAS recalls his initial interest in IT before his father guided him towards geography. Having received his education in a private school, he describes how he was exposed to various ‘occidental’ elements. When he read science fiction, he, for the first time, was confronted with ideas of how information can be processed by computers. In the early computer age, this for most Africans had been a fictitious kind of technology transfer, which in his case ended in an almost dream-like first-time physical experience of IT at IBM in Dakar, as he recalls:

The technology progress was translated through those science fiction books. (...) So, we were reading it and also dreaming of it (...). It is from [the stories of the villains who steal data from a laboratory] you started having those notions of information, data processing (...). So, one of our friends the mother was working with IBM [in Dakar]. We used to go and now we were seeing those main frame (where you have) those tape, turning at high speed. The place was air-conditioned, during the dry season you have to put a jacket before you enter those place. You say, okay you are dreaming (both laugh). (Interview 24, 07.12.2015)

However, before IT as a component of GIScience was to play a more significant role in his life, his father, a surveyor, guided him to an Earth-science-related path. Thanks to occasional opportunities to observe his father’s practices, my dialogue partner eventually developed an unexpected interest in geography and decided to study it. Individuals that have influenced a researcher’s interest have not always been part of their personal social environment. The head of a department for remote sensing and GIS recalls that, after his good experience with geography in school, a Nigerian OPEC minister indirectly consolidated his interest in Earth sciences:

He was a former OPEC minister, Mr Michael Feyide was OPEC minister in 1973. So, so that was somebody I looked up to and felt, well I could read any of the Earth sciences. (Interview 30, 13.01.2016)

In the case of some researchers, their path to an Earth science subject appears more direct and less dependent on specific encounters. For example, interests in physical geography have also developed for nothing less than a ‘love’ for the environment, where my dialogue

partners appreciate that they ‘walk on the land’, are ‘breathing the air’ and can ‘use water’ (Focus Group 9, 07.03.2016). In the end, a few researchers also had deeply pragmatic reasons. For example, some were not able to study more popular degrees, such as medicine, and hence simply chose a degree like surveying and geoinformatics as an alternative (Focus Group 10, 30.03.2016). Looking at the different paths that seem open, it is important to note that my dialogue partners often have been the first in their families who had the chance to study. Here, education as such has priority over any specific orientation (Interview 48, 06.02.2016, Interview 32, 18.01.2016).

### *Curiosity for a new technology*

At the stage of entering Earth science studies or research, remote sensing and GIS still were largely unknown to most of my dialogue partners. Their understanding of the environment initially originated from knowledge in their disciplines, such as ‘core geography’, geology, physics and biochemistry. In most cases, remote sensing and GIS only joined existing research interests through additional encounters. Professor Akinyede, who had studied geology, vividly remembers his crucial encounter. Between 1981 and 1992, he worked for the Nigerian Building and Road Research Institute in Lagos, where he focused on terrain evaluation. Though he had briefly been exposed to aerial photography during his undergraduate days in the 1970s, he unexpectedly encountered space-based remote sensing and GIS through a personal contact (Mr. Nadar) from India, who came to Nigeria as part of a knowledge transfer partnership in road construction:

Even though in my first degree I did a little course in aerial photography, but it was in the road building and research I now had opportunity to work with somebody who has/an Indian man, Mr. Nadar, who has the knowledge of remote sensing and GIS. (...) like a role model who boosted my interest in remote sensing and GIS. (Interview 43, 27.01.2016)

Akinyede not only later became instrumental in developing Nigeria’s space programme, but in his case an individual from another emerging economy had introduced him to satellite-based remote sensing and GIS and aroused his curiosity about these technologies in relation to geological questions. Notwithstanding the many institutions and Earth science departments that now offer GIScience-related degrees in Southwest Nigeria, also current early career researchers still often have encountered remote sensing and GIS indirectly. For my dialogue partner, who grew up in the small rainforest village Ndemili and studied geography, it was a textbook by a professor of geography that eventually drew his attention to remote sensing and GIS. He remembers how he read about aerial technologies

that allow to detect things beyond the capability of his eyes, and how he eventually satisfied his new curiosity by choosing GIS, remote sensing and aerial photography as elective courses:

And I remember that I read the story of a pigeon and a Paris picture that was snapped by a pigeon and all of that whole stories. And all of that I read it and it was fascinating and I read about films, how the black and white films, the infrared films and all of that were made. (Interview 26, 16.12.2015)

His colleague in ecology and environmental studies (Ile-Ife) had already been introduced to electromagnetic radiation during his degree in biochemistry, but his awakened interest only gained meaning during his national youth service at the International Institute for Tropical Agriculture (IITA). In his case, it was likewise a book that added remote sensing and GIS to an existing interest. He discovered how these technologies might not only be integrated into his interest in physics and his knowledge of geography, but how they would also broaden his area of interests:

Immediately I felt in love with electromagnetic. When I now picked up, when I find myself serving IITA, I went to their lab, I picked up a book in remote sensing and I noticed that they were talking about electromagnetic radiation and I felt 'wow', this is where I want to be. (Interview 22, 27.11.2015)

In the case of their colleague at the department of remote sensing and GIS at FUTA, it was not a book but a video about space and the moon landings that introduced him to an aerial perspective. This video, in combination with undergraduate courses in photo geology and remote sensing, consolidated his interest in technologies that promised an extended perspective on his environment:

So it was quite interesting to see the Earth from space. So 'wow', see clouds, how clouds move, 'oh this is the coastline of West Africa and so on and so forth'. (Interview 30, 13.01.2016)

For one researcher at the Federal School of Surveying, it was neither a book, nor a video, but an event in 2003 that brought remote sensing to his attention during his final year in urban and regional planning. Hearing about the launch of Nigeria's first EO satellite NigeriaSat-1, he was immediately enthused by this satellite in relation to his interests in the built environment. He emphasises this experience by recalling the almost exact launch date:

September, 17/16 2003, and I was like/I was the class (governor). I was telling my colleagues at school that this satellite that was launched I will make sure I use the data

from the satellite. I didn't know how but I was just interested that 'wow Nigeria has a satellite now. We must use it' (smiles). (Focus Group 9, 07.03.2016)

Overall, a combination of existing interests in science, observations of the environment and related studies of Earth science degrees appear as a first basis for lasting interests in remote sensing and GIS.

#### *Word-of-mouth recommendation*

Researchers have experienced the moment of encountering remote sensing and GIS at individual stages of their studies or research. A visitor from abroad, a book or Nigeria's EO satellites, have not been the only signposts. Often personal word-of-mouth has played a role in being introduced to remote sensing and GIS as an actual option in relation to existing interests. At the same time remote sensing is far from being a novelty at Nigerian universities. Institutions like RECTAS in Ile-Ife teach photogrammetry since the 1970s (Ogunlami 1993). Even earlier, in the 1960s, Adeniyi, an emeritus professor of geography in Lagos, was one of the first students to become interested in an aerial perspective that was then introduced as 'photo interpretation' (photogrammetry) in his area of science studies (geography) at the University of Ile-Ife (now OAU) (Interview 94, 20.04.2016). Two decades later, also Professor Salami, the founder of the Space Applications and Environmental Science Laboratory (SPAEL) at OAU, first encountered the technologies that would guide his research career during his undergraduate studies in geography. At that time, remote sensing was still introduced through aerial photography:

What we were doing was photo interpretation. That was how I got into (listen) into remote sensing and it was very interesting to me how from aerial photographs, you could interpret a lot of things about the Earth surface. (Interview 53, 17.02.2016)

Notwithstanding the long-standing existence of remote sensing in some departments, several younger researchers still often describe their first encounters with the space-based version of remote sensing (EO satellites) in the context of 'emerging' technologies in Nigeria. They talk about having, in the first place, 'stumbled'<sup>67</sup> across EO satellites through above-mentioned material encounters or individuals, who have pointed them at remote sensing and GIS. The emerging character of GIScience is constructed through continuous word-of-mouth recommendation of one or the other component (remote sensing and/or GIS), and for the first time indicates a slow institutionalisation of GIScience in the wider Earth science arena in Nigeria. Some of my dialogue partners had simply

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<sup>67</sup> As used by one geographer in this context (Interview 58, 24.02.2016).



'heard about GIS' after their first degree, like one staff at the Federal School of Surveying, who soon discerned related potential for geology, and hence in the late 2000s began to study at RECTAS, where he was eventually introduced to remote sensing (Focus Group 9, 07.03.2016). Around the same time, also one of his colleagues had his first encounter with GIS, thanks to the recommendation of one of his professors in geography. He emphasises the perception of GIScience in Nigeria as still emerging and points out that he only learned about remote sensing during studies abroad:

I was fortunate. I applied, I applied, I just looked outside Nigeria. So and I got admission to the University of Greenwich, United Kingdom for my GIS with remote sensing. I never heard of remote sensing until I got, till I got to England. (Focus Group 9, 07.03.2016)

Many researchers recall that information about remote sensing and GIS had indeed most often been advanced by visionary senior researchers. One geographer at OAU learned about the emerging field of GIScience in an informal conversation with a lecturer of geoinformatics during his undergraduate days. Looking at his own research interest, he soon discerned a chance:

I picked interest from her and based on the fact that I had science background. And since then I decided that I want to go to this area, to remote sensing and GIS, and the key issue, the global issue now is climate change. (Interview 3, 15.10.2015)

However, first encounters with remote sensing and GIS will likely become increasingly independent from personal communication. Today, several Earth science departments in Southwest Nigeria offer programmes with a focus on remote sensing and GIS and have collaborations in training staff and teaching students, such as with RECTAS (Jeje 2012, RECTAS 2012).<sup>68</sup> Students develop certain interests in relation to their Earth-science degrees, and depending on their performance, find themselves confronted with the choice of integrating remote sensing and GIS through a Master's programme.<sup>69</sup> This is how one geography lecturer at OAU describes her own case. At the same time, she joins her peers in arguing that the option to focus on remote sensing and GIS indeed is the result of most recent developments:

In 2003 GIS was still very new in Nigeria, still very new in Nigeria. Very few schools were offering GIS in postgraduate level, offering it as a degree, there were few. OAU happened to be one of them. (...) That was what brought me to Ife. But the interest, the

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<sup>68</sup> For example between the Department of Geography at OAU, ARCSSTE-E and RECTAS. (Jeje 2012)

<sup>69</sup> The department of Remote Sensing and GIS at FUTA even offers an undergraduate degree in Remote Sensing and Geoscience Information Systems.

introduction I have into remote sensing GIS in my undergraduate was actually what made me to pursue remote sensing and GIS. (Interview 21, 13.11.2015).

### *Encountering the practical aspects & choosing to stay*

After being ‘exposed’ to remote sensing and GIS, any further engagement with these technologies is contingent. Researchers have described how they have not simply been introduced to the new technologies, but how at some point ‘interesting’ examples of their practical powers convinced them to pursue further studies in GIScience (Interview 58, 24.02.2016). One of my dialogue partners had already been exposed to photo-geology during his undergraduate days. He recalls that those ‘people who came and taught’ photo-geology back then rendered it boring. In his case, photo-geology only became more specific and exciting, when people from the National Centre of Remote Sensing came and taught during his master’s programme. They finally provided clear practical examples that illustrated how remote technologies in space could meet his desire to do something ‘exciting’ and IT-related in geology:

They made me pick so much interest in the field. They came, they brought projectors, show satellite images, for the first time I saw one. You know about satellites roving in space capturing data but you haven’t seen one before. I saw it. And then they told us how we could use it for geology and I was interested. (Interview 51, 08.02.2016)

His colleague at OAU did not only first encounter remote sensing and GIS during his national youth service at IITA; it was also during this time that he learned about the practical aspects of these technologies and likewise ‘decided to proceed’:

I saw a new *tool* that could actually help me understand the world and the environment. So, I took a course, postgraduate diploma in GIS from the Federal School of Surveying and I started a course/Masters course in GIS in Sweden, that is Lund University, which was an online programme (yes, in Sweden), online programme but I could not actually finish because we/back then 2000, 2001 internet was really a serious challenge. (Interview 22, 27.11.2015)

### *Encountering remote sensing and GIS as an applicable ‘tool’*

What my dialogue partner has described as the discovery of a ‘tool’ is indeed not yet a guarantee that remote sensing and GIS are successfully integrated in a researcher’s life. Remote sensing and GIS often become further entrenched in their lives when researchers have the opportunity to successfully relate these technologies to their area of studies. This has not changed since the 1970s, when Adeniyi had spent some time in the Netherlands for his diploma and master’s degree. His practical experiences with aerial photographs in

studies of land use in Spain and Italy eventually convinced him that in the future there is no way around using remotely sensed data in relation to his previous experience with geography, geology and mathematics. After returning to Nigeria in 1973, two years later he pursued a PhD in Canada on urban land use and population estimation. That is when this perspective became further entrenched in his life:

And I then discovered that using remote sensing and GIS as a *tool* as it were will be an advantage to the field of geography, whatever field you are in whether it is transportation, urban, biogeography, settlement geography, name it. (Interview 94, 20.04.2016)

Years later, Professor Salami, his colleague at OAU, chose to study a PhD degree to fully engage with remote sensing in relation to geography. This allowed Salami to develop a long-term appreciation of remote sensing and GIS in relation to studies of land use dynamics and climate change (Interview 53, 17.02.2016). Any such appreciation is not static and is actively communicated to future generations, such as in the case of a lecturer at the department of remote sensing and GIScience at FUTA, who thanks to such communication developed an interest in using remote sensing data for epidemiological research on schistosomiasis (Interview 39, 25.01.2016). For some researchers this long-term appreciation has also developed during non-academic work. For example, after his master's degree in remote sensing and GIS, one geographer in Ibadan had gradually built confidence in remote sensing and GIS during his work in the 'oil service economy', where he became responsible for 'producing the first environmental sensitivity index map for Nigeria' (Interview 58, 24.02.2016). Establishing a long-term relationship with remote sensing and GIS eventually means to continuously integrate these technologies into a mutual learning process of 1) understanding more relations in the natural and built environment and 2) of further appreciating the relevance of this environment at a larger scale, as he explains in relation to his research on oil spills:

I have had to fly from Lagos down to Calabar, monitoring oil spill along the coastline. (...) The experience outside, having to work in an oil servicing company with a focus on environmental management sort of biased my research towards environmental related work. (Interview 58, 24.02.2016)

### **Having a tool to expose the environment**

In the case of my dialogue partner, who grew up in a small village of Nigeria's rainforest and later in the Jos plateau, an extended engagement with remote sensing from space and GIS has eventually allowed him to reassess the geography that he had already appreciated

through the eyes of a child. He emphasises the difference by describing his childhood observations as his ‘cognitive geography’. Through remote sensing and GIS, his playful encounter with nature is suddenly embedded in a multiplicity of coordinated observations, times and spaces that not only cover the environmental degradation that his small home village has experienced in recent years, but similar problems in a wider spatial context:

In geography, they were able to now finally solve my longtime childhood problem by creating a synergy between my geography, (...) geography I know, my (perspective) geography or what I call it my cognitive geography, my secondary school geography, my geographical knowledge and my everyday reality, and interwoven in together with the GIS and spatial technology and finally mix these things up and giving me a broader/a *better perspective* on how to solve problems. (...) [With GIS and remote sensing as a ‘platform’] geography, geology, environment, ecology studies, agriculture, bio studies, microbiology and all of that has to do with with the environment, can be brought in, interwoven together to solve a problem. (Interview 26, 16.12.2015)

Overall, technologies of remote sensing and GIS have gradually appeared as ‘tools’ in the lives of my dialogue partners. The foundation is laid when prospective GIScience researchers are introduced to the practical aspects of these technologies and have the opportunity to apply them. At the same time, entering Earth science-related paths in the first place, depends on a web of interests, observations and personal encounters.

Notwithstanding that GIScience technologies appear as a choice, the ‘direct experience of the workings of nature and its relationship with the social world’, that Dibua describes as being part of the knowledge of indigenous peoples (2006, 165), at this stage seems handed over to remote and invisible EO technologies on the part of researchers, who once had a ‘direct’ relationship with the environment on ground (‘cognitive geography’). Whilst a researcher’s direct experience with nature is not necessarily bound to one locale, one could nevertheless argue that researchers have become estranged from whatever one may identify as indigenous, since they feel that high-technologies in distant space eventually contribute to a ‘better perspective’ in relation to childhood (and subsequent) observations of the rain forest and urban environment. At this stage, the persistent determinist technology transfer perspective on Africa, which Mavhunga (2014), Dibua (2006), Macola (2016) and others counter, seems in parts maintained – fueling the modernisation nightmare. Despite the frequent unexplained reference to indigenous capabilities in relation to EO technologies on the African continent, at this stage any form of ‘indigenous’ seems detached from the implementation of remote sensing and GIS, whether in a relational or primordial sense (Kuper 2003, Kenrick et al. 2004).

In the context of any latent determinist account, we should however not lose sight of two aspects that have surfaced in this section: 1) the emerging character of remote

sensing and GIS, where their encounter largely depends on interpersonal communication and interests, and 2) the related choice of researchers to either follow these technologies or to take alternative routes in relation to their Earth science interests. This choice eventually depends on more complex experiences that researchers have with their ground-based research interests. They relate to conditions that Erickson (2002) highlights with reference to Max Weber's (1948) lecture *Science as a Vocation* (originally published in 1919). By relating Weber's ideas to his empirical study of scientists (physicists and biochemists) in the UK, Erickson shifts attention to scientists' 'external conditions' ('working conditions') and their 'inward conditions' ('motivations') (2002, 36-37). The next section will focus on inward conditions that accompany the implementation of remote sensing and GIS in Southwest Nigeria. In this sense, it also begins to consider them in relation to external conditions that are causal in this respect.<sup>70</sup> Here, specific experiences construct remote sensing and GIS as tools in their direct relationship to Nigeria's environment. The next section will consequently also explain what a 'better perspective' is really about and why it does not necessarily exclude indigenous knowledge – as long as it is understood in a relational context (Kenrick et al. 2004).

## Experiencing the Field from Ground and from Space

In Southwest Nigeria, researchers have developed specific understandings of what remote sensing and GIS mean in relation to their disciplines. This understanding, however, is not simply based on the use of remote sensing and GIS as a 'research tool', as gradually developed in Western Earth science disciplines since early forms of GIS were first introduced in the 1960s (Goodchild 1995). Their appreciation of remote sensing and GIS is constructed on different grounds that link to continuous individual and collective experiences with Nigeria's natural and built environment. Here, any personal and discipline-related legitimation of these technologies is largely based on researchers' twofold experience of doing research in the field (data collection) and on the field (analysis). The following section will first describe an ideal situation as it has been articulated by one of my dialogue partners in Lagos. In this situation remote sensing and GIS do not substitute the 'direct experiences' with nature on ground. The second part will discuss why remote sensing and GIS has nevertheless gradually become a substitute for a more ground-based perspective, despite various obstacles.

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<sup>70</sup> In the next chapter, this relationship will be extended by looking at external conditions in everyday research.

## Ground-truthing and oral (indigenous) data

Uluocha, a geographer from Lagos, articulates the same appreciation of GIScience like his colleagues. At the same time, he propounds a specific concern when GIScience gradually seems to become a substitute for something human that can neither be sensed by scientific instruments in space nor on ground (such as spectrometers). Any of the following human aspects that he refers to represent the past, present and the future that come together in a multi-dimensional ‘comprehensive scene’ of geography, social activity and time, where place in relation to remote sensing from space again becomes a ‘locale’ – at least for a moment (Kuukkanen 2012, 484-485). Uluocha reminds that his ‘forefathers’ had their ‘own way of managing the environment’ before they encountered European colonisers. Considering the influx of foreign techniques in mapping, he works on what he calls ‘traditional African cartography’ or ‘indigenous cartography in Africa’ to preserve the techniques of his forefathers in communicating geospatial information. Though European explorers had recorded ‘local names’ and knowledge for scientific purposes (such as about plants) during expeditions like the ‘Zambesi Expedition’ in Southeast Africa, as Dritsas (2010, 141) explains, in Nigeria maps now show a skewed colonial knowledge base with foreign names dominating as signifiers of place:

We are in Lagos. Lagos was not the original name. It was the Portuguese that renamed it Lagos. It was originally known as Eko, E K O, Eko all right, but when the Portuguese arrived here, you know, they said ‘wow this place looks very much like where we are coming from’. Because they took off from a port city in Portugal, known as Lagos. (Interview 93, 20.04.2016)

By further referring to the original name of Ibadan – Eba Odan – he provides an example of how much geographical information is lost. Eba Odan provides insights into how people have experienced the physical characteristics of their natural surroundings:

Okay, now Ibadan, although that is the white man rendition of that name, that is not the original name. That is not the original name. The original/Ibadan as it is now is spelled I B A D A N. (...) But people might not understand because they look at that place and saw it the way it is, and they gave it that name: Eba Odan. That is the place between the rainforest and the savanna. So, with that name alone if you go back to the original name, the indigenous version of that name, you will be able to understand the geography of that place, even without being to that place. (Interview 93, 20.04.2016)

The etymology of Nigeria’s *original* toponyms as an indicator of important physical characteristics of places seems in danger of being superseded by the knowledge that is created by means of remote sensing and GIS. Ndemili, the home village of my dialogue partner in Ile Ife, who translates Ndemili as ‘people of the water’, might be considered a case in

point. Uluocha reminds himself of his childhood encounters with the river Imo, where remote sensing can detect physical characteristics on ground, but not a villager's long-term experiences with their environment:

But there was a time that the river overflow its banks and we were (wondering), we were sad because we could no longer go there to swim, we could no longer go there to (scalp) sand. (...) The elderly ones, they now told us that is the way the river behaves, that every ten years it used to overflow its banks (laughs). They already know it. That is indigenous knowledge. They did not need satellite imagery for that. (Interview 93, 20.04.2016)

Despite his concerns, he sees much value in GIS and remote sensing and hence suggests to carefully *integrate* the knowledge of those who have a life-long relationship with their immediate physical environment. This position aims at breaking global environmental problems down into long-practised local adaptation and mitigation practices that no EO satellite can sense. The challenge that Uluocha articulates is the latent link between people, whose environment is sensed and the use-value of remote sensing technologies. In this case, indigenous knowledge is considered 'auxiliary knowledge' and is hence not overly different from the usual primary data that researchers collect on ground (Interview 93, 20.04.2016). The difference is that indigenous knowledge comprises feelings, beliefs and tacit knowledge that does not represent easily quantifiable data as it could be collected by means of questionnaires. Such knowledge does not alter the status of remote sensing and GIS as scientific tools, whose supposed objectivity in this context is described by a researcher at RECTAS. He refers to his observations of precipitation:

Sometimes it may rain in the campus here and in town you do not see rain. So, those are the elements and when you are using these techniques this science, remote sensing and co, now it will enable us to understand some phenomena. It is not magic, it is not a witchcraft or something witchcraft (laughs). (Interview 24, 07.12.2015)

Indigenous knowledge is then treated as qualitative data that entails potential insights, regardless of whether that knowledge is 'right or wrong' according to modern science – a verdict that could only be established by learning about any *beliefs* in the first place (from a positivist perspective):

And you find out that at times even part of the knowledge you are talking about could even be kind of ignorance, superstitious belief, which is quite common in Africa. (...) That is why you need to hear from the people. Because when you know their point of view, the way they are coming, the way they are looking at an issue, you will be able to assess it objectively and know whether they are right or wrong. (...) Any time the gods want goats, want you to sacrifice goats (laughs), maybe they want to eat goats, the water will overflow its banks. (...) Of course, scientifically it does not make much sense, because you can not even prove it. The gods, who are the gods? But to them that is

what they believe. (...) So, it is very, very possible to integrate indigenous knowledge into GIS, into remote sensing and GIS, especially in this part of the world. (Interview 93, 20.04.2016)

Uluocha describes how supposedly superstitious beliefs are deeply embedded in the social and natural environment that researchers look at. Any knowledge that is articulated in terms of beliefs is then primarily treated as data that needs to be read between the lines, as it is indeed deeply connected to ‘things that are happening’:

In a situation like that they have given you one important information and that is that from their own experience almost every ten years the river overflows its bank (...) So, you leave them to that belief [in the gods] but you have gotten the information you need. So, if you are producing your model, for instance about that river, the behaviour, the flooding patten of that river, you can incorporate it in a ten year : cyclic pattern and then you watch it to see if it works out. (Interview 93, 20.04.2016)

In the end, remote sensing, GIS and GPS remain at the heart of GIScience, but gain additional use-value if relevant human knowledge and observations can be located in space and time. Forming a symbiosis, they together map medicinal plants and fish breeding grounds (UNIDO project) beyond what our ancestors could have imagined and what satellite engineers envisage (Interview 93, 20.04.2016). Uluocha’s thoughts are in line with literature that increasingly discusses the integration of ‘ethnobotanical knowledge’ in ground-truthing practices. However, there are differences. For example, related weaknesses that Herrmann et al. identify, in Uluocha’s account appear as strengths. Herrmann et al. argue that the integration of ‘local knowledge’ and physical data was challenging as ‘standardized data collection protocols’ were missing. Furthermore, most local information was subjective and ‘may be subject to biases and exaggerate or mask trends’ (Herrmann et al. 2016, 131-132). In Uluocha’s case, these challenges become a matter of putting standardised and perhaps superficial positivist thinking temporarily aside. Instead, he suggests reading between the lines to find valuable information in allegedly subjective accounts. This allows to ‘marry’ indigenous knowledge with remote sensing and GIS to make these technologies meaningful to those who hold knowledge that cannot be sensed by any technologies (Interview 93, 20.04.2016). When Wienroth and Rodrigues describe the concept of social convergence in relation to technoscience, they refer to how ‘new opportunities for knowledge development and for the creation of new products and technologies’ may develop from ‘placing existing knowledges in novel combinations and new relationships’ (2015, 4-5). They emphasise that any relevant collaboration is not restricted to ‘existing technoscientific actors’, and that scientists’ increasing awareness of telic knowledge production in the wider society as well as citizens’ critical appreciation of



university-based knowledge products, now ‘shape scientific enquiry’. For example, some scientists actively collaborate with members of the public in producing knowledge (Wienroth et al. 2015, 6). In Uluocha’s case, his awareness of rural people’s occasional scepticism towards technoscientific interventions in their lands about which they hold first-hand (observations) or passed on (ancestors) knowledge, has certainly promoted the idea of social convergence. This is an ideal situation that, however, is challenged by the environment itself, as the next sections will discuss.

### **Troublesome trips to the field to establish the ‘truth’**

I was part of the team, a team composed by engineers, agricultural engineers. They, they use techniques of botany to study these things. And me my job is what? I start to use/do the land cover, land use through the aerial photographs or satellite images. And from there during the, during this/the ground truth I carry them in the bush. You say ‘okay here is dense forest. Let us discover the different kinds of vegetation, we can find there’.  
(Interview 23, 03.12.2015)

When my dialogue partner at RECTAS figuratively describes how he takes his satellite images or aerial photographs to the bush, he refers to the practice of ground-truthing as introduced in chapter one. Collecting data in the field often is necessary before a researcher can extract any meaningful information from satellite images and produce thematic maps. However, going to the ‘bush’, respectively entering ‘dense forest’ for matters of ground-truthing or collecting subject-related data, such as geological samples and aforementioned indigenous knowledge, is far from straightforward. Nigeria’s climate itself is a metronome for fieldwork, but can still be considered a routine:

Rock hammer and compas, taking measurements. It is interesting and this is the best time because the field is dry now. (Interview 51, 08.02.2016)

In various publications this routine often sounds seamless, regardless of whether it is in support of satellite data or not. In their study on stakeholder contributions to water supply in ‘rural-urban communities’ of Nigeria’s Ondo state, Ayeni and colleagues describe the acquisition of supplementary data as follows:

Data for the study area include detailed field inventory and documented information on water supply providers and infrastructure/facilities within the study area. All data collection activities were conducted between December 2008 and November 2009. (Ayeni et al. 2013, 65)

The conduct of ground-truthing in a study by Adediji and colleagues on forest degradation in the Omo Forest Reserve of Ogun State, sounds similarly practised:

The satellite imageries were processed digitally. Ground truthing was carried out to identify information classes for easy processing of satellite imageries. (...)

This was done in order to observed [sic] the various activities going on in the reserve such as logging, clearing for agriculture, bush burning by hunter and to differentiate different standing vegetation for easy interpretation of the satellite imagery. In this regard, the fieldwork was carried out within some selected area of Omo Forest Reserve. (Adediji et al. 2012, 243-244)

For many researchers such a 'field inventory', however, is an experience of disruption. In my own very limited experience, moving around in Nigeria became one of my primary challenges which I only mastered with the help of my hosts. The area of movement in Nigeria is restricted in the first place. As a guest I was limited to Southwest Nigeria. However, related security concerns are likewise on the minds of local researchers, who avoid travelling to parts of Northeast Nigeria. In addition, Nigeria's transport infrastructure is considered underdeveloped. Most researchers will above all rely on their own cars to go to the field. However, not only do occasional fuel shortages cause delays, but researchers usually have to manoeuvre roads that are filled with potholes. On most side roads a car's underbody will frequently hit the unpaved ground. In addition to the lowered speed and a significant loss of time, most researchers will nevertheless make sure that they arrive at their destination before sunset as overland drives are considered unsafe during night due to incidents of armed robbery. Even at short distances this aim can prove challenging. One evening my host and I just made it back to Ife short before sunset and were suddenly slowed down by armed police. With the sun setting behind us, this especially for me was a stressful situation, albeit the only one. A local textbook is forthright about the potential risks of 'land transport' and lists 'theft/robbery' and 'kidnapping' (Uluocha 2015, 104). However, only the personal accounts of researchers allow me to imagine the additional obstacles in more rural areas. One geographer from Ile-Ife vividly recalls what it means to go to one of Nigeria's remote villages to do fieldwork on the river blindness disease Onchocerciasis. He first describes the deprivations of a remote place, not only to illustrate the real causes of youth migration that he discovered (against the belief that Onchocerciasis is causing it), but also to show what remoteness in Nigeria means:

Don't forget they are deprived in all ramifications you could think of. They do not have access to basic facilities. No pipe water, no good road, no educational facilities, nothing. Just the buildings or the huts or whatever you want to call them, where people dwell. The basic economic activity is either farming or hunting or any of these primary activities. (...) In the (essence) of it, the opportunity to leave that community is like an escape from rural doldrums to what the future holds for the child. (Interview 14, 04.11.2015)

Going to such a remote community in Nigeria can be troublesome. It can literally mean that at one point your field assistant will withdraw, that you will ‘muster’ all your energy, shoulder your motorbike and just go:

Let me tell you there are some of these communities, that to reach them : you are talking of big rivers without any bridge, to cross you needed to go on a canoe and in fact there were some, when I got to the river bank there was no canoe to/and because of the determination to get the work done I had to/I had to enter the river. I was going/ I did the survey on motorbike. My field assistant at the point told me he was not going to cross a certain river (with me)/he told me vehemently he was not going with me. (...) At that point I had to make a decision. I took the risk, I took the risk. I muster with every energy I had in me, carried my motorbike. Because there was no way I could/I mean there was no canoe to ferry me across the river and then somehow I was lucky. I was able to cross (laughs). (Interview 14, 04.11.2015).

Others do not have money for a field assistant in the first place. They will have to administer questionnaires on their own:

And that (made me something to) take so much time because I could not get the field assistance that I need, who will help me to apply the questionnaire. And definitely that will affect the research a little bit. But at least I thank God for what I have been able to accomplish. (Interview 32, 18.01.2016)

In the end, managing to carry questionnaires to remote areas is only a first step. The continuous deprivation in many villages and unfulfilled pledges of development often makes them reluctant to participate:

In fact, some people are hostile. Once they see you coming with a form they say ‘sorry do not come to us’. They will tell you ‘some people were here yesterday, two days ago, last year they promised to come back and do something for us, they did not come back and you are coming with another form’ (...). (Interview 12, 27.10.2015)

My personal experience in the ‘bush’ was limited to what I was able to observe during overland drives and short excursions. Though still close to Ile-Ife, the educational trip to a gold mine gave me an idea of what researchers go through on ground. Nearby a dusty unpaved road, the miners were hidden in thick forest. Even the short distance that we had to walk felt like a segment where one can easily get lost. This was a group experience

to learn about the environmental impact of gold mining. It lasted not more than two hours, but to me it felt like a whole expedition (Figure 18 and Figure 17).



**Figure 18** Fieldtrip to a gold mine (Thorpe 2016).



**Figure 17** Fieldtrip to a gold mine (Thorpe 2016).

## **'Believing' in the 'new technology' as an extension of the senses**

Because if you look at some wind currents, they are removing sand from some part of Africa and those sands are deposited in Amazonia. (Interview 24, 07.12.2015)

Looking at transnational environmental phenomena, my dialogue partner at RECTAS describes remote sensing and GIS as a global 'common denominator'. He refers to the result of a process that will be the subject of this section. It will describe how researchers in Southwest Nigeria have gradually learned to appreciate remote sensing and GIS as a tool that allows them to reclaim responsibility for Nigeria's environment. Many parts of this environment are not only perceived as inaccessible, but the restricted access is understood as being embedded in erratic developments, as this section will further outline.

### *An unconventional vantage point*

You know that satellite data has an advantage to cover large areas, whereby it is not/you cannot access all the areas. (Interview 33, 18.01.2016)

As researchers are regularly confronted with their ground-based limitations of collecting data, they appreciate how distant technologies of sensing can provide a 'broader perspective of the environment' (Interview 58, 24.02.2016) that is considered in contrast to a narrower ground-based 'traditional approach', as one geographer in Ibadan describes. EO technologies open up an understanding of causal relations that would largely remain invisible from a position that is within the web of causes and effects on ground:

If you notice/this is a road and you see people selling all over the place (...). So, I asked one of my students to look into that issue and see the unanticipated effects on city development on informal sector. (...). The question is how do you use your geospatial science here. Very simple, we have a high resolution image which we actually pick from Google Earth. So, we are able to see the shops clearly and then we are able to map. (Interview 58, 24.02.2016)

Researchers further construct the advantage of seeing from above through their experiences with specific developmental and environmental issues that they not only want to address but that impede both the collection and analysis of data in the first place. For example, addressing security problems, such as illegal routes, by means of satellite data is also appreciated as tackling congruent restrictions of data collection:

Now again, traditionally you want to go on ground and look at those illegal routes but we know that going on illegal routes is not safe by road. So, you may not likely cover all of them, but from the high resolution image, you can actually get all of those things and then we can analyse them as much as possible. (Interview 58, 24.02.2016)

The new space-based vantage point is often contrasted to the ‘tedious’ ways of ‘traditional mapping’, such as in ground water exploration. The traditional approach is experienced as entrenched manual labour amongst most researchers who now use remote sensing data (Focus Group 9, 07.03.2016). Many researchers have reiterated the feeling that they are part of a transdisciplinary group that promotes new ‘advanced’ ‘high-tech’ tools in Earth-sciences in Nigeria.<sup>71</sup> For example, one researcher considers GIScience as a personal challenge that allows him to ‘stand out’ amongst those who ‘still use the old conventional method back here in our country’ (Interview 51, 08.02.2016). This group of researchers embraces remote sensing and GIS as a more accessible path to the field. One young geographer in Ile-Ife ‘wanted to do something different from the conventional way of doing things’, for similar reasons, as she recalls. Also, in her case, this objective is largely based on her memories of accessing the field to gather ‘first hand observations’. She speaks of ‘restriction to where you can go in those places’ and joins her colleagues in being grateful for the ‘new technology’:

You can be able to study an area without being in contact with the area. That (me) brought the interest for remote sensing and GIS. I just wanted to do something different from the conventional way of doing things. (Interview 21, 13.11.2015)

Being able to see things on ground without the necessity of ‘being in contact with the area’ of interest and by this mitigating the burdens of accessing the field, is with varying degree understood as progressing in one’s Earth science discipline, when this new form of data collection is combined with the analytical powers of GIS. One surveyor in Lagos recalls that her Master’s programme of 1998 was still limited to core surveying without ‘GIS or geoinformatics added to it’. Her related memories of going ‘to the field’ are likewise memories of the hardships of gathering data in parts of Nigeria, whilst financially gaining less from the data than those who use it. When GIS was finally introduced in her department, her experience with GIS promoted her desire to ‘move one step ahead’ for her doctoral studies by integrating remote sensing and GIS in environmental research:

You give [the data] to someone and that person that had not suffered the way you have suffered. You see the way I reason about it is you spend (...) been the first to get there as a surveyor, bush, swamp, before it needs development, surveyor has to be there. (...) (Interview 81, 29.03.2016)

For most researchers, this option of questioning the ‘traditional approach’ and of simultaneously broadening the scope of research, is perceived as having slowly developed over

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<sup>71</sup> This will be further discussed in chapter seven.

the last two decades. For senior researchers, their dependence on limited ground-based tools has been a long-term experience. This experience is now communicated to younger generations. One emeritus professor from Ibadan, for example, vividly recalls the ‘funny and crude’ way of mapping the Ibadan-Lagos expressway with his own car in the early 1980s. He remembers this as a time when the...

...level of accuracy was low and maps were bad or non-existent. So, we took existing 1:20000 maps of Ibadan and we updated it. We updated it. There was no GPS, there was no GPS in 1982 in this country. (...) How did I do it. You see, you know, there are (hotspots) in Ibadan, in Ibadan town that are very well known and from most of them roads go to the expressway. So, I will take my car, put somebody there. I will look at the kilometer of the car. I tell you it is 85.2 here. We drive down, forget corners. When we get there I say ‘okay we ride so many miles or so many kilometers or so many meters’. We then (...) and just do it like that. That was how crude things were then. (Interview 65, 29.02.2016)

Overall, reflecting on remote sensing, senior researchers emphasise methodological advantages in relation to the intricacies of the field. One geography professor from Ile-Ife, who now is one of Nigeria’s leading experts on climate change adaptation and mitigation, has a background in biogeography. Upon returning to Nigeria from his PhD studies in the UK (1985-1988), he began studying the soil restoration capabilities of a ‘particular plant species, called *Gliricidia sepium*’. He recalls how he soon ‘had this very strong feeling’ that the conventional methodological capabilities in studies of soil and vegetation had their limitations. His concern was that, considering Nigeria’s complex biodiversity, simple ground-based sampling would ‘miss out’ larger nexuses. Remote sensing then appeared to him as a tool that had the potential of releasing him from few data points on ground:

You know in the tropical environment unlike the temperate you may have within an area of this/if you have a very well-protected environment, you have so many species of plant within one by one metre square area. And so if you lay in our traditional way of/would lay (transects) and we (sample points). You do not take all the points. You locate your sites where you want to study. I always think that that methodology cannot get it, because you will miss out certain species that will tell you the rich stories which sampling will not tell you. (Interview 52, 11.02.2016)

Remote sensing eventually gave him ‘so much satisfaction’, as he emphasises, allowing him to ‘get more realistic information’ about the biological diversity on ground – a philosophy that he has passed on to his students. Overall, a GIScientist’s appreciation of remote sensing and GIS is related to cross-disciplinary spatial, temporal and economic concerns in accessing the field and in understanding the natural and anthropogenic complexity on ground. Any such appreciation is also related to specific spatial and temporal developments in the urban and rural field, that further construct conventional methods

as no longer *appropriate*. Before introducing these developments, I will discuss how this extended appreciation of EO satellites is reflected in the challenging integration of remote sensing and GIS in Earth sciences in Nigeria. Many younger researchers are not only aware of related efforts by senior academics but further promote the integration of remote sensing and GIS, based on their own observations and experiences with temporal and spatial developments in the field, which I will introduce subsequently.

#### *Pioneering & believing in the new technology*

When researchers describe how they have often stumbled into GIScience, this is salient considering that aerial photographs had already been used for many years in Nigeria. An aerial perspective is indeed articulated as a continuous ‘phenomenal transformation’, such as in the context of surveying in Nigeria. One former surveyor general of the federation and many of his senior colleagues express this ongoing process by remembering the tedious work of promoting the integration of an aerial perspective in Earth sciences in Nigeria. When he emphasises the temporal advantages, he recalls a project on flooding as if aerial photographs from aeroplanes had only been introduced yesterday:

It is a phenomenal transformation. Because, first of all, spacecrafts, other Earthcraft or spacecrafts (...) were introduced in Nigeria in 1949. These are the records we had at Office Surveyor General in Lagos, here. And so we used a lot of aerial photographs to do our initial maps from 1949. A lot of maps we did were from that period. (Otherwise) we by walking and traversing and you know, land survey methods. You can imagine how long it will take you to use a land survey method to map a state and what it takes you now to map a state. Now it has been phenomenal. :: It is so short now. It is so short. It has so much changed. When I did some work for Anambra state, when I was looking at areas vulnerable to flood, it took us a few weeks to do that because we had the data. (Interview 84, 31.03.2016)

By emphasising ‘walking and traversing’ as part and parcel of conventional land surveying methods, he reiterates the collective experience of physical travail on ground. Here, the gradual elevation of aerial photographs and satellite images to the status of advanced tools appears in a temporal context where aerial photographs still frame a new way of collecting data at ease and where space-based remote sensing constitutes an updated vantage point:

Because the synoptic view of the satellite imagery, compared to the aerial photograph that had some limitation because of the scale and because of those constraints to organise or to prepare a flight mission over a specific area, enabled more flexibility in the data acquisition. (Interview 24, 07.12.2015)



This continuous appreciation of remote sensing as emerging is grounded in the collective experience of integrating this technology in Earth sciences in Nigeria. Whilst RECTAS as a relevant institution existed since 1972 (Ogunlami 1993), promoting remote sensing in relation to Earth sciences in Nigeria has been far from linear. Younger researchers often refer to individual senior researchers as those who had ‘pioneered’ remote sensing and GIS in Nigeria. In my interviews with these senior researchers, they have recalled what pioneering means. When the emeritus geographer Adeniyi (Lagos) returned from Canada in the late 1970s, he had used remote sensing and GIS for land use studies. Enthusiastic for these technologies, he decided to promote ‘remote sensing and GIS as a tool’ for the ‘field of geography’ in Nigeria, where the existent practices of photo interpretation had yet been limited to cartography. He recalls how the use of remote sensing data then started spreading to other universities, and how organisations like UNOOSA increasingly supported this process in Nigeria:

We usually have a lab we call LABCARS, laboratory for cartography and remote sensing. In fact that used to be my address for a very long time. It started spreading from the University of Lagos to other universities and then we were having a lot of conferences. (Interview 94, 20.04.2016)

This ‘spreading’ however was a slow process as professional surveyors and geologists had soon displayed their entrenched vision of ground-based fieldwork:

They believe in theodolite. That is the best. They go to the field, go and measure and so on. (...) Again the same thing happens, you know introducing it to geology and they think the resolution was that bad. (Interview 94, 20.04.2016)

Pioneering and advocating remote sensing in Nigeria became Adeniyi’s focus, which he further followed by collaborating with scientists from abroad (Canada). This helped to train some of Nigeria’s first-generation advocates of remote sensing. Another pioneer, who also got ‘exposed’ was a geography professor from nearby Ibadan. This emeritus professor recalls how he combined his knowledge of GIS (acquired abroad) with the knowledge of yet another professor, who had more knowledge about remote sensing:

You see there are some of them that were also exposed. (...) I knew many things about GIS. I later on learned remote sensing. He already knew something about remote sensing. So, we are complementary and that was good for whatever we wanted to develop. (Interview 65, 29.02.2016)

However, all this cross-fertilisation did not fully take off until the 1990s. Different time designations during interviews indicate that the appreciation of GIS in the eighties up to the early nineties had yet been uncoordinated. For example, whilst one professor recalls

the early 1980s as a time ‘before there was any GIS’ in Nigeria and refers to GIS as something that emerged in the United States in the 1990s, Adeniyi (1981) already speaks of GIS as a ‘computer assisted technique’ in a paper from 1981.<sup>72</sup> In Nigeria, the promotion of remote sensing and GIS in geography has further depended on individual partnerships. For example, at the department of geography in Ibadan a grant from the US was used to train researchers at the University of Iowa, and to establish a GIS laboratory (Interview 65, 29.02.2016). This collaboration in 1992/1993 was an important moment for the integration of GIScience in Nigeria, as Jeje and Ojo recall in an article about developments at the department of geography in Ile-Ife, which eventually also became involved. The original objectives included the promotion of ‘the knowledge and application’ of GIS at institutions in Nigeria and relevant provision of equipment (Jeje and Ojo 2012, 25).<sup>73</sup> For the early pioneers of remote sensing and GIS in Nigeria, this technological integration was never intended to be limited to geography, but to allow their own discipline to more effectively tackle ‘day to day problems’ in collaboration with other disciplines. My dialogue partner from Ibadan recalls how more and more of his peers had been exposed to the new ‘set of techniques’ and were ‘all willing to explore new grounds’ in this respect (Interview 65, 29.02.2016).

Despite these developments in the 1990s, the wider promotion of GIScience was still troublesome. In the early 1990s, Adeniyi began to set up the African Association of Remote Sensing of the Environment (AARSE). When other researchers still commented on the limited basis for space science on the African continent in 1994 (Okeke et al. 1994, 1225), AARSE’s second newsletter had already been published (Adeniyi 1994b, 2). Taking remote sensing as a tool for development to the continental level, however, proved challenging for structural reasons:

The AARSE, you mentioned, came about in 1992 when we went for the conference organised by UN Outer Space and the American government in Arizona and every continent made presentations there except Africa. There was no single presentation made to represent the continent of Africa. That was where ten of us, who participated, formed AARSE. And I was us to lead as (...) president. It was very, very difficult to organise such a society in Africa at that time. With different systems of currency. (...) It was difficult for people to participate. I was almost running it as an individual type of thing. Because I believed in the technology, I believed that the greatest problem facing Africa is not having the knowledge of what they have. (Interview 94, 20.04.2016)

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<sup>72</sup> GIS indeed was introduced earlier and as of 1991 over 300 software products were already available. The first workable GIS dates back as far as the 1960s, when the Canadian government introduced the ‘Canada Geographic Information System’ (Goodchild 1995, 35-37).

<sup>73</sup> Talking about ‘the configuration of a typical GIS laboratory’ and holding a seminar on Nigeria’s environment were two events during the stay of Nigerian researchers in Iowa (Jeje and Ojo 2012, 25).

Furthermore, notwithstanding the presence of relevant UN-affiliated institutions, such as RECTAS, less than three decades ago GIScience had neither yet been supported by most African policymakers. They had often considered remote sensing a threat:

And the question is what secrets do you have. I mean if the satellite is in space, yes and anybody can acquire it and study it and they will know better than you are. If that is the case why don't you try to know as much as any other person will know about your resources. (Interview 94, 20.04.2016)

Whilst a limited developmental appreciation of an aerial perspective had been present amongst Nigerian policymakers in the early 1990s, related commissions had been largely uncoordinated and often ignorant of relevant capacity at Nigerian universities. My dialogue partner from Ibadan recalls that around 1990 Oyo state commissioned a company to do aerial mapping of Ibadan to improve the city's water production. Neither he nor the federal government knew about this project until he 'discovered the 1:1000 map series' in 1992, when Oyo's local government asked him for help during a controversy on census figures. He realised that based on their lack of knowledge about GIS, the government of Oyo state had never asked for the original spatial data, taking only the maps:

When they called me in 1991 or 1992, about the census, then I told them 'look, you ought to have taken the spatial data for this'. They said they did not know. (...) So, you know, that was how GIS was coming to this country. (Interview 65, 29.02.2016)

For a long time, foreign oil companies like Shell were the major actors that pursued mapping and surveying projects in Nigeria. In a publication by Adeniyi from 1992, a table on 'major remote sensing applications in Nigeria' indicates that only a few federal agencies showed interest in the use of remote sensing data for mapping purposes. Whilst the entries 'Federal Surveys' and 'National Population Commission' indicate some local involvement, Adeniyi immediately plays the significance down by writing 'local contractor but executed through foreign partners' (Adeniyi 1992, 29). Referring to the missing federal support for remote sensing applications, Adeniyi further writes:

By this practice, we have denied ourselves the ability to acquire the knowledge of how to apply remote sensing to solve local problems. (Adeniyi 1992, 27-28)

This perception of a slow institutional integration of remote sensing and GIS is further grounded in detailed agendas that had already been articulated in the 1980s. In 1986, Areola, as one of the early pioneers, speaks about a 'weakness in the institutional arrangements for data gathering in Nigeria', when introducing related efforts of the then-existent Nigerian Society of Remote Sensing (NISORS). Long before NASRDA was founded,

Areola calls for the ‘creation of a socio-political climate that values and places due emphasis on adequate data collection and evaluation in all aspects of development planning’ and can hence support a ‘remote sensing institute in Nigeria’(Areola 1986, 3-5).

In the eyes of the Ibadan-based emeritus geographer, GIScience has up till today only been appreciated ‘bit by bit’ in Nigeria, also thanks to the persistent promotion of maps by aid organisations. He only sees a larger extramural interest since the late 1990s, when Nigeria’s space agency NASRDA was established (Isoun 2008). Akinyede, the agency’s former director of space applications, describes how pioneering is a continuous process that he has pursued during his tenure (2001-2009). He established space agency-funded collaborations with university departments (like geography and geology) that already had GIS laboratories or had the potential to set them up. Space technology applications were then promoted and developed in relation to specific developmental issues in Nigeria’s geopolitical zones:

For example, in the Southwest I looked at the area of deforestation as a major issue. In the Northern part of Nigeria I looked at the area of desertification because of the rate that the desert is encroaching towards the Southern part. In the Southeastern part gully erosion was endemic. I think you listened to my presentation. I look at the issue of gully erosion that was becoming a problem. Then in the area of the conflicts between the nomads/I mean the cattle rearers and the farmers/I looked at there should be a way of using space to look at the grazing reserves and then see how these cattle rearers will not infiltrate into the farms. (...) (Interview 43, 27.01.2016)

Overall, GIScience as a ‘set of techniques’ has primarily been transferred by individuals at departments of geography since the late 1970s, supported by foreign and regional institutions like RECTAS (Jeje 2012, 51)<sup>74</sup>. Until the 1990s, these developments had been largely independent from direct federal support, such as from NASRDA. Nowadays more and more disciplines use remote sensing data. I have met researchers from veterinary medicine, forestry and ecology, who promote remote sensing and GIS as a contemporary methodological add-on. One lecturer in Akure, for example, describes how he pioneered GIS and remote sensing at the department of zoology in Ibadan, where he went for their additional expertise on schistosomiasis:

They were even asking me how do you come by to say that you want to use this GIS and remote sensing. How much of it do you know? When I say ‘well, I will be reading more and I have my mentor in Ife’ and that was Professor Salami, the University of Ibadan wrote him a letter. (Interview 39, 25.01.2016)

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<sup>74</sup> The role of RECTAS will be discussed in more detail in chapter seven.

Combining specific disciplinary knowledge with GIScience then defines related application areas in Nigeria, as he describes:

You will see, here in this department [remote sensing and GIS] that was/they said they needed somebody that has that GIS and remote sensing background and they could use it in the area of disease control or epidemiological study. That was how I was brought in and employed here last year. It has given me an added advantage, other than being just a zoologist alone, a geospatial epidemiologist, using remote sensing and GIS to study epidemiological diseases. (Interview 39, 25.01.2016)

In this case, remote sensing and GIS have been added to the ‘ordinary conventional method’ in epidemiology to understand the ‘spatial pattern’ of diseases and produce relevant maps (Interview 39, 25.01.2016). And many other researchers are now involved in ‘advocating’ remote sensing and GIS in their disciplines (Interview 26, 16.12.2015).

*A continuous transformation – constructing the vantage point in conjunction with increasing disorder*

Researchers describe the efforts of promoting an aerial perspective as a continuous and emerging process of conquering the mortal coil of ground-based methodological travail. The undaunted promotion of remote sensing and GIS in relation to conventional methods of data collection and analysis, is further grounded in the collective experience of an ever-increasing *disorder* on ground. Many of those who appreciate GIScience perceive that the urban sprawl of Lagos and Ibadan, can indeed no longer be followed through conventional methods. In a long and emotional statement one researcher at RECTAS illustrates some climate change-induced fast-paced cause and effect dynamics on local ground:

At the time, we enter this technology myself for example, when we are getting used to this technology and remote sensing, it was subsequent to the draught period where lots of people move from the rural area and are moving to the main town. (...). Now those coming into town are building, so you have that urban sprawl (...). You have problems of sanitation, problems of providing water, electricity and also transportation. (...) So, GIS now will become a useful opportunity to try to see how we can solve all those problems. (Interview 24, 07.12.2015)

The availability of remote sensing data in combination with GIS is perceived as gradually introducing an elevated era of environmental studies that can cope with ‘unprecedented’ rates of urban expansion:

One of our research products which was done by a PhD student was on modelling urban expansion, urban sprawl. (...) Lagos is expanding at a rate that actually was unprecedented. So many areas that were not part of Lagos have been overrun by Lagos. (Focus Group 10, 30.03.2016)

As part of an ongoing transformation, researchers continuously work on proving the space-based vantage point. Urbanisation is a major application area in this respect, where remote sensing and GIS are appreciated for revealing developmental discrepancies that occur at large scale (Interview 94, 20.04.2016). These can date back to the colonial era, such as Ibadan's colonial areas for 'blacks' and 'whites' that are now reflected in areas for the poor and the more affluent, as one researcher describes. A space-based perspective was of particular help in discerning these problematic structures in a sprawling city like Ibadan, which he describes as a city 'without standards':

That is why I said I want to study and then contribute to the change (...). And the most unfortunate thing is that Ibadan just spread without any town planning. Till today, till today (raps on his table), there is no town plan for Ibadan, no town plan. (Interview 48, 06.02.2016)

One researcher from Lagos reminded me that large portions of Lagos were below the United Nation's lowest standards for housing. Furthermore, activities in Nigeria's urban space are often conflicting in spatial terms. Car mechanics might work on unsealed soil whilst livestock is grazing in nearby litter. These are not simply my observations, but issues that my dialogue partners pointed out. For one geographer in Ibadan, the many consequences of rapid uncontrolled horizontal urbanisation are a reason for his interest in 'urban dynamics' with a particular focus on vertical growth. He intends to understand potential advantages of such 'smart growth' by combining socioeconomic data with remote sensing data:

Unlike the developed world, where you control your urbanisation, there is no proper control for our urbanisation here. And so you see cities growing horizontally without planning. That has caused lots of other problems. Traffic problems, slums, squatter settlement and so and so forth. (Interview 60, 24.02.2016)

In the end, proving the vantage point of EO satellites takes place in relation to different environments that are perceived as being in unbridled disorder. One geographer at ARCSSTE-E describes how proving the value of EO satellites means to show what this aerial perspective can actually 'bring out', such as for the revival of tree crops that are in danger of being extinct due to said uncontrolled urbanisation (Interview 2, 15.10.2015).

### *Time*

The promotion of a space-based vantage point is also constructed in relation to temporal aspects. One geographer in Ibadan is interested in understanding long-term dynamics between urban development and the depletion of green spaces. He values spatial data from

EO satellites as a means to overcome missing historical data on unplanned ground (Interview 56, 23.02.2016). Understanding uncontrolled urban expansion in terms of rates and directions by using remote sensing data from different periods serves many additional aims. Researchers suggest that they can partially regain control of developments on ground by providing models that can at least guide mitigation measures in areas that are now beyond the control of authorities:

We did a research which actually uses images/a sequence of images from I think about five epochs or so. It was actually used to model the rate of expansion in terms of the number of houses and also the spread, the direction of growth. (...) Because when people are able to know the direction in which expansion is taking place, it will help the government to be able to provide or organise the provision of their facilities. (Focus Group 10, 30.03.2016)

Satellite data is also understood as having specific advantages, where data on urgent issues is missing and cannot be easily collected. The advantage of ‘rapid mapping’ by means of remote sensing is, for example, appreciated during flooding that often takes place in areas that are difficult to access (Focus Group 10, 04.04.2016).

Researchers, above all, teach remote sensing and GIS as a ‘planning tool’. Future users shall be socialised as GIS practitioners who appreciate a space-based vantage point in relation to local environmental and developmental concerns (Interview 56, 23.02.2016). Remote sensing and GIS are not only taught as being able to unravel disorder on ground but to project into the future and re-establish order where any inventory is missing (Interview 24, 07.12.2015).

## Conclusion

Researchers have constructed remote sensing as a ‘tool’ in relation to their experiences with social and natural environments and with doing research on these environments by using conventional methods of data collection and analysis in their respective Earth science disciplines. At first sight, any promotion of indigenous knowledge, as it is increasingly emphasised in literature on Africa’s integration and development of technologies and knowledge (Dibua 2006), is set aside by GIScience researchers in Southwest Nigeria. They now seem to turn to transferred technologies that are considered appropriate to shed further light on their previous direct observations of the natural and built environment – the ‘cognitive geography’ – as one researcher has described it. Such a determinist interpretation of the integration of remote sensing and GIS in Southwest Nigeria will, however, not do justice to the experience of researchers.

This chapter has discussed that these technologies are largely a choice in a researcher's life that is based on complex interactions with social and natural environments. The initial appreciation of these technologies still often depends on individual interests and encounters that lead to an Earth science path, as well as subsequent encounters with users of remote sensing and GIS or relevant materials. Furthermore, the transfer of EO technologies and knowledge has been all but linear. Their integration into Earth science disciplines in Southwest Nigeria is perceived as a slow continuous process that was initiated by senior scientists from Nigeria, who by most researchers are still perceived as their pioneers.<sup>75</sup> Based on their experiences of doing research in the field (data collection) and on the field (analysis) in Nigeria, GIScience researchers have developed a collective understanding of what these technologies mean in relation to their disciplines and interests. This goes beyond a simple appreciation of GIS as a transferred 'research tool' (Goodchild 1995).

At this stage 'tool' means a 'liberatory technology' (Hollick 1982) that, however, is not adapted or designed in relation to a Nigerian or any ground in social or political terms. Despite local agency in carefully integrating remote sensing and GIS, some scholars and policymakers might be sceptic about the liberatory character of these technologies (chapter three). At this stage of the thesis, remote sensing and GIS should be considered liberatory to the extent that they allow my dialogue partners to traverse the ground with more ease. They appreciate being able to sense specific remote areas without the absolute necessity of physically going there (except for matters of ground-truthing). Having a view on a large area allows researchers to analyse relations between social and natural environments that they can often not easily access. They further appreciate this vantage point in relation to missing historical data on planning in an unplanned environment (as perceived). One lecturer in Ile-Ife, who works at the Institute of Ecology and Environmental Studies, gets to the heart of what remote sensing and GIS means to him and his colleagues. He describes it as a tool that should not be reduced to potential economic benefits but that can 'bring order out of a chaotic situation':

So, you see a lot of wastage [refers to water] because there is a lot of chaos in the situation. So, you see GIS is a tool to bring order out of a chaotic situation, not only a tool for rapid socioeconomical development. (Interview 22, 27.11.2015)

Researchers describe a remote tool that can help to regain competence and responsibility regarding Nigeria's environment over which they feel they are gradually losing control

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<sup>75</sup> This aspect will be further discussed in chapter seven in the context of capacity building.



based on fast-paced processes that are ultimately understood as being embedded in global economic relations. Using the new – already existing – vantage point of remote sensing helps researchers to do an ‘abstraction’ of a complex situation in which neither the environments on ground nor the tools for assessing them are bound to specific places:

You know they have some contract between those coastal regions in Africa, for them European boat to come and fish in African sea. What did they use before? Remote Sensing, because using remote sensing you do oceanography. You know where are the areas that are rich in phytoplankton and co. (...) So, that is why I am into this remote sensing and, well it is a complex world, but it is a very interesting world. :: You know, when you are able to do the abstraction of that reality, it makes it easier to understand and it will remove that antagonistic spirit (...). No, we can not live in an atomistic environment that is me alone, no. You have to liaise, you have to connect with other for you to be able to grow. And I think this remote sensing GIS, if we fully master it and implement it in our way of life or in our decision process making, it may change drastically a lot of things and maybe it will be the way forward to development. (Interview 24, 07.12.2015)

Dyce (2013) looks at the historical promotion of an aerial perspective in Canada. He refers to the early advocates of an advanced ‘geographical imagination’ for Canada – an ‘elevated’ modern ‘locus of vision’ (ibid., 80). In the 1930s, an aerial perspective became associated with ‘visual access’ to the country’s areas ‘that had once seemed remote’; an appreciation that has largely been directed towards Canada’s use of natural resources and economic progress (ibid., 80, 83). In Nigeria’s case the early promotion of an aerial perspective since the 1960s has been developing from a different angle, where a particular remoteness (access and analysis) is experienced in both rural and urban areas – detached from a national ‘geographical imagination’ and the prospect of revealing the ‘intimate secrets’ of national resources (ibid., 80). Over the years, remote sensing has, in the first instance, been appreciated as a means to approach a situation of missing data and unbri-dled developments. Unlike Canada’s case, the early geographers who advocated remote sensing in Southwest Nigeria, did not ‘[imagine] themselves as adjuncts to government nation-building with the special task of understanding and overcoming the country’s unique physical challenges’ (ibid., 82), but rather as being the actual pioneers in this respect. Related discourses on whether geographers should observe ‘nature first hand’ or whether the ‘nature of the air photograph’ might cover if not ‘out-do primary observations’ in combination with geographers’ analytical expertise (ibid., 83), relate to different experiences, where in Canada the prime appreciation has been that of a *better view* and understanding of natural and anthropogenic phenomena. In Southwest Nigeria different ‘meanings’ have been ‘invested in air photographs’ (ibid., 83-84) (and later EO satellites), with the prime objective of having *a view*.

In the context of using remote sensing data to bring order into a ‘chaotic situation’ and ‘complex world’, some researchers in Southwest Nigeria now elevate remote sensing data to ‘primary data’, that in combination with GIS can provide an ‘indepth analysis of both socioeconomic phenomenon and physical phenomenon’ (Interview 60, 24.02.2016). *Remote* sensing is eventually appreciated as a spatiotemporal relief whenever ground-based sensing is embedded in the same disorder that researchers want to address. It becomes a key to break a vicious circle:

You know if you have restrictions as you move, it makes it more/then you begin to resort to remote sensing. (Interview 51, 08.02.2016)

For example, you have images of different periods, is almost doing fieldwork. Because you have the history of that area through a period, and it will enable you to understand how that body is changing. (Interview 24, 07.12.2015)

[Remote sensing] has really helped us to understand our environment via satellites in orbit. (...) When I say environment not Earth, not this planet alone, other planets. (Interview 33, 18.01.2016)

My dialogue partner’s reference to other planets indicates that this discussion belongs to a new elevated era of looking at inaccessible environments. Traversing Nigeria’s ground to reach small villages can become a journey to unexplored places with various natural barriers like rivers and unknown reactions by those who live in these places. Whilst remote sensing and GIS at first sight seems to eclipse ‘indigenous’ knowledge on ground, it is an opportunity to bring this knowledge to a new light in the context of development agendas. It is an era in transition, in which traditional disciplinary methods seem gradually defeated. At the same time, the disorder, as one geographer from Lagos argues, comprises much indigenous knowledge and any developmental agendas can only be successful if such knowledge is newly appreciated as supplementary knowledge in analysing satellite images. In Uluocha’s account, GIScience technologies and knowledge eventually become a matter of democratisation, of ‘social convergences’ (Wienroth et al. 2015), and not of their disapprobation in relation to indigenous knowledge, as some literature might suggest in relation to other transferred technologies that suppress local knowledge and create dependence in their modernisation paradigm (Dibua 2006):

The most important thing, I believe in GIS, I believe in remote sensing, I believe in cartography, but if these things are not (imparting) positively on the people then it is of no use. It is of no use and for it to impart on the people, like I said, you have to democratise it. (...) How do you achieve that? Get the people involved. (Interview 93, 20.04.2016)

The next chapter will look at the day-to-day agency in GIScience to further understand the position of these technologies between low Earth orbit, Nigeria's ground and researchers – and eventually their liberatory status.

## Chapter Six

### You Cannot Bring the Satellite Down to ‘this Part of the World’ – Intricacies of Daily Capacity in GIScience

The last chapter has illustrated the many ways in which my dialogue partners perceive their natural and built environment – ranging from beauty to destruction. Remote sensing from space has entered the lives of researchers as a liberatory tool that allows them to take responsibility for their environment on behalf of society, to make some order out of chaos. This chapter provides a deeper understanding of how remote sensing and GIS are embedded in a daily research context. It will take a close look at the different forms of existence of those elements that are described as relevant in relation to daily practices and how this might construct a GIScience situation in which liberation is as much envisioned as it is challenged. Consequently, this chapter will also discuss how researchers eventually understand their own situation in a larger social and political context in which they are not only researchers but also citizens, who participate in public discourses – the ‘small talk’ about Nigeria (Achebe 1983, 2). That any remaining determinist interpretation of this situation is untenable becomes particularly visible when researchers articulate their positions regarding Nigeria’s own EO satellites.

Overall, this chapter will look at the intricacies of capacity in GIScience in terms of researchers and their agency in relation to technologies and knowledge. It will discuss how GIScience in Southwest Nigeria at first sight seems constructed as belonging to the dependent periphery (Hwang 2008) of a larger GIScience arena. It is thus important to mention that this chapter might at times appear as still proving Mavhunga’s (2017) and other authors’ concerns. At the same time, and in line with chapter five, my dialogue partners do not merely accept their situation but reflect on it from the micro to the macro level. I will hence adapt the structure of their contemplation for this chapter and allow my dialogue partners to empirically express their voice – their story. In this situation, my most senior dialogue partner even expressed the feeling that his straightforward statements might not be appropriate. This feeling has also found expression in other interviews, when researchers occasionally introduced their arguments by using words like ‘I have to be frank with you’ and even apologised for their ‘emotions’, upon realising that they often had hardly anything positive to say:

Maybe I am not the right type of person that you should actually interview because I am not happy about my country at all. (Interview 94, 20.04.2016)

## Lowering the Sights – Non-Human Elements Between Presence and Absence

As a visitor in Nigeria I was of course aware that whatever I experienced was of a temporary nature in my life. At the same time, some of the experiences of my dialogue partners increasingly became my own. This has helped me to better understand what it means to use a space-based tool on the ground in Southwest Nigeria. In line with this, the following section will describe the *being* of those elements that are important for my dialogue partners.

### Satellite data – working around and tailoring ‘in this part of the world’

In Southwest Nigeria, remote sensing data has not only become a central element in Earth science research, but a challenge. One geographer at the University of Ibadan describes the financial pressure that he faces when planning to use specific data for his research on urban growth. The Ikonos data that he had identified as most appropriate is of high resolution and shall cover a specific period:

For a single data I was asked to pay around 380 Dollars for my study area. And my study area is not more than 2km<sup>2</sup>. :: I was asked to pay around 380 Dollars. (...) I need/ which means that if I am going to buy those three years, I will spend nothing less than 1000 and above 1000 dollars. (Interview 60, 24.02.2016)

Researchers often assess the high costs for data of higher resolution in relation to their own location. One researcher in ecology confirms that ‘access to spatial data is still very expensive’ and considers the financial constraints as a unique problem in his immediate environment that he describes as ‘this part of the world’ (Interview 22, 27.11.2015). This spatial reference is shared by many researchers. It has become a denominator of location for much of the collective experience that researchers describe in relation to satellite data. This is accompanied by a change of expectations regarding how a research problem can be addressed. One scientific officer expresses how instead of using the data that he identifies as most useful, he works around the missing data by making ‘use of what is available’:

[Y]ou know what you want to do, but you don’t have the data source to do it. (...) So, what we normally do every (blessing) day is that when we have this problem you actually make use of what is available. (Interview 26, 16.12.2015)

‘Working around’ means to use data that is not of the spectral, temporal or spatial resolution that has been identified by a researcher as most appropriate for their individual

research problem. For most researchers this means to revert to the tried and trusted, such as USGS that provides free and full access to data from Landsat satellites:

I have never been able to procure any high resolution satellite image apart from Landsat that is free, that we use for most of our applications. (Interview 22, 27.11.2015)

Notwithstanding that Landsat data is not ideal for many research projects, it nevertheless becomes the actual 'desirable'. Landsat data supports the ability to at least do some meaningful work, whilst commercial high-resolution data is reduced to a chimera:

So, if you see out of every ten papers written in Nigeria, more of nine or ten is going to be based on LandSat. The reason is because, it is not because of Landsat is the best image (...). But (laughs) because it is there available and since the English word said, when the desirable is not available, the available will become what : desirable. (Interview 26, 16.12.2015)

Despite a collective appreciation of Landsat's free medium resolution data, the related need to lower one's sights is accompanied by much frustration. One lecturer at the Department of Surveying and Geoinformatics at the University of Lagos emphasises the limited use value of Landsat data:

I don't know the type of geospatial information you want to get from the 30 metre (laughs) if I am not doing just clustering or pattern combination or things like that. (...) I cannot work at the local government level using such data. (Interview 81, 29.03.2016)

A colleague at the department of geography at OAU likewise points out that falling back to Landsat means that you can often neither do the research that you have planned, nor make use of your actual capacity, such as in terms of software proficiency. For his own research on 'deforestation, afforestation, desert encroachment, land use, land cover change', Landsat, however, is sufficient ('okay'):

I find it so easy [software] except the affordability of remotely sensed data. That has been the constraint, but we, we can go for the LandSat data (...). (Interview 1, 13.10.2015)

The limited use value of Landsat in terms of spatial resolution is only one concern that researchers have. Most researchers aim at understanding change in the environment and need data from different periods to make accurate projections. Where relevant data, such as Landsat, shows errors, or where data has temporarily not been archived for parts of Nigeria, alternatives can usually not be acquired. The temporal aspect further narrows down the ability of working around. One researcher at ARCSSTE-E describes the resulting practice as *tailoring*. Identifying relevant data in relation to a research objective indeed

is not the only skill that is required, but being able and willing to adapt one's objectives to the data that is available becomes another skill:

If I'm going to do any work on that phenomenon, I will be looking for data that is ['freely'] available and then, you know, tailor my work towards the time that those data were available. If I want to work on 1985 for example, I look at the date that is available. There is not 1985 data. The next one is 1986. So, I will take 1986 and work on 1986. Because if I have to work on 1985 it might require that I will need to purchase the data and by the time I purchase a stream of data that might be required for the work, it might be too expensive. Especially with the foreign exchange rate. By the time I convert from Naira to Pounds, (oh) that is [cutthroat]. My whole salary is gone, my whole saving is gone. (Interview 9, 16.12.2015)

One of his colleagues emphasises how tailoring means to accept that original objectives can often not be directly addressed:

You are only going to get 1986, 2001. (...) The (next thing you are) going to use is 2012 and the recent OLI Landsat 8 (...). That's how the research will be. That is it. (Interview 26, 16.12.2015)

Another researcher joins his colleagues in praising USGS for granting access to at least some free data, such as Landsat and Aster, but emphasises how also access to such free data can at some point be restricted:

But I expect that I should have access to better quality data, view hyperspectral images that have up to 50 bands and above, which will make my work much easier. But you know for now I have to just make do with what I have or what I can have access to. It is the Aster. The Aster, if you apply to NASA as a privileged user, you can have access to it. But (even at that) you have limitations to the access you can have. Maybe you have downloaded like once or twice. (Interview 51, 08.02.2016)

When his colleague refers to the data that he would use to get 'better results', he describes the collective daily pragmatic attitude towards satellite data as 'improvising': 'The only thing we do every day here is to improvise' (Interview 26, 16.12.2015).

#### *Data management in 'this part of the world'*

The common locational denominator 'this part of the world' that some of my dialogue partners have used to describe the location of their data situation, is often further constructed through debates over related policies. One researcher gets straight to the point, when he argues that 'there is no policy, strong policy that gives us data' (Interview 22, 27.11.2015). One of his colleagues does research on urban green spaces, which would ideally include high resolution data from SPOT (from 1986 onwards) or GeoEye for later

years. He describes what a lack of data policy means in spatial and temporal terms. Any attempts to access commercial data consume time and resources, when he goes to ever-new places where relevant data might potentially be stored, but often discovers that ‘due to poor management of these datasets’ not all data is available (Interview 56, 23.02.2016). The data-related understanding of ‘this part of the world’ is further constructed through the experiences of researchers, who have studied abroad and, like one researcher from Ile-Ife, communicate to others that ‘you cannot compare what we have *here* [in Nigeria] with what you have *there* in UK (laughs)’ (Interview 3, 15.10.2015). One staff at the Federal School of Surveying in Oyo likewise refers to his experience in Europe to illustrate what ‘coming back’ means in terms of data access:

But coming back *here*, there is a major gap I must say. But we are trying to teach the people here what we have learned *there*. (Focus Group 71, 07.03.2016)

Experiences of ‘here’ (Nigeria/West Africa) and ‘there’ (outside Nigeria) construct GIScience in relation to ‘this part of the world’. For example, where potentially useful databases have been identified on the internet, these are often experienced as exclusive. In other words, researchers who only travel digitally, also experience location directly in relation to GIScience. When researchers from Southwest Nigeria access databases they often learn that they live in a part of the world that has limited rights of access to specific data, and for which data often has not been archived in the first place (Interview 26, 16.12.2015). Overall, adapting research aims to what is available, implies a feeling of not only lagging behind in terms of location, but also behind a collective research capacity:

So, you are limited :: even when you have *capacity* to write and discuss and provide good current research. You are limited by what you have. (Interview 26, 16.12.2015)

On the one hand, budgetary limitations and the need for careful decisions in acquiring the most ‘cost effective’ remote sensing data sets, are also emphasised in general literature on GIScience. For example, regional and country-wide mapping does often not require expensive ‘very high resolution (VHR) data’ (Liu et al. 2016, 277). At the same time, in Southwest Nigeria this process takes place at a different level, where most commercial data cannot be acquired in the first place and free data has not always been archived. Without being designed as exclusive, data nevertheless becomes somehow political (MacKenzie et al. 1999) in relation to researchers, when it cannot be constructed on ground and is archived in repositories that are experienced as geographically restricted. Hence also initiatives, such as GMES and Africa (chapter two) are if at all only mentioned to emphasise the deficiencies in the distribution of data:



Of course some projects have been funded by the EU, USAID and some other international organisations. Most of these data collected are in different depositories, in different (...) universities, organisations. There is really no standard of bringing them together. (Interview 22, 27.11.2015)

The notion of fragmented data depositories reflects much of the data situation as it has been presented so far. I was able to experience what this wider fragmentation means in the context of mentioned global EO projects, when I attended a MESA workshop at OAU in 2015. The workshop was designed for researchers from West Africa (ECOWAS), who are involved in the programme. However, most of these specialised programmes and their data seem detached from the wider GIScience arena in Southwest Nigeria as they are linked to specific institutions. EO programmes that seem easily accessible from a European perspective appear as part of a larger dispersed data landscape, where USGS (Landsat) is the most visible pharos. Though Europe's Copernicus programme likewise provides free data, it has not been mentioned by researchers. Acknowledging that Sentinel-2A (land monitoring) had only been operational during my research stay (ESA 2018a), according to my observations, it was only at AARSE 2016 in Uganda that Copernicus was actively advertised to users from the African continent.

### **GIS/ Remote sensing software – ‘crack’ or stay behind**

In addition to data, remote sensing and GIS software become part of a collective experience of underdeveloped capacity in relation to other places. The acquisition of commercial software can for most researchers become as much a chimera as high-resolution satellite:

Then the other problem is accessing GIS software. It is too costly, particularly for people/for those of us who are *in this part of the world*. (Interview 60, 24.02.2016)

One researcher describes the software that he would ideally use for his research on land use dynamics, vulnerability mapping and water quality. However, as he is not able to acquire such software, adjusting original expectations once more becomes part of his daily routine. This is accompanied by the feeling of falling short of personal capabilities and analytical standards:

IDRISI Selva have (...) capacity for landscape modelling, land-use dynamics study, but I don't have it. What am I going to do? I fall back to what? My normal ENVI (...) That does not mean that IDRISI Selva is difficult for me to handle or to work, but because I don't have access to it. (Interview 26, 16.12.2015)

One appreciated alternative is the use of open source software. However, similarly to free Landsat data, free open source software is considered as not always meeting analytical demands (Interview 12, 27.10.2015). Instead, researchers have described with candour their situation in which most 'licensed software' from commercial providers can often only be obtained through 'informal sources':

But to be candid most of the ERDAS we are using they are from informal sources. Individuals having it. Maybe they use it to do a project or what have you and through that they make it available to their colleagues. (Interview 32, 18.01.2016)

Obtaining specialised commercial software from 'informal resources' can mean to 'crack' software, as researchers have emphasised:

But to be sincere to you and honest to you I don't have money to buy the licensed ones. So, most of us here have to use the cracked or what we call/we call it crack. (Interview 26, 16.12.2015)

His colleague in surveying and geoinformatics gets straight to the point regarding software that should be made available:

I personally, we want to have ENVI, ArcGIS, everything on my system, not cracked, I want to pay for it. (Interview 81, 29.03.2016)

### *Work below capacity*

Looking at software and data in combination, researchers repeatedly contemplate on their experience of maximising the use of what is available, and how their GIScience-related knowledge capacity is held back by this practice:

Sometimes here in Africa we are/our research is limited to not our knowledge, our capacity but because of the data and the software availability. And that is the thing. So, you discover that you have the knowledge to do more, but you are limited. (...) In ArcGIS now there is a hydro-analysis extension. I don't have it. (Interview 26, 16.12.2015)

Using unlicensed software constitutes an everyday experience of not being able to stay in the loop of software and technology-related developments that take place abroad:

I am still using ArcGIS 10, not licensed in quotes. We have higher versions outside but how do you get them? : The university has been given a license for ArcGIS, but just for a year. (Interview 12, 27.10.2015)

Staying outside the GIScience-related IT loop, is a collective experience of not being able to demonstrate the local knowledge capacity to ‘other parts of the world’, which further entrenches the experience of ‘this part of the world’:

I should be able to move forward, so that when someone looks at that work from other parts of the world, it really makes more meaning (...). (Interview 2, 15.10.2015)

In the end, commercial software is only of value if you can acquire or at least crack it, as one researcher emphasises: ‘If you cannot crack it, fine then you just forget about it’ (Interview 26, 16.12.2015).

### **Instruments – not a time for decommissioning**

Whilst remote sensing data and software are part of most researchers’ direct experience of lagging behind their own capacity, other elements do further construct a collective experience of scarcity in relation to GIScience.

#### *Delaying elements*

Throughout my research I have experienced what it means to ‘make use of what is available’ in terms of tangible and intangible resources. In addition to appropriate data and software, the GIScience situation in Southwest Nigeria often lacks elements that precede the use of the latter, such as during teaching. This discomfort is described by staff in geoinformatics, where a ‘remote sensing work station’ might be missing or malfunctioning and hence requires ‘word of mouth to describe how to do image processing’, as they emphasise (Focus Group 10, 04.04.2016). In the end, researchers and lecturers need to find ways to also work around malfunctioning or missing equipment:

They are about 25 [computers], but most of them are not working (...). It is a lecturer that will serve as an engineer to repair them and to install software for the undergraduate here. (Interview 12, 27.10.2015)

Being expected to be a computer engineer as much as a researcher and lecturer, means that the experience of being outside the purview of one’s own research capacity is further promoted. Many additional technologies, such as malfunctioning servers and handheld GPS, entrench a researcher’s feeling of being bound to the limitations of a local GIScience situation that is experienced through a collective productivity loss:

I bought this phone with my money. The data plan that I have there. I have to put it there myself. That is where I check my mails, because the university server it never works. (Focus Group 10, 04.04.2016)

This experience is intensified through GIScience technologies that cannot be easily acquired locally. One researcher had been looking for a long time for a handheld spectrometer to improve his understanding of the spectral signature of tree crop in the field, instead of simply relying on unsupervised classification of available data:

But in the course of this research there are some, I have some limitations, which I would like to share. I want/there is a particular equipment that I try to look for. The spectrometer. Why I actually wanted to use the spectrometer, is to see how I can look at the spectral signature, spectral signature of tree crops. If I have different trees in a particular community, how can I differentiate between one tree and the other. I couldn't lay my hands on that particular equipment and when I wanted to go out for it, it is a bit expensive. (Interview 2, 15.10.2015)

## **A Collective Loss of Capacity – Preparing for Failure of Implicated Elements**

That is why I said that we have not started. Absolutely we have not started. Our journey is far. Our journey is very, very far. (Interview 58, 24.02.2016)

In addition to the experience of scarce technologies, this section looks at long-standing collective experiences of constantly anticipating technology-related failure in a wider societal context. My observations indicate implicated elements, whose frequent situational absence is hence partially acquiesced. This constructs a wider understanding of falling behind a collective GIScience capacity in relation to location.

### **'No light'**

Before travelling to Africa's second biggest economy I expected to experience relatively stable power supply in urban areas. Looking back, I was unprepared. One researcher, who is based in Lagos, the most urbanised part of Nigeria, has described the situation with a clear demand: 'We want to have access to power' (Interview 81, 29.03.2016). Power outages became part of my daily routine. On some days they lasted for a few minutes, but more often lasted hours or even days. Whilst in my case, this usually only meant that I was not able to digitise my notes, transcribe and charge my devices, for my dialogue

partners, the situation is a long-term experience of losing additional time and of ‘working around’ in a perceived past, as one lecturer at the Institute of Ecology at OAU explains:

Because most of the problems we deal with are problems that should not be problems. (...) For instance now you find yourself in 2015 and there is no light in the place and sometimes you can find yourself for three days there will be no light. You begin to wonder is it that/sometimes we behave as if we are living in times before the invention of electricity. (Interview 22, 27.11.2015)

In the GIScience situation, the notion of being behind in terms of global time is indeed most visibly constructed through discourses on electricity. During a presentation that I attended in Ile Ife, a newspaper article from the 1980s was displayed. It stated something along the lines ‘No more power outages for Nigeria’. Amidst much laughter, the presenter asked the audience what Nigeria had achieved in this respect. The collective ‘off the grid’ experience means that the already challenged capacity in GIScience is further diminished. To illustrate this, staff at the Department of Surveying and Geoinformatics in Lagos emphatically confronted me with my own wellbeing as a guest after days without power:

As you are seated here right, you are supposed to be very comfortable, not in terms of/not in terms of the food that we can give you, but at least the environment must be conducive. For the past/for the past four/five days no light here. There is no electricity. That shows you if an institution like this can be in darkness, I wonder what you think of people in town (another group member: it is affecting the production). (Focus Group 10, 04.04.2016)

‘There is no light’ is an expression that has accompanied me throughout my stay. It not only became an expression for a loss of human and technological capacity in GIScience, but it became a synonym for ‘this part of the world’ (Focus Group 82, 04.04.2016). In the end, power is the prime desirable element in GIScience. At the same time, its frequent absence seems most acquiesced as it is entrenched in everyday life:

Without power there is nothing you can do. As you can see, you are sweating, I am sweating (both laugh). (...) And that is why (when people) leave and they go out to Europe or any of those other countries. When you look at the output, you will be amazed. (Interview 58, 24.02.2016)

Through the absence of power, I gradually realised how many elements belong to GIScience, such as air conditioners. One researcher, who had experienced stable power supply



**Figure 19** Reminder at RECTAS about handling UPS units (Thorpe 2016).

in the UK, even describes ‘power failure’ and all its implications as a local ‘routine’, when he rhetorically asks me whether I had ‘experienced power failure’ in Nigeria (Interview 3, 15.10.2015). I have experienced this routine in various GIScience moments. One geographer in Ibadan, who wanted to show me a 3D model of his study area apologises:

Unfortunately, I do not have power here. I would have shown you the 3D model of the study area I built. (Interview 60, 24.02.2016)

When charging my electronic devices became my personal challenging routine, I learned to constantly prepare for power failure and to value the time when power is available. This is time-consuming and in the case of GIScience involves the additional handling of

intermediary technologies, such as UPS units (battery and inverters) that can temporarily cover periods of electricity blackouts (Figure 19).

### *Internet*

One connected element constitutes a concern of its own in relation to a loss of capacity during power outages:

Getting good internet due to poor electricity within the university system. Especially in this site of the university it is really, really bad and it is really affecting my productivity. (Interview 56, 23.02.2016)

One researcher in surveying and geoinformatics (Lagos) further describes what poor internet connectivity during daytime means. The ‘middle of the night’ becomes the best time for her to download satellite images. She can still sleep as the download of one file takes hours due to poor internet connectivity (Interview 81, 29.03.2016). This is contrasted to her own experience and that of some of her colleagues abroad, where ‘within minutes, seconds, you have downloaded your data’, as researchers remember (Focus Group 9, 07.03.2016). However, despite all frustration, there is always gratitude for any small improvements and for having internet in the first place.

### **‘No fuel’ – ‘no light’**

Other elements seem implicated but largely silent in the context of capacity in GIScience. This requires zooming out of the situation and look at those elements that belong to other larger arenas. I refer to elements that either support the national grid or run generators, such as gas and oil. Related infrastructure, like gas pipelines, however are often vandalised and can hence not support the power stations, as researchers explain (Interview 81, 29.03.2016). Furthermore, ‘there is no light’ often is synonym of ‘there is no fuel’. I soon realised that buying fuel for generators and cars is another challenging *routine* that further constructs the experience of wasting time and capacity. I have experienced periods of fuel scarcity during my stay, and those few gas stations that sell fuel during such periods often have long queues of cars, motorbikes and minibuses which constitute the major means of transport in Nigeria, and hence means to go to work. For my dialogue partners, the frequent fuel scarcity is also one of the most direct experiences that something does not work at a larger political level. That Nigeria, as an oil producing state, experiences frequent

fuel shortages, has often been described as symptomatic of long-term developments that have thrown Nigeria back in time, as the next section will further discuss:

You are lucky that you do not have to move around in your own vehicle. (...) Meanwhile the boys here are not happy, they go there and blow up the pipes that carry fuel. (Focus Group 10, 04.04.2016)

## Since the 1970s Time Stands Still – Cautious Enthusiasm for (EO) Technologies

Researchers do not accept that their experiences of scarcity in relation to their geographic location defy any explanation. Instead I found recurring discourses, debates and discursive constructions in relation to their daily experience, which further construct ‘this part of the world’ in relation to GIScience. This construction appears detached from all the promises by international actors, such as ISPRS, AfriGEOSS, GMES and Africa and eventually the UN’s (1986) principles in relation to space-based remote sensing, that all with varying degree promote ‘non-discriminatory’ access to remote sensing data (chapter two). These programmes have hardly played any role in my conversations with researchers. What matters is that my dialogue partners face challenges in *accessing* data of higher resolution, where one qualification is the ‘ability to discover, retrieve, and manipulate data’ (Turner et al. 2015, 175). Considering Jason et al.’s (2010, 576) positive assessment of Nigeria’s experience in the DMC, where Nigeria enjoyed a ‘guaranteed influx of satellite data’ to the benefit of ‘local user groups’, this subchapter will not only look at Nigeria’s EO programme as the elephant in the room, but it will also look at debates and discourses over the general state of technologies and related policies in Nigeria, that – for my dialogue partners – explain the data situation from a local perspective. As related issues are directly visible to researchers they constitute their prime concern before any potential role of international EO programmes.

### ‘Then even, when you hear that Nigeria has these satellites...’ – hopes, frustration and disenchantment

And luckily in 2003 NigeriaSat-1 was launched. We used to say that that is when Nigeria joined the space club by launching the first satellite, NigeriaSat-1. (Interview 53, 17.02.2016)



Looking at the data situation described, this appreciation of Nigeria's EO satellite NigeriaSat-1, as it can also be found in literature (Isoun et al. 2013), might come as a surprise. The general position towards Nigeria's satellites is indeed ambiguous as this section will discuss. Akinyede, as one of the early promoters of remote sensing in Nigeria was directly involved in the development of Nigeria's space programme during his tenure as the director of space applications at NASRDA. Akinyede explains that one of the original aims of NigeriaSat-1 was to overcome dependency on foreign data:

Then the high resolution like Ikonos and/they were very expensive. (...) The access and the cost at that time, those are the things that we wanted to bridge by having our own satellite. (Interview 43 27.01.2016)

These motivations reflect a data situation as it is still described more than a decade later. Akinyede explains that the original purpose of distributing the data of NigeriaSat-1 to research institutions across Nigeria had nevertheless been partially successful. Before he had left NASRDA over two hundred students and researchers had benefited from NigeriaSat-1 data, as a survey indicates<sup>76</sup> (Interview 43, 27.01.2016). One of his senior colleagues is one of the users who has benefited from NigeriaSat-1. The data has helped him to overcome the time constraints that he had previously experienced with the acquisition of SPOT data, for which he had to wait 'one solid year' (Interview 53, 17.02.2016).

#### *Testing of NigeriaSat-1 and preparing NigeriaSat-2*

The first phase of Nigeria's EO programme with NigeriaSat-1 indeed echoes some success. Many researchers were involved in calibrating and validating its data. Akinyede explains that NASRDA 'provided little funds for stakeholders or for experts' to carry out 'pilot projects', such as on deforestation and erosion (Interview 43 27.01.2016). One geographer at the University of Lagos had been involved in one of the teams that looked at the use value of NigeriaSat-1 data for cartography. He describes the data's limited use-value for the production of large scale maps, unlike what is expected from the national second-generation satellites NigeriaSat-2 and NigeriaSat -X (Interview 93, 20.04.2016). These two EO satellites of higher spatial resolution were already looming on the horizon during the validation phase of NigeriaSat-1. Akinyede emphasises how important it was (and still is) to continuously convince Nigeria's leadership of the need of spatial data to support a national EO programme. Looking at the past challenges with Nigeria's

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<sup>76</sup> For the survey also see Isoun et al. (2013).

‘demographic survey’, the then-president Obasanjo with his military-based spatial experience, had immediately supported the second-generation satellites<sup>77</sup>:

But the president already perceived that if we are able to have a high resolution satellite that can capture houses, hamlets, villages (...) that that is another way to at least estimate/give an estimate of the population before the actual count. (Interview 43, 27.01.2016)

*An ambiguous ground-based situation – disenchantment with NigeriaSat-2’s federal data*

Whilst NigeriaSat-2 had been anticipated with many hopes, Akinyede largely frames his experience with Nigeria’s satellites as a closed chapter in his life. He regrets that he has not sufficiently managed to bring Nigeria’s satellites into the public domain before he ‘left the place’ (Interview 43, 27.01.2016), and further states that the past and current use of Nigeria’s second-generation EO satellites is outside his ‘purview’:

Because I have left the place a long time ago/how much they have used these satellites which they have for the benefits of the country is not really quite within my purview. (Interview 43 27.01.2016)

What sounds like disenchantment became more explicit during interviews with other researchers. The exclusivity of foreign high-resolution data has gradually recurred in a national context, and even affects those who once were directly involved in developing Nigeria’s data acquisition from space:

Then even, when you hear that Nigeria has these satellite, the satellites, most of them are not accessible. (...) I was formerly working with ARCSSTE-E, very close to people even at the helm of affairs, very close to some people. (...) So, they themselves are not really on top. (Interview 22, 27.11.2015)

One of the researchers, who is ‘waiting’ for Nigeria’s EO data works at the geography department at OAU. Like many of his colleagues, he has close working relationships with nearby ARCSSTE-E as one of NASRDA’s institutions. He looks for opportunities to use other data than Landsat to extend the scope of his research to the study of urban morphology. However, he notes that he must not count on NigeriaSat-2 data through NASRDA’s centre on the same campus:

*Our* NigeriaSat-2, which was recently launched is not available. By the time you get to ARCSSTE-E there, because they are in the custodian of NigeriaSat-2, they will tell you the data is not available. The data is not available, you know and it is *Nigeria data*, so is not available. That makes the research so difficult for us, especially if you want to look

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<sup>77</sup> Furthermore, a Nigerian communication satellite was commissioned during his tenure at NASRDA (Interview 43, 27.01.2016).

at the urban morphology you need the high resolution spatial data. (Interview 1, 13.10.2015)

His colleague at the department of surveying and geoinformatics in Lagos further expresses what it means to scale back hopes for *Nigeria's* ('our') satellites. She was involved in validating NigeriaSat-1 and refers to the current situation with much frustration. Expressing her disenchantment, she recalls her encounter with the representative of SSTL (the UK-based company that built Nigeria's satellites) at AARSE 2014 in Johannesburg:

I spoke with the guy, because in Nigeria they have been deceiving us. Where is the ground receiving station of NigeriaSat-X (she raps on the table). It is not in Abuja. I am bold to say it because if it is there, there is no way/We have written almost four letters, four/ (...)

(...). I said 'but you have *our* data. If you see very beautiful'. So when it comes to satellite data from Nigeria I and I am not sure anybody in the University of Lagos, any researcher, has gotten access to that. There is nothing. But if I/you ask me if I have seen the products. Beautiful products displayed in Johannesburg at AARSE conference. (Interview 81; 29.03.2016)

Instead of finding the data on her desk in Lagos, it was in Johannesburg, where she found it in glossy brochures.<sup>78</sup> Her colleague in Ile-Ife recalls the contrasting experiences with data from NigeriaSat-1, which could be directly obtained from Abuja with as little as a student ID and an institutional letter (Interview 1, 13.10.2015). Researchers' emphatic statements about Nigeria's missing remote sensing data do not only concern their own research. My dialogue partner at the department of surveying and geoinformatics in Lagos makes an emotional plea on behalf of her student, who needed high resolution data for her project on population census (identify types of settlement) and had already done relevant fieldwork:

She came crying here in my office, in tears. We have finally used SPOT, but that was not the current one. We had to look for archival data, looking for people that have worked in that area. (...) [but] up till today I have not seen one product [of the promised satellite data] (raps on the table). And I am in research. I knew the director. I knew almost everybody there. My seniors are in that office, but nobody has come out to tell us 'this is the situation on ground'. How do you access what you don't have. (Interview 81; 29.03.2016)

The unclear 'situation on ground' in relation to Nigeria's satellites constructs an ambiguous data experience in Southwest Nigeria. Researchers at Nigeria's Federal School of Surveying and colleagues at the department of remote sensing and GIS at FUTA, summarise

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<sup>78</sup> I was likewise able to talk to the representative of SSTL, but do not have consent to use the data.

one of the major debates, when they emphasise that staff at federal institutions hardly have access to *federal* data, which some have referred to as ‘our’ and ‘Nigerian’ data:

You need to go through a lot of bureaucracy and it is even expensive. (Focus Group 9, 07.03.2016)

If my country should have a satellite that is acquiring images of the Earth on a regular basis and a federal institution like FUTA cannot have access to that kind of a data, so what is the essence? (Interview 32, 18.01.2016)

The problem we have with NASRDA is that, yes they have taken Nigeria to the space community. (...) But I was expecting that they should give universities, research institutes access to those data. (Interview 33, 18.01.2016)

The ambiguity of this situation becomes further visible, when one of these researchers considers misuse of the data, such as for commercial purposes, as one potential reason for NASRDA’s stricter data policies. Notwithstanding this ambiguity, NigeriaSat-X data has in few cases been made available, such as at FUTA and the University of Lagos (Interview 33, 18.01.2016; Interview 77, 24.03.2016). Furthermore, one retired professor, who now runs his own consulting company, joins the debate and expresses some hope:

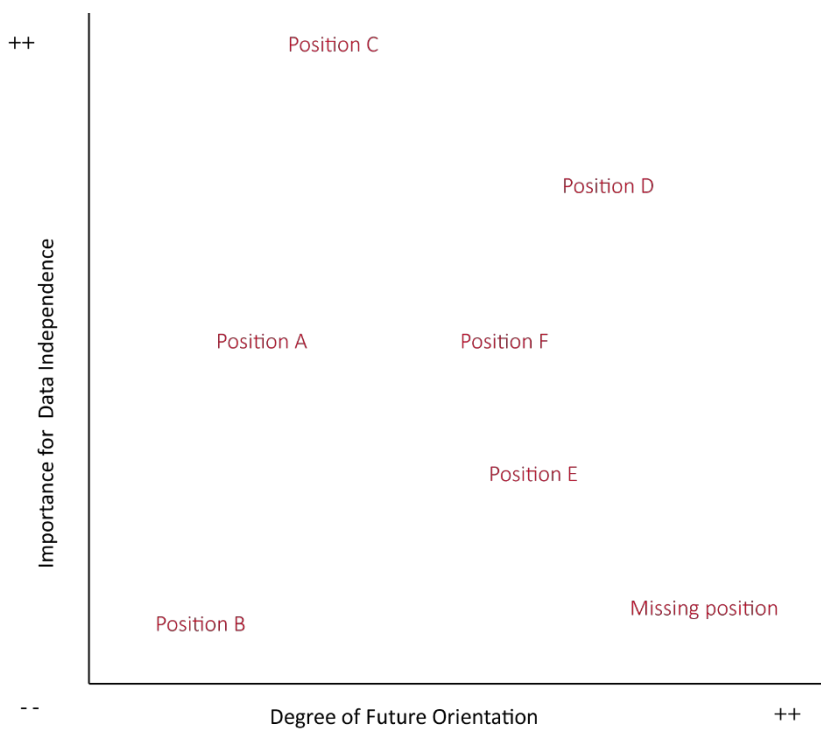
Whether we got in by design or by error, I think it is a good thing that we have gotten in. I do not know how much it cost. Now, but eventually some knowledgeable people started working in NASRDA and they started thinking why don’t we do a 2.5 resolution, that is NigeriaSat-2 and NigeriaSat-X, and these to me are good developments. (Interview 65, 29.02.2016)

The collective ambiguous position towards Nigeria’s satellites is eventually constructed through various individual positions that range from frustration and scepticism to hope (see Figure 20). Giving up hope indeed is no option for some researchers. I asked the geographer Uluocha why he decided to mention Nigeria’s satellites in his latest text book (2015, 207) on research methods in geography and environmental science. Answering my question, he describes Nigeria’s satellites as symbols of progress that many people would not be aware of (Interview 93, 20.04.2016). Like most of his colleagues, who initially express their continuous trust in Nigeria’s satellites, he later confides that this largely originates from the positive experience with NigeriaSat-1 as access to Nigeria’s remote sensing data now depended on laborious negotiations with NASRDA:

I think they need to look at that aspect because the more accessible it is, the more people use it and the more people are aware of it also. (Interview 93, 20.04.2016)

Whilst also two staff at ARCSSTE-E refer to Nigeria’s satellites, and highlight that Nigeria’s first EO satellite sparked hopes in Nigeria’s progress and regional lead in space

technologies, with some success in ‘forest mapping, land use mapping’ and in the disaster monitoring constellation, one of them states that Nigeria’s satellites have not ‘really been used to the optimum’, emphasising the ambiguity around *Nigeria’s* data. Furthermore, he joins some of his colleagues in arguing that neither the public, nor most academics on campus are aware that Nigeria has ‘satellites in orbit’, which shall support societal benefits (Interview 2, 15.10.2015, Interview 18, 11.11.2015). One of my senior dialogue partners in geoinformatics summarises the trajectory from hopes to disenchantment, when he argues that the Nigerian government is ‘trying’ with their satellites (Interview 17, 10.11.2015).



**Figure 20** Positional map on Nigeria’s EO satellites; by author based on Clarke (2005).

Positions amongst researchers in GIScience in Southwest Nigeria on what Nigeria’s federal EO programme means in terms of data independence (early positions) and the actual experience-based assessed future orientation. Based on research by author and Clarke’s positional map (2005).

**Position A**

Most common: once NigeriaSat-I data was distributed, hopes for better access to data developed. However, based on their actual data experience at federal institutions and lack of visible impact, researchers largely consider Nigeria’s EO programme premature.

**Position B**

Only indicated: some researchers have not mentioned Nigeria’s satellites at all.

### Position C

Largely senior researchers: clear hopes/mandate for data independence but disenchanted by institutional politics.

### Position D

Only few researchers: strong hopes for data independence developed during NigeriaSat-I evaluation with support for the national EO programme. Despite acknowledging recent difficulties in accessing data, they are still largely supportive.

### Position E

Only few researchers: leaving grounds for establishment of national EO programme undecided, but generally hopeful regarding NigeriaSat-2 and NigeriaSat-X.

### Position F

Rare: experiencing easy access to data at any time.

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### *The base has been lost – the premature upstream focus*

The disenchantment and ambiguity in relation to Nigeria's satellites also finds expression in the words of Professor Adeniyi from the University of Lagos, who had established AARSE. His following observations of work at the space agency's remote sensing centre in Jos, which he had helped to establish, can be further contrasted with the more positive indirect experiences of one of his younger colleagues:

I was the chairman of the establishment of the remote sensing centre in Jos. But :: the output of some of these efforts, they have not seemed to have justified : justified the reason why we moved into it. (Interview 94, 20.04.2016)

Though Adeniyi confirms positive developments in using remote sensing and GIS for administrative purposes in Nigeria's capital Abuja, he argues that compared to other countries, the use of geospatial information was lacking impact in Nigeria. By referring to the state of basic data, he further constructs a collective ambiguous experience with federal data and related loss of capacity. Topographic maps have not been updated for decades but are needed for most work in GIS (Soneye et al. 2013):

In the 70s and 80s we see maps, topographical maps, different maps, but today it is very hard to even get those things. And those are at the base. (...). I mean they [students] still do part of their study in cartography and map reading. Which map are they using. If you ask them, you will be surprised, that map of 1970, you are giving it to somebody to interpret (laughs) (...). (Interview 94, 20.04.2016)

In this ambiguous situation, many researchers discern disputable priorities by Nigeria's space agency. As the agency is perceived as not directly contributing to the development of satellite technologies, they are expected to at least invest in 'downstream' capabilities:

But you may say 'okay if we do not have people contributing to that, why don't we have people capable of downstream aspect of it, of utilising the products. (Interview 94, 20.04.2016)

One of ARCSSTE-E's former employees relates this discussion to criticism from abroad and argues that Nigeria first needs to show impact before investing its resources in ever-new space-borne technologies. Planned missions, such as a Radar satellite, were even further detached from Nigeria's ground-based downstream capability, as he warns:

If people, critics from abroad now, could (say to) Nigeria why do you have to spend so much launching a Radar satellite, then sometimes they may be just right, because the one that you have launched so far, you have not really been able to show to the world that this is what you have done with it. (Interview 22, 27.11.2015)

His senior colleague in geoinformatics at OAU likewise appreciates criticism from abroad, when he states that Nigeria's EO satellites have yet to prove that they are more than white elephants in space by showing measurable impact:

To so many people they will be believing that Nigeria wasted the money. Why because there is no data to show whether it has positive impact or not. We have NigeriaSat-2 now. We also have to be thinking of the impact. (Interview 17, 10.11.2015)

He and some of his colleagues emphasise the need for impact assessment as they find one positive application of federal geospatial projects in the thoroughly assessed Abuja GIS (AGIS) (by the current director of RECTAS)<sup>79</sup> (Interview 17, 10.11.2015).

### **Losing momentum – institutional boundary work**

Overall, the need to 'work around' data requirements has not been overcome by launching Nigeria's satellites. *Nigerian* data does hardly exist in most researchers' experience. If at all, its acquisition largely depends on senior researchers. This situation is partially explained through two gridlocked controversies.

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<sup>79</sup> Abuja GIS (AGIS) has been assessed 'as an e-government policy initiative', where 'e-land administration services' have been expected to reduce corruption (Akingbade et al. 2012).

## OSGOF/NASRDA

One controversy relates to the custody of geospatial information in Nigeria. In this case, NASRDA is in 'conflict' with the Office of the Surveyor General of the Federation (OSGOF), which some researchers and policymakers deem in charge of 'spatial data standards' (Interview 22, 27.11.2015). One former Surveyor General of the Federation even closes the controversy by describing the chapter of a relevant spatial data infrastructure (SDI) as 'history':

One word that the spatial data infrastructure is history. It started from Officer Surveyor General and at a point/(...) They moved it to national planning and for national planning NASRDA took over. (...) (They) were able to come up with a policy but that policy was never approved by Federal Government. And I think over time/because this policy was ready in 2002/all of us were participants. And over time, the momentum that NASRDA had, the (...), they were no longer pushing it. (Interview 84, 31.03.2016)

The notion of losing 'momentum' in the context of institutional disputes reflects a general feeling that researchers have expressed in explaining their situation. The base, such as in terms of data policies, has been set, but is eventually lost to long-term controversies over responsibilities. With this situation in mind, one researcher in ecology would not be willing to defend Nigeria's space programme from allegations:

I knew South Africa went into it for socioeconomic development and they are really using it a lot, but for Nigeria I am not so sure (...). (Interview 22, 27.11.2015)

### *Surveyors/geographers*

At first sight, this dispute is also reflected in what appears as boundary work (O'Mahony 2013) between Nigeria's geographers and surveyors, where some members of each group claim authority with regard to spatial data. Surveyors, for example, have occasionally been portrayed as having delayed the appreciation of space-based geospatial information in Nigeria. In the early days most surveyors had considered data from EO satellites as too coarse, as Adeniyi recalls (Interview 94, 20.04.2016). Looking at debates over accuracy and the prestige of surveyors in Nigeria, one geographer in Ibadan still discerns a misunderstanding amongst policymakers regarding what geospatial data comprises. He argues that decision makers need to...

...realise that geospatial is more than surveying (...). So many people feel that/when you talk of georeferenced data/geospatial data, you are talking about the profession of surveying and you tend to see surveyors that do not have enough knowledge (...). (Interview 58, 24.02.2016)



He points out the missing mutual sensitivity for different demands in terms of ‘precision’ and considers related ‘conflicts of interest’ as a major reason for disputes over Nigeria’s geospatial data infrastructure (Interview 58, 24.02.2016). Adeniyi, who also is the ‘chairman of the presidential technical committee on land reform’ considers this ‘conflict of interests’ gridlocked. He explains that his committee had decided to use high resolution satellite data and aerial photographs for the rapid demarcation of parcels of land. The implementation of this work has now stalled for two years due to this conflict:

The surveyors felt that ‘no we cannot do that’. You still have to carry theodolite and foot beacons and so on (...) but [in this case] every parcel of land is covered and is as seen as on high resolution satellite data. (Interview 94, 20.04.2016)

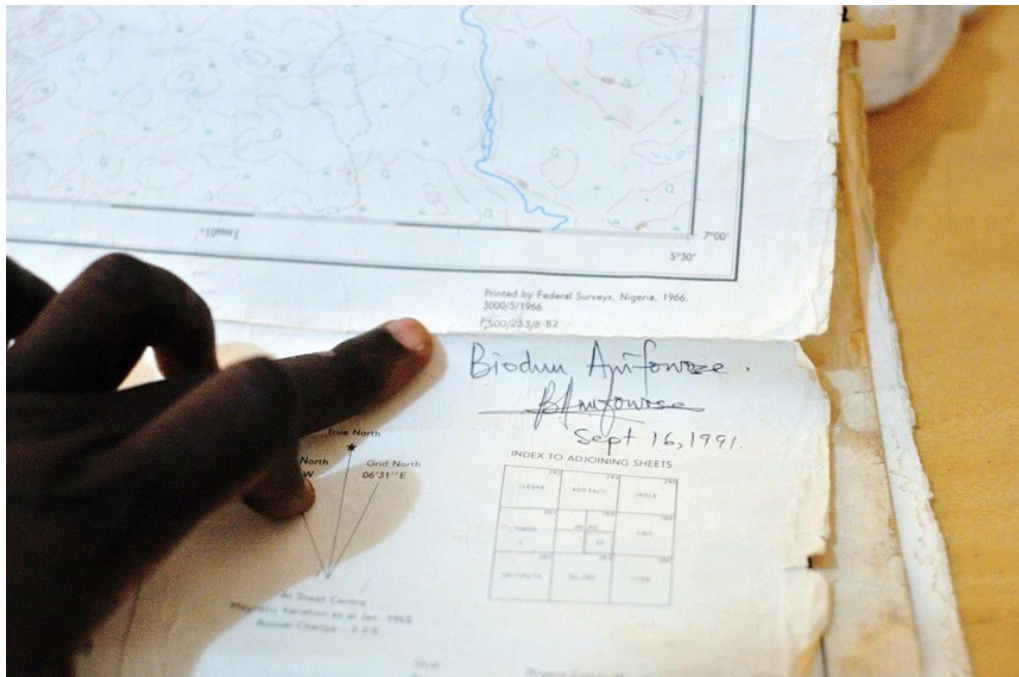
Overall, direct experiences with data custody, that researchers find inexplicable, reinforce doubts about the future of organised data custody in Nigeria:

We were (in a state) as a committee. (...) Now we say [to the local surveyor general] ‘where is the map for this local government’ and he answered: ‘look I am from this local government, we don’t have a map covering the area’ (laughs). (Interview 94, 20.04.2016)

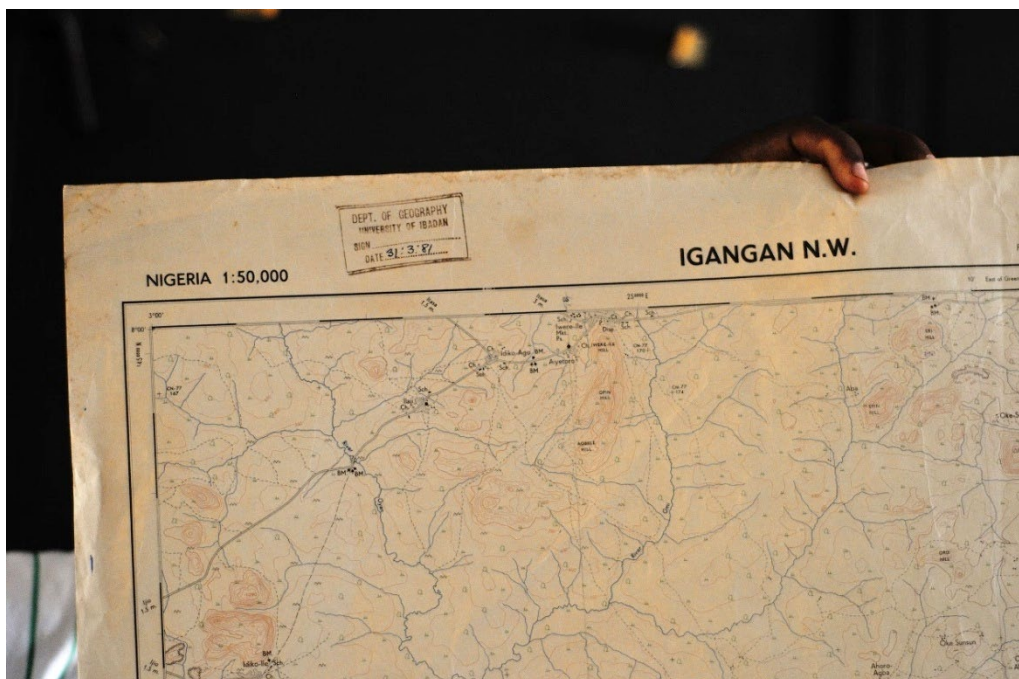
The lack of a coherent data base became a visual experience to me. Commercial satellite data and topographic maps primarily appeared as relics from a more glorious past (as perceived by researchers) that I often came across by chance. These comprised discarded analogue Landsat data from an era in which Landsat images had to be purchased like most high-resolution data nowadays. One of the discarded Landsat images states that it is ‘a confidential trade secret’ that may only be used by the ‘purchaser’ (Figure 23). Furthermore, researchers did not only refer to a lost base of up-to-date topographic base maps, but actually showed me departmental maps from the late 1960s that up to today are appreciated as the most beautiful cartographic work (Figure 22 & Figure 21). The topographic map (1:50,000) of the Igangan area (1967) also includes the following note (Figure 22):

Users noting corrections or additions to this map are requested to annotate and send it to the Director of Federal Surveys, Lagos, Nigeria. The map will be replaced.

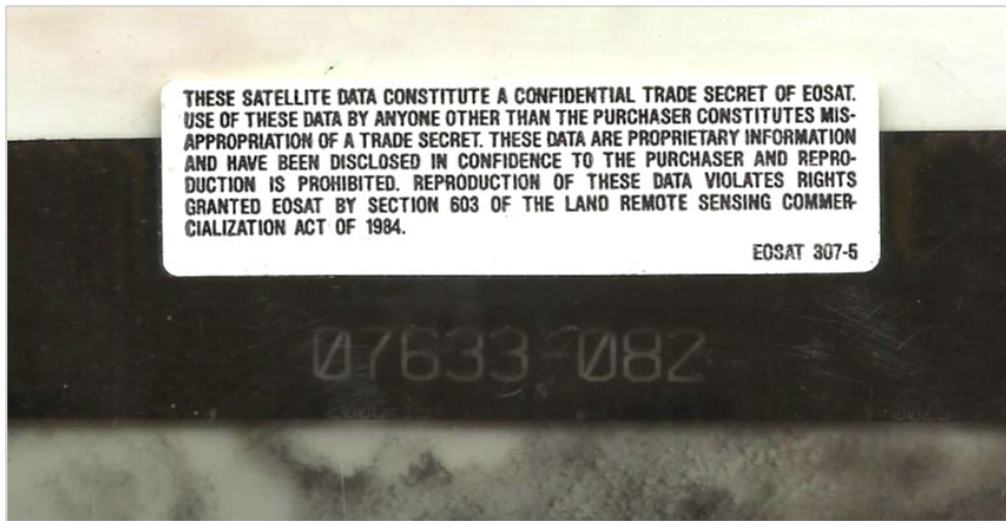
Despite the existence of OSGOF and now Nigeria’s space programme, this replacement has hardly taken place since the 1970s (Soneye et al. 2013, Ogedegbe 2014). At the same time, the related dispute over data custody is no direct explanation for the lack of up-to-date maps (see chapter seven). The absence rather indicates wider policy-related issues that will be addressed in the next section.



**Figure 21** Topographic map by Federal Survey Nigeria (printed in 1966), archived at Department of Remote Sensing and GIS, FUTA, Akure (Thorpe 2016).



**Figure 22** Topographic map by Federal Survey Nigeria (printed in 1967) and acquired in 1981 by the Department of Geography at the University of Ibadan (Thorpe 2016).



**Figure 23** EOSAT's terms of use (1984) on discarded analogue Landsat image at Department of Geography, University of Lagos (scan by author of thesis 2016).

### Appropriate society versus appropriate technology – no space for top down space age

In a country like Nigeria honestly speaking looking into the future can be very, very challenging. Because everything is in a state of flux. You see, the society goes through a lot of social turbulence honestly speaking. (Interview 32, 18.01.2016)

Whilst Nigeria's satellites do not play a major role in everyday research, they are nevertheless present in the form of political, economic, spatial and temporal elements that are part of a discursive construction of a missing political future-orientation. The situation that comprises all elements from data to power supply is considered imbued with *politics*. This section will hence look at debates and discourses that researchers use to make sense of their own situation in which experiences of spatial and temporal incompleteness have become entrenched. These eventually support many of the policy positions towards capacity development that will be presented in the next chapter. Researchers describe how their situation has developed over time. Wider structural issues had made them 'users' at a larger scale. Some researchers see this process reflected in the practices of companies from abroad that would often not see any serious basis for collaborative research in Nigeria, even where their concern is Nigeria:

They never contact local researchers. We cannot blame them, because local researchers, have no access to facilities to do meaningful research. As you are here now, we are going to be like this for throughout the week. No light. (Focus Group 10, 04.04.2016)

*Missing encouragement – ‘low expectations’ towards technological development*

Researchers have often expressed their user role in conjunction with their low confidence in the implementation and development of technologies in Nigeria, beginning with their experience of maintenance. My own observations are not consistent in this respect. In line with studies on appropriation, I observed how decommissioned technologies from Europe are maintained and work despite their heavy mechanical load (Bellucci et al. 2012). My dialogue partners, however, show less optimism based on their personal research situation. One senior academic at the department of remote sensing and GIS at FUTA, for example, expresses disillusionment about the hardly existent development of small-scale technologies for training purposes despite available human capacity:

For example, no department of geoscience or geospatial technology in Nigeria can be seen to be fabricating some little equipment, which will have been things like spectrometers, spectroradiometers. It is expected that since we know what these equipments and we know how expensive they are if they are to be bought from outside, nothing prevents our departments, electrical/electronics, remote sensing and GIS department as well as the department of physics to come together to be able to fabricate such little technology equipment that can be used in training. (Interview 30, 13.01.2016)

His colleague (ecology) in Ile-Ife sees one reason for Nigeria’s and other African countries’ passive attitude towards technological development and science (as perceived by him), in the missing encouragement (Interview 22, 27.11.2015), which staff at the Department of Surveying and Geoinformatics in Lagos see manifested in their immediate situation:

There is no light. We do not have facilities (one of the group members mentions that it is not a problem of manpower). We have got manpower. (Focus Group 10, 04.04.2016)

Adeniyi is not only disillusioned by decades of unsuccessful development assistance but sees potential for successful leapfrogging if Nigeria finally concentrates on the *real* capacity building needs ‘to move forward’ (Interview 94, 20.04.2016). Overall, most researchers see a major obstacle for any encouragement to ‘advance in technology’<sup>80</sup> in entrenched political and societal structures, that prompt most citizens to survive in the first place (Interview 33, 18.01.2016).

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<sup>80</sup> I treat technologies and productivity as described by my dialogue partners. I acknowledge that *technology* is more broadly defined (see chapters three, seven and eight).

### *Geospatial 'afterthoughts' in Nigeria*

Researchers' distrust towards Nigeria's awareness of their technological capacity building needs, is not only grounded in their daily experience with GIScience, but also with their research products. Researchers experience various symptoms that indicate a lacking appreciation of GIScience and its products in policy making. One lecturer at RECTAS, for example, argues that countries outside sub-Saharan Africa usually hold the prime knowledge of *Africa's* resources, and hence an advanced position in negotiations on investments in African countries:

I do not have an updated map of the forest and I did not use remote sensing and GIS to estimate what I have in that land. But someone in Europe or America has already made all those investigations and got all those information and has a more or less approximate value of what it is, or how much it can cost. And (we) negotiate (laughs). (Interview 24, 07.12.2015)

One scientific officer from Ile-Ife likewise draws pessimistic conclusions regarding the impact that remote sensing and GIS can have in Nigeria, when relevant topographic base maps are missing at federal institutions all over Nigeria:

I'm talking to you now, we don't even have annual maps, biannual or even once in five years maps that tell us how many of our (vegetation) resources are depleted. We don't have comprehensive soil maps. The last topographic maps we have are the once that we captured in the 60s, in the 50s, 60s and 70s. (Interview 26, 16.12.2015)

The link between outdated topographic maps and missing institutional appreciation of geospatial information, after 'remarkable growth' in the collection of spatial data and production of maps between Nigeria's independence and the 1970s, has also been discussed in local literature (Soneye et al. 2013). In this context, Adeniyi directly points at the elephant in the room. He reiterates that NASRDA had lost track of downstream developments and doubts that all local governments are aware of Nigeria's remote sensing centre in Jos:

In other words, the institutions that were set up to propagate the beneficial deployment of remote sensing and GIS, they are not doing so. (Interview 94, 20.04.2016)

Overall, most researchers argue that spatial data is a continuous 'afterthought' in Nigeria's political arena with serious social and economic consequences:

I do not know whether you have been able to go into inside the cities to see the : greatest disorder that anybody can imagine (me: disorder?). Disorder, spatial disorder that you can see. There are buidlings that cannot be reached by (vehicle), guardians because it is

an *afterthought* (...)/using remote sensing and GIS could have assisted them in the planning. (Interview 94, 20.04.2016)

You are still using 1960 data to make policies in 2015. (Interview 26, 16.12.2015)

Researchers in particular express concerns over deficient environmental impact assessments (EIA). For example, during the 2016 conference of the Association of Nigerian Geographers (ANG), I had the chance to visit the controversial artificial peninsula *Eko Atlantic City* in Lagos (Figure 24 & Figure 25). Many GIScience researchers see various problems with this anthropogenic change to Nigeria's coastal geography, such as coastal erosion. They doubt that any proper EIA with geospatial data has been conducted (Interview 81, 29.03.2016). In conversations and interviews, researchers often highlighted the, to their mind, alarmingly low appreciation of geospatial information in Nigeria's political environment by illustrating potential everyday situations, such as of a Nigerian soldier that is sent...

...to a place and is using a map of 1972. He goes there and asks them what is the name of this place. (...) Maybe there was one coconut there and they called the place coconut street, now the coconut is no longer there and now you notice there is a mango. The people are now/the generation that is present now knows it as a mango bus stop. And the man says, but is a coconut that is here [on the map]. (Interview 26, 16.12.2015)

In this context, one lecturer at RECTAS describes any GIScience-related proposals that are presented to policymakers, such as a 'local government chairman', as a fight (Interview 28, 06.01.2016). At the same time, the amount of policy-related GIScience research at institutions in Southwest Nigeria covers various environmental cases (including BSc level) (see Table 8 in appendix).

### *Systemic failures*

The GIScience situation as it has been described so far, is further perceived as being the result of larger political and social rifts that corrode any stable basis for promoting GIScience. The situation is appraised through debates on 'systemic problems' in Nigeria. These are grounded in collective perceptions of how other countries work and, according to my observations often in conflicting ways relate to discourses on African communitarianism, individualism and liberalism.<sup>81</sup> Some researchers, for example, see wider societal issues partially reflected in the GIScience situation and criticise a missing willingness in sharing data amongst some of their peers and departments. However, this must not be generalised

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<sup>81</sup> See for example Metz (2015) and Aborisade (2015).

as will be discussed in chapter seven. One is tempted to describe such practices as individualistic, whilst many other practices that I have observed in and outside the GIScience situation rather reflect communitarianism. This underlines the importance of a micro-level perspective on practices in a *society* that is often a priori related to essentialised concepts of common cultural values, if not knowledge systems (chapters three and four). Having considered GIScience inductively in relation to experiences, encounters and practices, one may postulate that researchers have not only constructed their own social worlds,<sup>82</sup> but have both collective and individual views on their natural environments and society, and hence data to explain their own GIScience situation (Clarke et al. 2015, 174, Abu-Lughod 1991). For example, one researcher not only explains how satellite images have helped him to see differences in the unplanned urban structure of Ibadan but argues that ‘the traditionalists’ prevent any structural change that ‘modern people’ (authorities) aimed at implementing. He even describes such issues of governance as a ‘cultural problem’:

If the traditionalists say ‘no, we do not want that. We do not want this to be changed because this is how our grand-, grandfather left it with us and we have been using it this way. (...). We want to conserve our culture. There is nothing you can do if you are an authority. It is a pity. There is a cultural problem then. (Interview 48, 06.02.2016)

In line with this confrontation between two groups, one of my senior dialogue partners describes group-related ‘politics’ as one reason for his personal disenchantment with capacity development at one governmental institution, where at some point people with their ‘own vision’ came in:

I also was posted out of the place and the position was filled again with other (tribes) or whatever. This is politics (laughs). (Interview 43, 27.01.2016)

His experience with governmental bodies is shared by other senior GIScientists, whose disenchanted accounts about institutions remind of a ‘patrimonial political culture’, which Omeje describes as ‘entrenched values, norms and networks of inherited traditional patterns of politics (...), which reflect the outward features of institutionalized administrative states, while operating along patron client-networks and trajectories rooted in historical patterns of authority and social solidarity’ (2006, 3). This can lead to a situation in which researchers do not often feel ‘backed’ by the bodies that the government has set up. Adeniyi perceives this situation as eroding the federal system with consequences at various

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<sup>82</sup> This will be further elaborated in chapter seven.

levels, such as for the land use act. Most power was with the governor, whilst supporting bodies that should assist ‘in managing the land’ become phantom structures:

He [Adeniyi quotes a scholar] said planning in Nigeria is like going through the bush in the night without a torch light and it is still the same thing today, honestly. (Interview 94, 20.04.2016) <sup>83</sup>

#### *A ‘derailed’ nation*

The perceived systemic failure is also constructed through the experience of *lost* or abandoned elements. Researchers all over Southwest Nigeria showed me instruments that were acquired during the 1960s, 70s and 80s. These comprise stereoplotters, hydrological instruments and other equipment that are still stored in laboratories. Some of the instruments, such as stereoplotters that have not been used since the 1990s, appear as if researchers had just recently abandoned them during work. All these elements, including many learning materials and commercial data (such as aerial photographs), belong to an era before Nigeria had eventually ‘derailed’ over conflicts of ‘ethnic supremacy’, as one young lecturer argues (Interview 33, 18.01.2016). Here, senior researchers look back to



**Figure 24** Visitor Centre, Eko Atlantic City, Lagos (Thorpe 2016).

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<sup>83</sup> At this juncture it is important to mention that my dialogue partners have acknowledged that their image of the ‘rest of the world’ might be overly positive, and that Western societies are not free from nepotism. They nevertheless see fundamental differences. (Interview 22, 27.11.2015)





**Figure 25** Eko Atlantic City, seawall and Bight of Benin (Atlantic Ocean), Lagos (Thorpe 2016).

the 1970s as the most glorious decade, when also their capacity was most appreciated (Figures 21-23 and Figures 55-64 in the appendix):

And we had government at that time in the early 70s, wanting to see the results of what you were doing. I was gradually doing land use mapping and so on and they were waiting for it. 'Peter, where is the product of that study you are doing?' (Interview 94, 20.04.2016)

The notion of a 'derailed' country is shared by both senior and younger researchers. It has occasionally been discussed in relation to a decline of values during 'twenty-eight years' of military rule, which had destroyed or weakened institutions (though this already includes the 1970s and can indeed not be generalised) (Adejugbe 2002). This in turn had set the ground for an entrenched vicious circle of 'corruption' that had eroded innovation and business (Interview 94, 20.04.2016).

#### *Explanatory note*

I am not only deeply grateful for the trust that my dialogue partners have placed in my research project, but this implies that I do not accuse any of my dialogue partners of having kept quiet about their opinion on the colonial past. Notwithstanding the serious

implications of the colonial era, in interviews and conversations, it has, if at all, only been mentioned to frame post-independence developments that affect a researcher's capacity in relation to a contemporary world. This world has then often been considered from an unemotional economic perspective:

You know, the world is so competitive, and those people are benefiting from our underdevelopment. They are not likely to be our best friends in terms to getting us out. You see like what Abraham Lincoln said: 'there is a limit to which you can help others to do for you what you should do for yourself'. (Interview 94, 20.04.2016)

## Conclusion

These are just my own personal observations. (...). So, it is a very good opportunity for me to tell you my own view. Now, I am not blaming anybody in particular because it is a system, it is a system. (Interview 22, 27.11.2015)

Researchers who aim at addressing the *disorder* in their environment (chapter five) by means of remote sensing data, eventually see their envisaged agency, as related to their actual knowledge-based GIScience capacity, challenged by being entrenched in both the causes and effects of this disorder. Here, the GIScience situation is further constructed in relation to a locale, based on collective experiences of *working around* data needs and of *tailoring* research objectives (such as on urban morphology) with those few elements that are available. Researchers are aware of material resources (from data to stable power supply) that could support their objectives outside their local situation. They learn about these resources through digital experiences (internet), periods abroad, reports from colleagues and eventually also feedback from the wider arena to which *tailored* objectives often seem narrow. Here, one geographer adds that in disaster-related GIScience, studies such as on road accidents in Nigeria, might in the wider arena be considered peripheral in the first place. This would overlook that Nigerian researchers not only look at large-scale phenomena, but 'are still trying to cope with basic, fundamental issues' that represent '[their] environment', as he further reminds (Interview 75, 21.03.2016). These are issues that often support their interest in GIScience in the first place (chapter five).

A geographically locatable loss of time in relation to practices of tailoring and working around, is further experienced through elements that affect the wider society and precede any capacity towards available remote sensing data, equipment and software. The irregular presence of power supply is entrenched in everyday life to such an extent that this experience almost becomes a footnote in relation to GIScience, whilst tacitly

demanding a continuous preparation for failure to alleviate a loss of physical capacity. By further zooming out, this experience of *scarcity* is both further entrenched and partially explained through my dialogue partners' ambiguous experience with data from Nigeria's EO satellites. This experience is eventually accompanied by discourses and debates over a lost *institutional basis* for any meaningful technological capacity building in Nigeria and support of capacity in GIScience, including relevant societal appreciation.

Considering Mavhunga's (2017) concerns over the deficient portrayal of the African continent as a collective victim of technologies (though at a different level), practices of tailoring research objectives in relation to available datasets should indeed not be reduced to mere determinism, where any space for local knowledge seems suppressed (Dibua 2006). First of all, tailoring takes place in relation to a researcher's knowledge about the local environment and a detailed understanding of data needs (such as temporal, spectral and spatial resolution). In line with this, these practices should remind of experiences on ground that nevertheless support researchers' continuous engagement with GIScience (chapter five). Furthermore, this chapter has demonstrated that it would be deficient to prematurely understand the implementation of remote sensing and GIS as having failed. This would undermine the researchers' critical reflection about what appears as the construction of a geopolitically locatable GIScience community (social world) through its experienced and theoretical association with different places (Marcus 1995, 96). In line with this, the next chapter will discuss how, based on this situation, certain powerful policy positions and practices have developed in the context of capacity maintenance and capacity building in GIScience in Southwest Nigeria. In other words, whilst this chapter has described the researchers' attenuated agency in relation to their own research capacity, the next chapter will provide an extended perspective on their agency (Clarke et al. 2015).

# Chapter Seven

## Experiencing an International ‘Roundabout’ of Capacity Building & Taking *Appropriate* Action

It does not mean that if you are not launching satellites, you are not in the space programme. You are already in the space programme once you use a space product. (Interview 22, 27.11.2015)

The last two chapters have discussed how remote sensing technologies have become integrated into the lives of researchers in Earth science disciplines in Southwest Nigeria. Their appreciation of remote sensing and GIS is based on individual and collective experiences with developments at the intersection of Nigeria’s natural and social environments. These developments eventually and paradoxically diminish a researcher’s agency towards EO satellites as related to their actual GIScience capacity. Whilst researchers have articulated this local situation in relation to relevant elements from a wider GIScience arena, this understanding is yet incomplete.

This chapter will provide an extended perspective on collective agency in GIScience in Southwest Nigeria. It will first look at how researchers understand capacity building and maintain capacity in their situation. Specific relations to the global GIScience arena, that comprise material and personal relationships in and between different places, will play a key role in this respect. These relations support a collective understanding of what the GIScience situation in Southwest Nigeria can look like in the foreseeable future in terms of capacity building, which will be discussed in the second part of this chapter. Overall, structural issues that in chapter six are described as impeding the implementation of GIScience technologies and practices, will be considered from a different perspective. This discussion shall reveal a yet unheeded agency towards capacity building in GIScience in Southwest Nigeria that has much more to do with careful preparation than mere integration of technologies and knowledge.

### Going, Staying and Returning

As discussed in chapter five, the origins of GIScience in Southwest Nigeria are largely grounded in the abroad training of a few researchers, who upon returning to Nigeria have promoted the transfer of remote sensing and GIS. When one emeritus geographer from

Ibadan explains the development of his early research interest, he emphasises that this largely has its origins outside Nigeria – in the wider world:

I wrote my PhD in 1974. That is a long time ago and by which time geography was in a transition stage and much of what interested me was not/did not originate from this country but from my interactions with people in the wider geography world. (Interview 65, 29.02.2016)

Instead of unidirectional knowledge transfer, he emphasises interactions that take place within a wider arena of geography. As chapter five has indicated, UN-initiated regional centres like RECTAS have not played a direct role in integrating GIScience within Earth sciences in Nigeria. This section will discuss why *interactions* in the wider arena also play a more important role for researchers' current understandings of capacity building in GIScience, and why regional capacity building institutions nevertheless play a significant role for a researcher's underlying positionality in this arena.

#### *Capacity building – a definition*

First of all, the concept capacity building needs some attention. Already in 1995 Cohen expresses his concerns over an almost diluted term, which has been used to describe all those strategies by different entities that shall support development. One of Cohen's concerns is that own definitions are suggested without much attention to the 'definitional and historical meaning' of capacity building. The context in which the term is now used ranges from 'professional education' to development aid and a 'national development culture'. Cohen hence suggests to give the term at least 'greater conceptual clarity' to improve the realisation of 'capacity building programmes' (1995, 408-409).

A historical and established definition of capacity building, that Cohen considers useful (here for the public sector), focusses on how capabilities, efficiency and competencies of individual people, such as 'chief administrative officers' and 'department and agency heads', can be strengthened regarding the drafting, management, implementation and evaluation of any strategies and programmes that aim at improving 'social conditions' in societal entities like communities (Shafritz 1986, 79 in Cohen 1995, 409). In the case of GIScience, this can be translated into strengthening a researcher's capabilities and efficiency towards their utilisation of remote sensing data for societal issues (from planning to evaluation).

At this stage it seems important to briefly recall chapter four. Such capacity building only became a focus from the 1980s onwards, when mere technical assistance (TA) in its

developmental context of unidirectionally transferring ‘knowledge or techniques’ to developing countries was considered a deficient approach (Morgan 2002, 1; 10). At the same time, TA often has been looked at through a ‘simplistic’ dichotomy of ‘pass’ and ‘fail’, where such ‘analysis obscures more than it reveals’, as Morgan argues (2002, 4). Morgan reminds that ‘systemic and societal dysfunctions’ are circumstances that from the outset limit any impact of TA (Morgan 2002, 4). This remark in relation to TA also reflects the problematic macro-comparative dichotomy of optimism and pessimism towards EO in developing countries. Looking at concerns over capacity in the micro and macro context of GIScience, as it has been discussed so far, we should neither simply apply a ‘pass’/‘fail’ lens to understand capacity building in Southwest Nigeria. This is of particular relevance regarding the African continent, where capacity building has been under critical observation for a long time:

(...) [G]rowing attention is being focused on capacity building in Africa. Given the magnitude of funding for projects on that continent and the implementation problems plaguing those investments, aid agencies are demanding increased attention be given to the problem of ensuring that professionals and managers in government institutions be increased and made more effective. (Cohen 1995, 410)

To avoid an analysis in the context of determinist developmental narratives, the following sections take a second look at agency by focussing on interactions between researchers as well as small incremental developments. This means to further pay attention to a critical issue that many international development organisations have not been able to develop – ‘the capacity to build capacity’ (Morgan 2002, 10, 20). In line with this, this section will set the basis for understanding GIScience-related capacity building activities in Southwest Nigeria (second section) by discussing how capacity is currently maintained and how capacity building is understood in relation to the wider arena.

## The promised arena

We just manage based on individual efforts to get going but then we know what the situation is in the Western world, *where people take this thing for granted*. (Focus Group 10, 04.04.2016)

The last two chapters have described a situation in which a researcher’s own visions of methodological liberation by means of remote sensing and GIS are not only constructed but likewise diminished – where the natural environment is perceived as interacting with socioeconomic forces in a largely unregulated way. In this situation, most researchers, in the first place, work towards maintaining their capacity. Researchers, who have entered

the wider GIScience arena play a significant role for this understanding. Going abroad eventually means to appreciate that one has left behind *scarcity*, as one emeritus professor in Ibadan indicates:

Because you meet people. I went two/three/four times like that [to Iowa]. It is like you are leaving the little you can get here to develop yourself, capacity building. (Interview 65, 29.02.2016)

RECTAS and ARCSSTE-E are two major UN-affiliated regional capacity building institutions in GIScience that are both located on the premises of OAU (Ile-Ife), and hence in close vicinity to Earth science departments (see chapter two). In addition to returning researchers – and most often in combination – they not only likewise play an important role for a collective experience of *what is taken for granted* in the wider arena but facilitate access to the latter.

#### *RECTAS and ARCSSTE-E – gateways to a wider GIScience arena*

During my stay in Ile-Ife, I lived in a guest house that belongs to RECTAS, whilst ARCSSTE-E was in walking distance of OAU's Earth science departments. Despite their vicinity and some collaboration, the arenas in which university departments and the two regional institutions operate are *prima facie* different, as ARCSSTE-E's former director Akinyede indicates:

The UN provided the curricula for [ARCSSTE-E], for all the established centres, that will run the same curricula, remote sensing and GIS, satellite communication, satellite meteorology and global climate and basic space science. (Interview 43, 27.01.2016)

Those who work or study at these regional centres describe the special character of these institutions in relation to the wider arena, which one of ARCSSTE-E's former employees describes as 'kind of an international framework'. He recalls his encounters with students from different parts of English-speaking Africa and his visits to sister centres in Morocco and India, where he acquired different additional insights about GIScience (Interview 22, 27.11.2015).

For much longer, RECTAS has been playing a role in 'exposing' researchers to a wider regional and global GIScience arena since 1972 (Ogunlami 1993). It is not by chance that most of the 'pioneers' of GIScience in Nigeria (chapter five), have at some point been 'either directly or indirectly' affiliated with RECTAS, as one researcher emphasises. Relations between different Earth-science institutions across Southwest Nigeria and both

centres often concern the training of staff and students as well as research collaboration, such as with the nearby department of geography (OAU):

Between the 90s and present time RECTAS has really given an aid to this university. (...) If I can say more than sixty percent of them got their technology from RECTAS. (Interview 26, 16.12.2015)

One staff from Nigeria's space agency, who in his own words already enjoyed a new level of 'exposure' to GIScience at ARCSSTE-E, nevertheless plans to proceed to RECTAS for their additional capacity (Interview 76, 21.03.2016). Many researchers have described RECTAS as a repository ('deposit') of knowledge and materials, where students and staff from different African countries connect GIScience to a wider regional arena:

It was like I have gotten to where the deposit is. (...) Then we had two classes, one is anglophone, one is francophone. (...) Now, that RECTAS motivated me. I had resources in the library and I was given a computer. (Interview 26, 16.12.2015)

My own accommodation at RECTAS was close to their halls of residence as well as offices and laboratories. I experienced an atmosphere that was different from the main campus (OAU). Francophone students and staff from Mali, Senegal and Benin, who experience the regional arena by physically moving within it, often told me about their travels between Ile-Ife and their families in other West African countries. Students usually emphasised the temporary character of their stay in Nigeria and shared their observations about Yoruba food and the local climate. Furthermore, whenever I entered the premises of RECTAS after a day on the central campus, I at least had the feeling of entering a different place, with more agency to act in a regional and global arena of GIScience. Every evening I passed a public notice stating: 'RECTAS is a United Nations Economic Commission for Africa institution with diplomatic immunities and privileges (...) Entrants must receive Management's authorization'; signed by the Ministry of Foreign Affairs. A few meters further down the road, eight flags that represent the member states fly at full mast (Figure 26).

### *ITC – the unexpected destination*

The salient status of RECTAS as a repository of knowledge, equipment and connections, however, becomes more visible by further looking at the core of their capacity development. Most of my dialogue partners at some point referred to the role that the



International Institute for Geo-Information Science and Earth Observation (ITC)<sup>84</sup> plays at the centre. The centre's repository largely builds on a long-term partnership with this institution in the Netherlands. ITC had already helped to establish RECTAS during the 1970s (Disco 2010, 113, Ogunlami 1993, 9), and ITC's materials continue to play an important role at RECTAS, as researchers emphasise:

I had opportunity [to explore], I had books, I have so many manuals, mostly from ITC, mostly from ITC. Those manuals were wonderful. They [RECTAS] had manuals that will teach you how to georeference, manuals that will help you to classify or digitise the data, manuals that (are on) videos, that help you to scan or teach how to scan. (Interview 26, 16.12.2015)

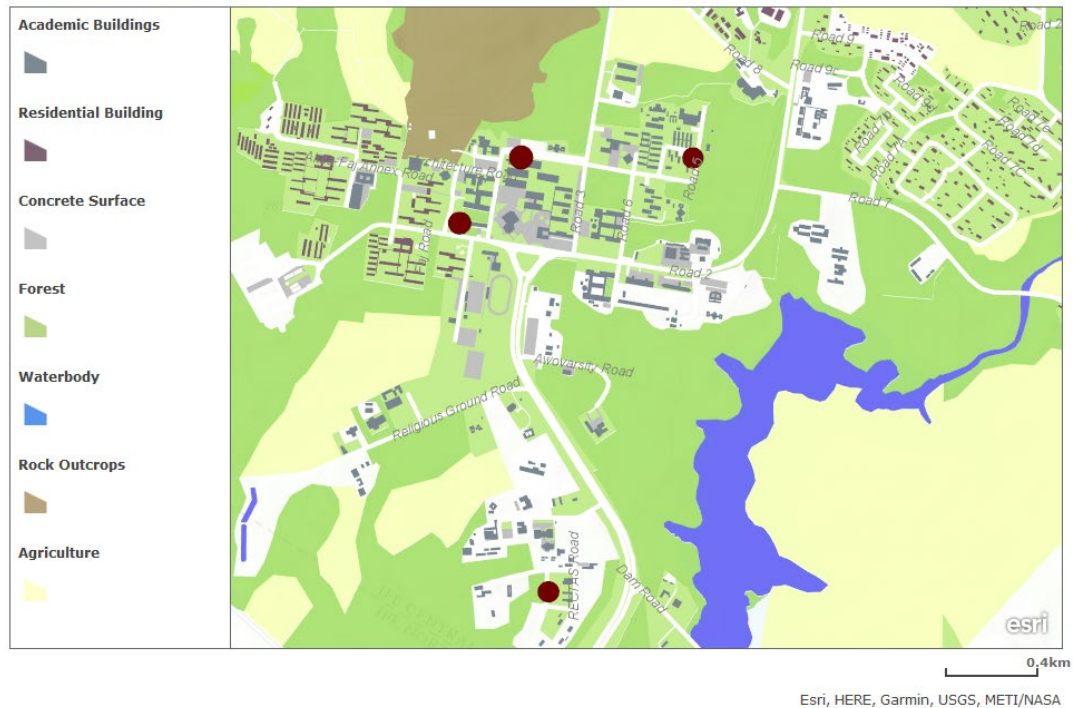


**Figure 26** Entrance gate of RECTAS (Thorpe 2016).

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<sup>84</sup> ITC has become a faculty of the University of Twente in 2010 (Disco 2010).

**Sites of Research at OAU**



**Figure 27** Sites of research at OAU; produced with ArcGIS Online map hosted by Esri (by author of thesis 2018). Based on web map by *oagis* (2015) (no use restrictions).

RECTAS is located in the south, the main campus in the north.

Another researcher recalls how, upon arriving at RECTAS, he was unexpectedly confronted with the option of entering a wider global arena of GIScience, provided that his performance in Nigeria meets the requirements for a master's programme in geoinformatics at ITC in the Netherlands:

We were two that were shortlisted. A guy from Ghana and myself. So, we now proceeded to ITC. (Interview 33, 18.01.2016)

Joint courses that lead to an ITC degree were established under ITC's Joint Education Partners (JEP) policy in 2002 that intends to foster capacity building at ITC's partner organisations in developing countries and ease access to its programmes in the Netherlands (Disco 2010, 119-120). This relationship does not only constitute a direct connection to the wider arena of GIScience, but the next sub-section will discuss why many GIScience researchers in Southwest Nigeria consider ITC as a destination of its own, that has become crucial for their understanding of what capacity building means in their situation – where RECTAS is not the only mediator.

## Encountering the 'agora'

In 1993, the then-director of RECTAS called for additional support from international donors and asked other UNECA member states to become members (Ogunlami 1993, 9-14). However, with currently only eight member states (RECTAS 2012, 2), staff at RECTAS point out their continuous dependence on international support. Notwithstanding their UN-affiliation, both regional centres are likewise embedded in a situation of diminished capacity. Here, the relation between RECTAS and ITC is more than a knowledge transfer partnership, but a lifeline. Looking at how ITC has accompanied RECTAS for a long time, one researcher expresses the feeling that ITC had been 'designed for Africa':

They (released) so many materials, resource materials, CDs and everything. In short, at a time, I felt that the school was designed for Africa. (...) they followed RECTAS all the way and were able to support our programme, knowing that it is not easy for students to be coming down there, because of only the flight ticket alone. (Interview 26, 16.12.2015)

He describes a relationship that at first sight reminds of a relationship between a donor and a dependent, where the latter is grateful for any incoming resources that allow to maintain capacity in teaching and researching, such as those that ITC has left over:

Sometimes they bring their notes, their leftover (...). Those books they could not use, they bring it here, and I tell you the truth. It became like the biblical case where the woman said even the crumbs that fell from the table actually will be necessary, actually will be necessary. (Interview 26, 16.12.2015)

Whilst the metaphorical 'crumbs' are appreciated, one staff at RECTAS emphasises the pressing need for more in-depth transfer of knowledge to further develop research and training capabilities. He joins his colleagues in arguing that any such capacity is largely based on being trained abroad. He went to ITC in 1999 and remembers this as a time of 'transition', when RECTAS eventually entered the digital age, leaving behind the analogue use of photogrammetry stereoplotters. At ITC he was able to acquire capacity to support this process:

I did GFM4 [geoinformation, production and management] at ITC with specialisation in digital cartography. I was well-trained in ITC. It is a wonderful place. One of the best training centres in the world of course. (Interview 48, 06.02.2016)

RECTAS largely maintains its status as a regional capacity building institution through staff that is trained abroad. This is all but taken for granted on their part as foreign sponsoring is usually required for such a training (Interview 28, 06.01.2016).<sup>85</sup>

#### *Becoming a knowledge broker at ITC*

In line with this, researchers from any of the GIScience institutions in Southwest Nigeria, who have been trained abroad, have learned to appreciate a role as *knowledge brokers*. This appreciation will be discussed by looking at what knowledge transfer for capacity building means in the case of ITC. Whilst the concept of a ‘knowledge broker’ is loosely defined, it shall in the following be understood as a ‘key player in any community of practice for they introduce elements of one practice into another’ and ‘build shared models of understanding, sites of social negotiation that can redress the problem of fragmentation of knowledge and information’ (Lingard et al. 2007, 503-506). This is how Lingard et al. look at knowledge brokering in an ‘interdisciplinary health research team’. In this case, the focus is on the translation, coordination and integration of ‘diverse perspectives’, where brokers often move in different social worlds (memberships) (2007, 501, 506). In other cases, brokers are described as translating knowledge between a science community and, for example, policymakers, with various potential ways of communication (Pielke 2007).

#### *ITC – GIScience for a developing world*

Akinyede, NASRDA’s former director of space applications (now CESRA), first learned about remote sensing in Nigeria. However, looking back at his career, he states that...

...everything emanated, started from after my training in ITC. I mean the knowledge. ITC has given the knowledge of the application of remote sensing and GIS in particular to any areas of human development, socioeconomic development. (Akinyede, 27.01.2016)

Akinyede is the embodiment of a unique relationship between ITC and Nigeria’s GIScience community. Not only have many researchers referred to Akinyede as their source of knowledge and inspiration, but in a special publication that celebrates the 60th anniversary of ITC, the Dutch institution emphasises that in 1986 Akinyede was the first-ever PhD

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<sup>85</sup> During a major capacity building initiative at the beginning of the new millennia, researchers at RECTAS also went to France, such as to the former *Groupeement pour le Développement de la Télédetection Aérospatiale* (Interview 48, 06.02.2016).

candidate at ITC (Disco 2010, 96-97). One of his colleagues at FUTA underlines the importance of having somebody, who has not only been to ITC, but has been the first *African* to have a PhD from ITC (Interview 30, 13.01.2016). The frequent reference to ITC in interviews and emphasis on the institution's relevance for capacity building, made me follow related experiences of researchers from Southwest Nigeria. I became a visiting researcher at ITC in September 2016. This stay broadened my understanding. ITC is not simply a *Western* institution that builds capacity in GIScience but has developed in relation to a developing world.

During ITC's first decade, the 1950s, their focus was on aerial surveys, where aerial photographs were used for the production of topographic maps (aerial photogrammetry) and for photo-interpretation to understand developments on ground. The Netherlands enjoyed much expertise in those practices, which inter alia had developed in the context of mapping their colonial territory, the Dutch East Indies (Republic of Indonesia). The first post-war prime minister of the Netherlands and founder of ITC, Willem Schermerhorn, has played a key role in building this capacity. Schermerhorn himself had a background in civil engineering, geodesy and surveying, and before the war had promoted 'appropriate technologies' for photogrammetry. This included a much 'simpler stereo-plotter'<sup>86</sup> for the relatively flat territory of the Netherlands, and in collaboration with his colleagues, the successful promotion of new techniques of aerial triangulation for the largely inaccessible terrain of Dutch New Guinea (Disco 2010, 15-20).

This capacity became relevant in the context of the Netherland's postcolonial and post-War development policies that together led to the establishment of ITC in 1950. With the founding of the United Nations in 1945 and their agenda of transferring knowledge and skills to developing countries to support world peace, many donor countries aimed at having more direct control in the 'neo-colonial' world order through technical assistance. After World War Two, the Netherlands had been a largely 'demoralized' country, as ITC emphasises (Disco 2010, 20-21). However, Schermerhorn, who moreover had just negotiated independence of the Dutch East Indies, discerned a new leading role for the Netherlands in the context of a UN (EcoSoc) resolution on mapping the developing world. The UN suggested to set up local cartographic services in developing countries and to train their staff abroad. Schermerhorn confirmed that the Netherlands would be able to host the training centre. The ITC (then the International Training Centre for

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<sup>86</sup> See relevant discussion in chapter three about terminology in developmental and innovation studies in relation to both Africa and industrialised countries.

Aerial Survey) was eventually established as ‘a foundation under Dutch law’ in 1950 (Disco 2010, 20-25).

Awareness of being a knowledge broker for GIScience in Southwest Nigeria is constructed in relation to subsequent relationships between ITC and their students and alumni from developing countries. When I went to ITC to learn more about this relationship, staff directly asked me whether I had met their alumni during my time in Nigeria. Similarly, one researcher at RECTAS recalls how he first learned about one of the directors of RECTAS during his stay at ITC:

‘Sir are you Dr. Kufoniyi?’ He said: ‘yes, why are you asking’. I said: ‘I went to ITC (...) I said that I came from Nigeria. So, some people asked me whether I know you. (Interview 48, 06.02.2016)

Alumni in return articulate the relevance of ITC for their capacity building in Nigeria. Akinyede reminds that he was only appointed as the director of space applications at NASRDA based on his knowledge from ITC, which allowed him to contribute to Nigeria’s space policy in relation to socioeconomic development:

Because having gone to ITC myself and I have trained, and I know the importance of remote sensing and GIS in applications in all various areas of socioeconomic development. (Akinyede, 27.01.2016)

Here, Akinyede and his colleagues, who went to ITC, express a particular awareness of their additional knowledge. They remember ITC as a ‘community of practice’, where the practice brought about a whole new perspective of what is possible in terms of remote sensing and GIS. One staff at RECTAS goes as far as speaking of a new level of *literacy* (Interview 28, 06.01.2016). This literacy is based on different experiences that have become part of a researcher’s socialisation as a knowledge broker, during which they have learned to ‘build shared models of understanding’ (Lingard et al. 2007, 503-506) in relation to the following two experiences.

#### *ITC – a global experience in an ‘African village’ in the Netherlands*

At ITC, researchers, in the words of one alumni, enter ‘a big roundabout where you meet plenty people, plenty nationalities’ (Interview 23, 03.12.2015). His colleague further recalls how he realised something special about this roundabout in relation to the African continent:

Then you call it an African village almost (laughs). It will amaze you, sometimes you look out and you will see a number of Africans tracking on the streets. You are

beginning to wonder whether you are in Lagere road in Ife (laughs). (Interview 28, 06.01.2016)

A central experience at ITC are the encounters with other students from different places on the African continent and the rest of the world (social worlds), who all bring in additional perspectives and research problems:

Because there you see the various possibilities of using/putting geoinformation to use (...). That to me was one of the first stepping stones to jumping into the GIS world because I was completely illiterate of those developments as of that time. So my stay in Holland has widened my understanding and the need for GIS applications. (Interview 28, 06.01.2016)

As part of their development as knowledge brokers, researchers gain additional application-related literacy with a wider understanding towards translating, coordinating and integrating different perspectives. This literacy is eventually grounded in the experience that people from various countries come together in one place as they are interested in learning more about the same technology and science for their socioeconomic development:

You see people that are from your place pursuing what you are pursuing. (...) Because you see Ugandans, you have Zambians, you have Ethiopians, you have Chinese people coming. It gives you a very broad sense of appreciation of the values that they place to data. (Interview 28, 06.01.2016)

During my stay at ITC, I soon realised how this awareness is constructed in a carefully planned place. ITC's annual international food festival that features delicacies from all over the world is only one of many related observations. One researcher at RECTAS describes how the collective aim of going to ITC is also based on the communication of such transnational experiences, making ITC 'the centre everybody wants to go to' to acquire knowledge. He affirms his colleague's appreciation that people from different countries are interested in the same technology, data and knowledge, that they work under one roof, and literally move together:

We were dancing Salsa. Some Dutch ladies, some Dutch ladies 'this guy can dance'. So, one of them just came and proposed to me to dance and then I danced right away. (Interview 48, 06.02.2016)<sup>87</sup>

This experience of ITC as an 'African village' that is immersed in an international 'round-about' does not come by chance. On their own admission, ITC is not simply an institution that has been set up in the context of technical assistance, but that against all odds has further developed their mandate of capacity building *for* a developing world (Disco 2010).

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<sup>87</sup> Alumni from other countries have emphasised similar experiences (Disco 2010, 86).

Despite many governmental and political changes in the Netherlands, that have eventually transformed ITC from an independent capacity building institution to a faculty of the University of Twente (UT), ITC still aims at ‘maintaining its traditional identity as mediator between “western” technologies and the practical needs of geoinformation organizations in less developed countries’ (Disco 2010, 118). One staff at ITC explains this identity as follows:

In our view if we want to solve the big societal problems of this time, it is something that is very difficult to achieve in an isolated manner in one country. (...) So, for us it is only natural to continue doing this. (Interview 97, 08.09.2016)

This position towards a developing world is exemplified through different practices at ITC, such as the following three:

1) During the first decade ITC immediately adapted to their international students by offering additional courses in mathematics and physics. ITC also built facilities that allowed them to take care of their students from various backgrounds, and bring them together under one roof, where they learn, work and live together – as already India’s Pandit Nehru admired during his visit in 1957 (Disco 2010, 15, 29-32). Unlike a non-place, that Augé (1995) had described as a locale, where global citizens predominately transit, ITC is as much a ‘roundabout’ as an intimate locale for those who are in the roundabout at the same time; where global aspects of food, climate, health and social norms are constantly negotiated as a group (Disco 2010, 86-89).

2) This is further epitomised in the official ITC mace. It is ‘carved from African ebony’ and has been presented to ITC in 2003 by the then director of RECTAS. When ITC formally became a faculty of the University of Twente in 2009, this mace was handed over in a ceremony (Disco 2010, 106; 118).

3) Whether symbolic or not, when this mace was handed over, a long process came to an end during which ITC had been quite reluctant to join the neighbouring University of Twente (UT), and hence formally the Dutch academic system (Disco 2010, 94-98, 115). They feared that their ‘identity as an institute for international development’ might become eroded if they liaised too closely with UT (Disco 2010, 32-34, 115). In their annual report of 2002, ITC still emphasised their incompatibility with the Netherlands’ academic system. Whereas ITC was interested in capacity building *for* developing countries, the ‘Dutch universities’ were rather interested in their own capacity building through



international students, as ITC argued. After different policy-related developments, ITC eventually agreed to become a faculty of UT by 2010 (Disco 2010, 94-98, 115-118).

*ITC – as a different community of practice*

For Nigerian researchers, another experience at ITC has been that of teaching. They point at a positive difference in the level of academic expertise and a lecturer's temporal and social engagement in communicating knowledge. This is complemented by practical exercises in the field, where students are trained in translating their problems and problem-solving approaches (Lingard et al. 2007):

They give themselves time to explain to you for you to understand. (...) And we worked together also. We have these what we call integrated projects, where you work with other people from other countries. You exchange ideas, you do many things. (Interview 48, 06.02.2016)

Both communication and exchange of knowledge constitute a decisive experience that researchers emphasise as part of their learning process in constructing common understandings. One embedded experience is that of having space for constructive debates without top-down judgements. Though one of my dialogue partners at RECTAS has not been to ITC himself, he has a clear vision of this and other places (such as conferences) in the wider arena. He compares them to the Greek *agora*:

You know you come to the agora and you express your mind and you talk and other people also will contribute. And that is where we have big thinkers, the debates. It was not in the purpose of destroying, it was constructive. (...) We call different people working in almost more or less the same area or the same idea, we meet. This is what I was doing, this is how I did and so on and so forth. (Interview 24, 07.12.2015)

Adeniyi made all these learning-related experiences at ITC as early as the 1970s. He describes them as emerging from a different 'system' with a 'close relationship between theory and practice' that had inspired his own capacity development initiatives in Nigeria (Adeniyi, 20.04.2016). Notwithstanding, that such practical exercises have over time been integrated in teaching of GIScience in Southwest Nigeria, ITC is continuously experienced as a different community of practice that can provide a more in-depth experience of what is possible in GIScience, based on a combination of practical experiences, encounters with people from different places and additional resources. Institutions like ITC are appreciated for eventually filling what one researcher describes as their daily 'vacuum' (chapter six):

The time in ITC is very very :: it was eventful. It was eventful in the sense that we have/we were taught many things and it was able to fill the vacuum for all the deficiencies in our curriculum here. (Interview 33, 18.01.2016)

### *ITC as the 'agora'*

Looking at their experience at ITC, researchers have described a new form of knowledge production, as compared to their experience with GIScience in Southwest Nigeria. At this stage I will further discuss the valuable reference to the *agora* that one of my dialogue partners has made. Nowotny and her colleagues provide a detailed description of this 'archaism' when they defend their suggested paradigm of a new form of knowledge production (Mode 2) as 'socially distributed, application-oriented, trans-disciplinary, and subject to multiple accountabilities' (2003, 179). Nowotny et al. state that the agora is the...

*...problem-generating and problem-solving environment* in which the contextualization of knowledge production takes place. It is populated not only by arrays of competing 'experts', and the organizations and institutions through which knowledge is generated and traded, but also by variously jostling 'publics'. (Nowotny et al. 2003, 192; my italics)

In the context of knowledge brokering between a GIScience arena in Southwest Nigeria and a wider arena, this agora for now should be broken down to various 'experts' (researchers) who come together as representatives of different institutions that are embedded in specific micro and macro-level issues (chapter six). Here, it indeed is...

...not simply a political or commercial arena in which research priorities are identified and funded, nor an arena in which research findings are disseminated, traded, and used. The *agora* is a domain of primary knowledge production – through which people enter the research process, and where 'Mode 2' knowledge is embodied in people and projects. (Nowotny et al. 2003, 192; italics in original)

When my dialogue partner appreciates the agora as a locatable arena of constructive knowledge production in relation to GIScience, ITC can be considered a continuously evolving embodiment of socially distributed, application-oriented and transdisciplinary knowledge production (Nowotny et al. 2003) that joins researchers from all over the world to negotiate various research problems in relation to GIScience and different disciplines:

It is not for us to decide what kind of knowledge people need. People who come to study here, they have a very strong say in the composition of their own academic programme. There are a number of choice options that people have and they make their own choices based on their own requirements and their own areas of interest. (Interview 97, 08.09.2016)

Modules shall ease the integration of disciplinary knowledge into remote sensing and GIS in the boundaries of ITC's standards and those of the Dutch academic system. Specialised knowledge can then become 'appropriate' by being a choice in relation to a research problem in different places across the globe, that is based on a shared understanding of remote sensing and GIS. It is hence anything but a simplified form of knowledge (in analogy to appropriate technology):

Societal problems are not so much in urban planning or in disaster management but problems are found in the area of overlap between those two. (...) [This flexibility] will enable people to do course modules in different departments but composing it in such a way that it is supporting the work that they need to do. One example that I can give is a group of students [from a climate and meteorology organisation] that we are working with at the moment. (...). Before they arrive, we have talked to their bosses and together with the students and their bosses, we have indentified research topics that they are going to work on. (...) [W]hat the people get out of their programme is *appropriate knowledge*, because it is exactly what they need. (Interview 97, 08.09.2016)

#### *The agora-based responsibility of knowledge brokering*

Researchers do not take this agora for granted. One researcher remembers the excitement of his late father, who reminded him that 'he had no opportunity to travel out' (Interview 28, 06.01.2016). Researchers, who have been to ITC and other GIScience institutions abroad, have described how they have learned to appreciate this form of capacity building. They have experienced a research and training process that involves collective and application-oriented production of knowledge.<sup>88</sup> The founder of the Space Applications and Environmental Science Laboratory (SPAEL) at OAU not only describes how his stay at ITC has led to an increased effectiveness in his research area but articulates a related responsibility to integrate such in Nigeria. Part of his awareness of having become a knowledge broker is then based on his skills of constructing shared understandings. He refers to a 'cross-fertilization of ideas' and recalls how, when he looked at deforestation by using NigeriaSat-1 and other satellites, he acquired additional knowledge through 'interaction' with researchers from ITC. This experience eventually allowed him to integrate the additional knowledge in his local situation and further cross-fertilise it:

I went there to discuss with them and then we look at the problems together and then we agree on the best strategies to use. How do we go about it. In terms of cross-fertilization of ideas. (...) That kind of exposure at ITC and interaction helped me in coming

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<sup>88</sup> This *agora-based* understanding of capacity building will be further elaborated in the remaining chapter. Related experiences are also made at other foreign institutions: 'But bulk of my experience and awareness actually come from my exposure to study in King's College, London. (...) The way they taught there actually changed my orientation' (Interview 3, 15.10.2015).

back to really (fine-tune) my own strategies in implementing the initiative. (Interview 53, 17.02.2016)

Integrating and further developing shared understandings from abroad means to again evaluate them in relation to local socio-environmental issues in Nigeria:

Someone did it in Israel or someone did it in Australia or did it in India. You try to model it in Nigeria or you try to model it in Senegal and you see how it will work and those people, that community will benefit from it. (Interview 24, 07.12.2015)

Experienced knowledge brokers, who are aware of their additional capabilities of translating, coordinating and integrating perspectives from different communities of practice (cognate social worlds in a global GIScience arena) (Lingard et al. 2007) aim at enabling as many researchers as possible to have a similar experience by sending them abroad or to regional centres that have direct links to the wider arena. Furthermore, a researcher's awareness of their additional GIScience literacy and skills of brokering such, often prompt them to life-long capacity development. Despite his retirement age, Akinyede currently serves as the director of CESRA at FUTA, where he has also facilitated the implementation of the Department of Remote Sensing and GIS (Akinyede, 27.01.2016). This role of a knowledge broker is promoted through mutual trust between agora-like environments and their alumni. ITC does not only emphasise their huge network of worldwide alumni that they have built in over 65 years (25.000 alumni), but also the trust that they have in their alumni regarding their utilisation of their additional capacity:

We know for a fact that [anonymised alumni from Kenya] is playing a very significant role in institutionalising the use of spatial information in policy and decision making. We see a net effect of what our alumni are doing and at the same time our alumni form a very valuable and important base that we can work with, both in academics and in government agencies, but also in the private sector. (Interview 97, 08.09.2016)

Instead of unidirectional knowledge transfer, ITC emphasises cooperation since the 1970s, and has continued developing a worldwide network through capacity building that now includes joint research and consulting (Disco 2010, 114-115). This hence also supports the researcher's role as a broker between Southwest Nigeria and the wider arena:

And the best intelligence that we get, that we use in the revision and the development of our own programmes, we get from our alumni, because they tell us what they need. (Interview 97, 08.09.2016)

*Second-generation brokers*

Many younger researchers appreciate that ITC has promoted *Africa's* capacity in GIScience through their alumni (knowledge brokers):

One thing I want to mention is that I still want to do some applause to ITC, what they have done for Africa, particularly the people they brought in, because some of them they are alumni here/at the end of the day became like the frontiers that you know helped. (Interview 26, 16.12.2015)

They appreciate individual senior researchers as their 'icons', 'pioneers', 'key figure of GIS in Nigeria', if not Africa, or indeed as their 'ITC products'. These knowledge brokers had 'developed locally and further got exposed internationally' and can hence open the eyes of those who have not yet been exposed, as the head of the department of remote sensing and GIS at FUTA states (Interview 30, 13.01.2016). At the same time, some younger researchers are aware of their own importance in this respect. They might themselves have been 'exposed' abroad or directly liaise with senior knowledge brokers. One young researcher at OAU's institute of ecology, who had worked for ARCSSTE-E, is one of these second-generation knowledge brokers, who combines his own experience abroad and his close relationship with first-generation brokers. He emphasises that he had the chance to work 'with some of the key scientists' in Nigeria's GIScience arena (Interview 22, 27.11.2015).<sup>89</sup> Young researchers do at the same time stress that in contrast to the agency of their pioneers, their role is primarily one of maintaining and directing capacity in a situation of perceived increasing disorder and diminishing resources (Interview 22, 27.11.2015). When younger knowledge brokers further aim at implementing the *agora*, they try to at least materialise experiences of sharing knowledge and materials, such as topographic maps from Denmark:

Those are materials I use to (...) to brandish, make brandish to my students, so that they know that I am not from village, but have come from Europe (laughs) with trainings on the use of geoinformation. (Interview 28, 06.01.2016)

In the context of a researcher's awareness of being a knowledge broker, *exposure* is a key term. It not only implies the duty of brokering the agora and embedded ways of producing problem-oriented knowledge, but it indeed is embodied (Nowotny et al. 2003, 192). This is expressed by both those who receive such capacity in Nigeria and those who broker it and are aware of their 'leverage':

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<sup>89</sup> This comprises joint publications.

When they said I am the brain box of the department, I cannot be a brain box. It is part of my *exposure*, my experience that has given me the leverage, the opportunity to serve. (...) Most of these popular scientists, popular scholars, international scholars, renowned scholars/I have met some of them. And the interaction will go a long way to encourage me to continue my research. (Interview 33, 18.01.2016)

The researcher's development as a knowledge broker is embedded in constant reflections of their experiences abroad against their experiences in Southwest Nigeria. Perhaps most important, however, is that researchers also contemplate on potentially naïve ideas of going to Europe, and by this further substantiate their own role as *returning* brokers of knowledge:

I also noticed that people deceive themselves by thinking that they can, they cannot solve their problems in Africa. They have to go to Europe. (...) Yes, because I saw some Africans there, suffering. (Interview 48, 06.02.2016)

### Returning as a knowledge broker

A researcher's awareness of being a knowledge broker, however, can only be fully understood by again looking at the daily research situation as it has been described in the last chapter. This section will discuss how researchers largely understand capacity development as an issue of individual relationships, which reinforces a knowledge broker's role.

#### *Left behind once back*

Returning to Southwest Nigeria for most researchers is an experience of being 'left behind'. *Abroad* also comprises other emerging economies, where researchers might have worked with useful technologies that they are not able to get hold of once they are back in Nigeria, such as high-resolution images that one of my dialogue partners had used at the Indian Institute of Remote Sensing. Furthermore, those technologies that eventually are acquired, can usually not be updated as this is not in the financial capacity of most institutions. Such experiences accumulate to the feeling that any capacity development in Nigeria constantly lags behind technological developments. Researchers who depend on those, who had been exposed abroad, but also knowledge brokers themselves, express a feeling of not being able to catch up with developments in the global GIScience arena:

We have many people with/that have gone to school to study GIS, remote sensing, but there is problem of training and retraining. Because these things they are evolving. It is an evolving technology. Every year, new versions of software, you know every year they are launching new satellites and with different specifications and characteristics. (Focus Group 9, 07.03.2016)

One lecturer at RECTAS describes how theoretical and practical knowledge that is acquired abroad cannot be sufficiently demonstrated, practised and integrated in Nigeria. The relevant experience of lagging behind in terms of technologies becomes further entrenched when researchers see how foreign actors come to Nigeria and work with technologies that they cannot afford, whilst relevant knowledge is in place in Nigeria:

You know those organisations, those institutions will easily be able to carry out that work even though the manpower exists locally. But it is the equipment that lacks. (Interview 24, 07.12.2015)

### *Institutional discontinuity*

Those researchers who work at the two regional centres usually consider this opportunity a privilege. However, this appreciation is largely related to their original capacity of linking researchers to international institutions. Most times, when I visited ARCSSTE-E (and Copine)<sup>90</sup> the building was usually cut off from power supply and the centre's small offices are often used by more than one person. However, staff always welcomed me in what one researcher describes as their 'crammed' place (Interview 9, 22.10.15). Whilst RECTAS has more space, limited equipment and power outages do likewise belong to their daily routine. Furthermore, during my stay the new director was working on re-establishing capacity building-related ties that have so far been described as stable. When researchers describe ITC as an agora that can be reached through RECTAS, they largely refer to the past as this direct partnership has ceased. Adeniyi directly refers to discontinuity at Nigeria's institutions (chapter six) that corroded any stable basis for capacity development in terms of knowledge brokering:

When [anonymised] was there it was doing very well, but I do not know what when the person who followed him/because they ran into problems. (...) What was his [the new director's] view on all of this? (Adeniyi, 20.04.2016)

At ITC staff have emphasised that the quality of training at partnership institutions must eventually live up to the Netherland's academic system, when joint degree programmes end with a Dutch degree. In other words, ITC cannot risk losing its accreditation and acknowledges that they had 'pulled the plug' of the joint MSc programme with Nigeria as

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<sup>90</sup> During my research stay, ARCSSTE-E and the Cooperative Information Network (COPINE) shared one building on the campus of OAU and some resources. COPINE is also known as the Advanced Space Technology Application Laboratory for Southwest Nigeria and likewise belongs to NASRDA under the Ministry of Science and Technology. Unlike ARCSSTE-E's focus on capacity building through teaching, COPINE focusses on GIScience research and immediate applications ('solutions'), such as in environmental management (Interview 26, 16.12.2015).

researchers struggled to keep pace<sup>91</sup> (Interviews 97, 100, 101, 09.2016, Interview 51, 08.02.2016). Despite these developments, researchers continue to apply with ITC, but in most cases soon feel the consequences of their weakened base for capacity building:

About two years ago I got admission for a short term programme in ITC Netherlands, but I couldn't get sponsorship, at least to just have upgraded my knowledge. (Interview 1, 13.10.2015)

Another researcher showed me his letter of admission that proves futile as he likewise lacks the financial means to fund his stay in the Netherlands. Whilst researchers do not look for any responsibilities outside their own situation, some feel that they are nevertheless unintentionally held responsible for what they actually wish to address – the disorder on ground. The only time researchers openly wonder about missing support from the wider arena is in the context of the United Nations. The UN had given some of the first impulses, but since then provides only reduced means for capacity building at the regional centres (Interview 8, 21.10.2015). However, change of leadership is considered one of the major uncertainties. One researcher recalls how he and colleagues had planned to use a foreign satellite as part of a desertification monitoring project and how the deal was scrapped once a new director came in:

We were not expecting them to fund us or to support us in any other way, but we want to use the satellite as a vehicle for our data. (...) That was the deal/that was always possible but (clicks his tongue) you know when leadership changed and then no funding in the centre. (Interview 15, 05.11.2015)

Considering this situation, researchers often feel 'at the mercy' of themselves when it comes to funding any materials that can support the training of students and hence the establishment of the agora (Interview 13, 29.10.2015).

*Institutions abroad can only point you in the right direction*

Despite the collective experience of falling back to a situation of scarcity after returning as a knowledge broker, researchers locate responsibilities for change in their situation. Institutions abroad are primarily considered as guiding lights that can set the basis for capacity development by facilitating knowledge brokering. Researchers understand their responsibility in unemotional global economic terms, where any knowledge and technology transfer is not blindly appreciated, as one researcher at ARCSSTE-E emphasises:

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<sup>91</sup> During my visit to ITC, ITC was reassessing the situation and considered signing a memorandum of understanding with RECTAS.



Do you really, really think that it is in the UK's interest for example for Nigeria to become a space-faring nation in the true sense of the word? (Interview 15, 05.11.2015)

Researchers emphasise their awareness that only few entities will reveal all their knowledge. This, however, must not be understood in the context of a corrosive modernisation paradigm in which any dependence of African countries is considered further entrenched through blue-sky promises of technology and knowledge transfer (Dibua 2006). In the GIScience situation neither technology transfer is called into question, nor any reluctance of foreign actors to reveal their (tacit) knowledge. Instead, they emphasise a self-evident need for (capacity) development in Nigeria that, for a start, could be based on the consumption of literature and occasional invitations of foreign experts (Interview 22, 27.11.2015).

*'People find reasons not to come to Nigeria'*

Inviting researchers from abroad does, however, likewise prove challenging. Researchers perceive that any transnational 'exchange of knowledge' has steadily declined over the last years. However, only a phone call from one of my dialogue partners finally indicated the severity of the situation. A couple of weeks before he called me, he emphasised the importance of staff exchange with developed countries and told me that his former host, a professor from Germany, is 'coming over to Nigeria' (Interview 33, 18.01.2016). A few weeks later, he did not hide his disappointment as his host was meanwhile reluctant to visit Nigeria. Knowing that I grew up in Germany, he asked me whether the professor could get in touch with me. Here, security concerns that are widely published in media, do cause many headaches for those who invite researchers from abroad. When I applied for insurance cover for my stay in Nigeria, the first response email stated that 'Nigeria is an extremely hazardous destination' (email 01.07.2015). Researchers in Nigeria do not blame people from abroad for not knowing that the security situation in Southwest Nigeria is different from the Northeast of Nigeria:

If you are not interested you would not travel down here. You have the fear of this Boko Haram, you will not know that Boko Haram is not, is not operating in the Southwest. That fear may be there (...). (Interview 39, 25.01.2016)

Those foreign researchers, who eventually come to Nigeria, might nevertheless soon pack their bags for other reasons, as one emeritus geographer in Ibadan indicates by remembering his past experience with two guests:

The time like he (anonymised) came for two weeks, there was no water, there was no electricity. They were to work to me for one month, they left after two weeks. He told me this story later on. He said one day he woke up and called (anonymised colleague), saying: 'Mike, what the hell are we doing in this place'. (...) I got their tickets rewritten and they left. So many/that job that looked impossible, the three of us wrote a minimum of three papers. Gerry would talk about myself. If anybody who works in that type of condition, that I worked, that he saw and survive, he must be a genius (both laugh). I say 'I am not a genius. I am only very determined'. (Interview 65, 29.02.2016)

The relevance of this situation in which foreign scientists do prima facie not see any basis for their work is substantiated when being 'determined' becomes a collective stance of returning knowledge brokers, based on their understanding of having acquired capacity and hence responsibility for the development of their country.

### **Maintaining capacity by scouting**

Younger knowledge brokers work on developing an independent network of relations within Southwest Nigeria and with the wider arena to maintain their personal and institutional capacity. Existing relationships with contacts from abroad, such as former supervisors, can constitute an important foundation in this respect as they can facilitate grant applications and conference participation (Interview 3, 15.10.2015). Cultivating such relationships involves much effort, as one researcher at ARCSSTE-E indicates when he recalls his temporary contact with a librarian from the International Space University (ISU) in France (Strasbourg), where he had studied:

Then she will use the linkage between the International Space University library, you know they have foreign partners, and she will get the paper for me and send it to me. But after some time I lost the link with her. (Interview 9, 22.10.2015)

This network does not only comprise actors from abroad but senior knowledge brokers, peers and the own family in Nigeria, where capacity is transferred in various forms of moral, financial, material, spiritual and knowledge-related support.<sup>92</sup>

#### *Scouting for data, knowledge and equipment – working for routine*

Furthermore, maintaining capacity means to work for a research routine by actively 'scouting' established personal networks for relevant elements. The verb *scouting* has been

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<sup>92</sup> The clear majority of my dialogue partners regard faith/spirituality as a major source of strength.

used by one of my dialogue partners and beautifully describes what working for a daily research routine means in physical and intellectual terms.

#### *Data – a personal investment*

When I ran into one of OAU's geographers one afternoon, he seemed in a rush and told me that he was 'scouting' for important data by going to different institutions on campus. He later tells me that in his case scouting means to 'run from pillar to post' without any guarantee that he will find adequate high-resolution images for his research on urban green infrastructure, but emphasises that 'beggars do not have choice':

You have to scout/that is the word/you have to run from pillar to post, begging people if they have ever come across such data. You know if you were to be in US or UK, you can just log into USGS and you have all these archived data and you could download, high resolution, superb for your work. Things like that are not just available over here. If I could show you the satellite image that I got eventually from people that you have worked with/your personal effort. (Interview 75, 21.03.2016)

Researchers illustrate how most remote sensing data becomes their personal investment by physically scouting for it. This often involves considerable financial contributions. One researcher at the department of remote sensing and GIS at FUTA remembers how he bought Ikonos data in Nairobi, where he went for further training. Whilst looking for the receipt of 164000 Naira (320 GBP as of April 2018), he tells me that he was only able to travel to Nairobi after he had sold his car (Interview 39, 25.01.2016). Data-related scouting does often take place abroad, when researchers discern specific windows of opportunity after having covered travel-related expenses. One lecturer in surveying and geoinformatics takes her hard drive along whenever she travels outside Nigeria to not only backup available data but to make use of the stable internet:

The moment I get myself out to the UK (laughs) or to Kuwait and I connect myself to the internet, I download all my files, whatever I need from the internet. That is what I do when I am out of the country. (Interview 81, 29.03.2016)

These personal investments do eventually also benefit other researchers. They appreciate those colleagues that have invested resources in scouting and are willing to share their acquired data:

You get them [data] by asking people around. They tell you that 'okay I have this data, you can have those data'. (Interview 56, 23.02.2016)

There are people that are really working hard, people that are opportune to have foreign partnerships and they can source the data from there. (Interview 9, 22.10.2015)

### *Careful scouting*

Researchers advise students that in a situation like theirs, they do not only need to think twice about their data needs but must appreciate that there are institutions that provide medium resolution data for free (USGS, Landsat). This can hence reduce scouting to a few mouse clicks (Interview 58, 24.02.2016). At the same time, hardly any researcher has referred to existing grants from commercial data providers, such as Digital Globe (2018). In case they have heard of such, the complexity of applying for data, often is an additional burden in their research situation, where any data acquisition is already contingent on the opportunity of downloading:

We have been hearing of minimal grants from (...) some of these commercial data companies/that they give out something to students for their research. I have not had that opportunity but accessing those things used to be very, very complex. Especially in a situation whereby the technology and highspeed internet is not available. (Interview 32, 18.01.2016)

### *Google Earth*

Google Earth has become an unexpected target in scouting for remote sensing data. Researchers acknowledge that they cannot process data from Google Earth like raw or processed data from original providers but argue that they have to learn how they can nevertheless extract a few visible features from such secondary data before becoming idle, such as during the planning stage of their research (Interview 24, 07.12.2015, Interview 58, 24.02.2016). Using alternative sources like Google Earth means to carefully think of the actual level of accuracy that is needed for certain applications in a situation, where much data is not available:

You can still do, bring something of value from something that is not so of good quality or/it depends on you. (Not until) you have so much money or very big grants or launch a satellite of 13 Billion. (Interview 22, 27.11.2015)

### *Software*

Scouting for software can again become a time-consuming activity. Without licensed software, researchers are soon restricted in publishing their results and will invest much time in finding licensed software (Interview 26, 16.12.2015), such as by asking around whether anybody has acquired a license and is willing to share it (Interview 60, 24.02.2016).<sup>93</sup>

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<sup>93</sup> Some universities have partnerships with Esri that provides at least a temporary license of ArcGIS.

Whilst some researchers scout for trial versions, this strategy has many drawbacks, such as limited functionality, and eventually involves an additional investment of time:

Do you know what will happen after 30 days? It will stop working. Then sometimes we reformat our system and download another trial version. (Interview 26, 16.12.2015)

### *Power & Internet*

Any appreciation of access to resources via the internet, such as online tutorials (e-Learning), is only of value if a power-dependent stable internet connection is available, as several researchers emphasise. However, as the erratic nature of power supply is entrenched in everyday life, it is one of the elements that is most difficult to control in terms of a capacity maintenance. Scouting in the context of power supply and internet access are directly linked to the private realm. This can again mean to ‘run from pillar to post’ to find a power source:

Since Monday I be having to carry these heavy bag around campus looking for where I could find electricity to work. I went to a friend’s office down down (!) the campus road yesterday to be able to find power, to power my laptop to be able to work. (Interview 9, 22.10.15)

In the case of power supply, personal and departmental investments, such as in generators, support other researchers. In addition to electricity, almost all researchers invest in their own internet connection by using their mobile phones for tethering. Where such investments are not feasible, scouting for internet access again means to move around or to literally and figuratively wait for windows of opportunity. The same researcher, who successfully found power in the office of one of his friends, demonstrates how he also found a particular spot near the window of his own office that allows him to make use of the university’s erratic WLAN signal:

And so, if I’m gonna use interent now, I will have to open my laptop and place it on the window (he demonstrates it), so I can receive signal. If I put it here, the signals will be very weak. (Interview, 22.10.15)

Beyond knowing where internet can be found, researchers do also know the best time for accessing it. This scouting practice is embodied in an additional unexpected technology. A *mattress* has become an important technology in the GIScience situation. It can support a researcher’s ability to do a ‘serious job’ at night, when the internet connectivity is most stable:

But [the internet] is always fast at night. If you see, maybe you don't notice the mattress in my office. You see the mattress (laughs). I use to sleep at night any time I come to office. (Interview 1, 13.10.2015)

### *Knowledge*

Researchers do constantly scout for additional resources to maintain and promote their capacity. Literature, for example, is acquired from a wide range of foreign institutions, but largely those that have played a role in training knowledge brokers. Most important for any access to knowledge-related resources again is the internet, where researchers also look for webcasts that can support their capacity (Interview 15, 05.11.2015). However, considering that a stable internet connection is a precondition, webcasts eventually expose the complexity of *scouting* for capacity. Researchers need to scout for various elements at the same time.

### *Scouting – one personal effort benefiting many*

Overall, *scouting* describes a process in which researchers make their own provisions by looking for functioning resources. Personal investments, which includes the communication of resources, also benefit others in the situation. Scouting has become part of a collective solution towards maintaining capacity. It is a process that GIScience researchers in Southwest Nigeria have internalised based on their awareness of a wider situation that allows for more stable provisions:

In Nigeria we prepare for eventualities. You know when I travelled for AARSE conference in South Africa last year, I never sighted any generating plants [generators]. (...) But here, you, you might have, let electricity go off, you'll be hearing noise [of generators] (imitates noise). (Interview 1, 13.10.2015)

Furthermore, scouting is neither limited to above-mentioned elements, nor to the core GIScience situation. Laptops for example might be borrowed from family members and like all other scouted resources are then used with utmost care (Interview 9, 22.10.15).

## **The heterotopia next door**

As so far discussed, the arena of GIScience in Southwest Nigeria is constructed through experiences with Nigeria's natural and social environments, material provisions in GIScience (as a means to understand the latter) and related practices of maintaining and building capacity through knowledge brokering and scouting. The production of knowledge is

carried along individual biographies that have been informed in different places, where a place like ITC in the Netherlands might be better known in Nigeria than in the Netherlands, as researchers from Nigeria and ITC joke alike. Agora-like places become part of the essence of the GIScience arena in Southwest Nigeria – an arena that is distinct in terms of capacity, yet un-sited in its constitution (Cook et al. 2009). This becomes clearer if we take a look at a *heterotopia* that I have encountered during my stay in Nigeria. Heterotopia is a concept that has been coined by Foucault. Upon reflecting on ‘utopias’ as ‘unreal spaces’, Foucault also contemplates on...

...places that do exist and that are formed in the very founding of society — which are something like counter-sites, a kind of effectively enacted utopia in which the real sites, all the other real sites that can be found within the *culture*, are simultaneously represented, contested, and inverted. Places of this kind are outside of all places, even though it may be possible to indicate their location in reality. *Because these places are absolutely different from all the sites that they reflect and speak about*, I shall call them, by way of contrast to utopias, heterotopias. (Foucault [1967] 1986, 24; my emphasis)

If we treat *culture* as the GIScience arena in Southwest Nigeria, then I have indeed entered a heterotopia on the 1<sup>st</sup> of March 2016. Four of six principles that according to Foucault can constitute a heterotopia, are of particular relevance in further understanding the constitution of this arena and the fundamental role of knowledge brokers and their experience-based understanding of capacity building in this respect.

According to Foucault, a heterotopia can be a ‘single real place’ where ‘several spaces, several sites that are in themselves incompatible’, are juxtaposed, such as a sacred Persian garden that ‘was supposed to bring together inside its rectangle four parts representing the four parts of the world’ (Foucault [1967] 1986, 25). Another principle relates to a break with ‘traditional time’, such as in a museum. The fifth principle speaks about the ‘opening and closing’ mechanisms of a heterotopia, which in the first instance is not ‘freely accessible like a public place’. Finally, the sixth principle relates to a heterotopia’s function in relation to remaining spaces. It can be a space of illusion ‘[o]r, else, on the contrary, their role is to create a space that is other, another real space, as perfect, as meticulous, as well arranged as ours is messy, ill constructed, and jumbled’ – a ‘compensation’ like colonies, as Foucault suggests (ibid., 26-27). At a much smaller scale, I have perhaps entered an international heterotopia in a ‘jumbled’ fraction of a postcolonial world. The situation that researchers envisage for their GIScience arena in Southwest Nigeria seems realised in a Nigerian city that many researchers have described as out of developmental control (see chapter five).

After five months of fieldwork, researchers at the University of Ibadan had advised me to visit an international institution in their neighbourhood. On our way to this institution my host and I first left the campus of UI, which already reflects an order that stands in contrast to the urban environment. The scenery along the road was dominated by a sea of fragmented roofs until I spotted a group of trees behind a wall. We had arrived at IITA, the International Institute of Tropical Agriculture, where one of my dialogue partners from OAU had started his 'GIS career':

Maybe you also wish to visit their lab (...). I actually started my GIS career in IITA. I was serving the GIS lab. That is where I was interested. The place is like (...), you have people from all over the world, scientists from all over the world of different countries working there. (Interview 22, 27.11.2015)

I soon began to understand the 'difference' that he further pointed out. Before we entered the premises of IITA, we had to register. Once we had passed the gate, I spotted a wide alley, well-maintained green areas and functionalist buildings. Upon entering one of those buildings, I not only felt the refreshing air from an extensive AC system but glanced into sterile laboratories. I had certainly not entered a film set designed by Ken Adam but was about to experience a place where GIScientists and other scientists look at pressing agricultural issues that lie outside their patrolled walls. Expats, who I never met outside, work and live together with scientists from African countries. It is a place where Nigeria and other tropical countries become an ordered microcosm that can be analysed by all those means that most GIScientists in Southwest Nigeria lack, including fresh air. Visiting the GIS laboratory at IITA, where an alarm signals the end of the work day, became an eye-opening experience: The utopia of one group coexists with the heterotopia of another group (Figure 28 & Figure 29).

One Nigerian scientist, who is part of this heterotopia since 1993 shares the GIS laboratory in the 'geospatial and remote sensing unit' with five colleagues from different countries. He explains that IITA is part of the bigger consultative group for International Agricultural Research (CGIAR), where IITA focusses on agriculture on the African continent in consultation with international donors. The work in the GIS laboratory includes the monitoring and modelling of diseases and natural resources to pursue IITA's mandate in food security, and in many ways indeed appears as an inversion of the local GIScience arena:

1) Primary data: The GIScience unit is a research and support unit for other units at IITA. Another unit, for example, comprises economists, who go to the field to collect



socioeconomic data or other data (such as soil samples), which my dialogue partner at IITA later integrates in a GIS-based analysis:

There are soil people who collect data on soil. There are people on all kinds of disciplines that bring data to us and we say ‘okay we want to see, let us do analysis’.  
(Interview 67, 01.03.2016)

The collection of primary data, such as on cassava, is separated from the work in the GIS laboratory. This stands in contrast to researchers outside, who usually collect such data on their own – where related challenges can even support any substantial interest in remote sensing data in the first place (see chapter five):

[Our scientists] went to cassava farms and they were able to monitor the incidence, the severity/I mean the incidence of these diseases on the cassava and then they came with the georeferenced information of incidence level, high, low, whatever, and then we were able to map. (Interview 67, 01.03.2016)

2) Remote sensing data: Not only access to Landsat data is more straightforward at IITA, but also high-resolution data is considered reasonably cheap:

In fact, we have a server that we have an archive for Landsat for the 1980 epoch and then the 2000 epoch, that is for the entire Africa (laughs). (...) But the commercially available ones, they are also becoming more, more available nowadays. (...) It is Quickbird for example. If you get maybe 5 months old satellite image, you just/less than 10 Dollar per km<sup>2</sup>. (Interview 67, 01.03.2016)

I asked my dialogue partner at IITA whether researchers from outside can have access to this commercial high-resolution data. He not only acknowledges that such provision is limited to Landsat data, but shows awareness of the challenges in data acquisition outside the walls of IITA – where IITA could at least help in downloading Landsat data (Interview 67, 01.03.2016).

3) Partners: GIScience-related collaborations exist with global partners and national institutions, such as the National Root Crops Research Institute (NRCRI). Also, regional researchers, such as from FUTA and UI, come to IITA to provide their knowledge about their region. However, by adding ‘in fact we use them’, my dialogue partner at IITA does unwittingly further demarcate his institute from the local GIScience arena. Furthermore, even where local GIScientists are able to collaborate with better funded institutions, their daily situation of scarcity dominates their experience, which is further emphasised by missing references to IITA in most interviews and conversations.

4) Capacity building: IITA offers training. Whilst they go to places all over the African continent, students also come to IITA for their industrial training. This makes the heterotopia open to at least some people, who will later point out the ‘difference’. Though the heterotopia is most visible in Ibadan it is not physically bound and has members in different places on the continent (Interview 67, 01.03.2016).

*Between exclusive and inclusive heterotopias*

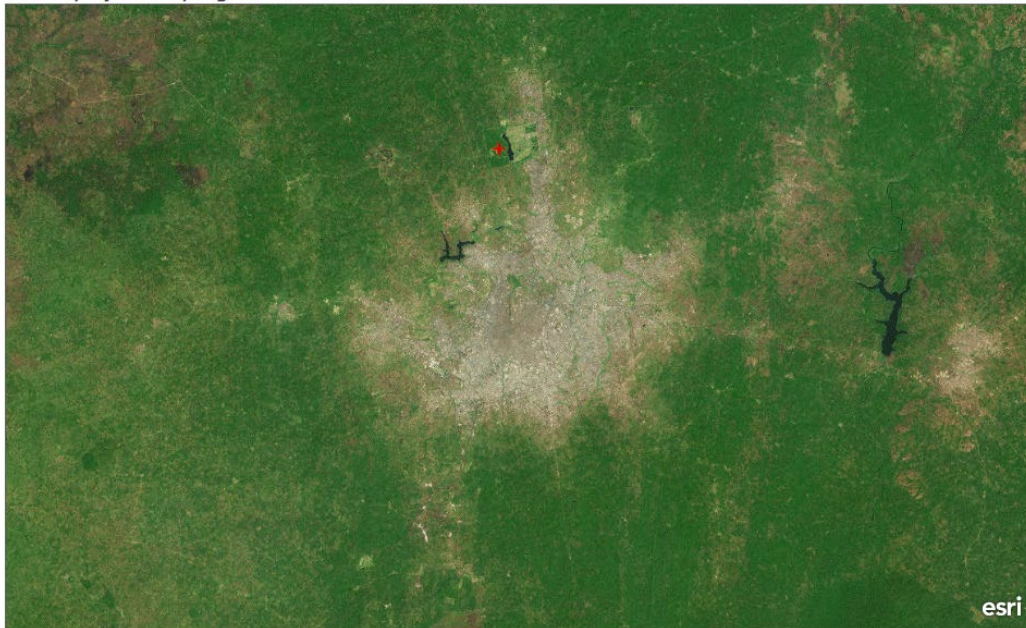
**IITA area, Ibadan, Nigeria**



**Figure 28** Satellite image of IITA in Ibadan (large scale), produced with ArcGIS Online map hosted by Esri (by author of thesis).

IITA is west of the road at the centre of the image.

Ibadan, Oyo State, Nigeria



Earthstar Geographics, CNES/Airbus DS

**Figure 29** Satellite image of IITA in Ibadan (small scale), produced with ArcGIS Online map hosted by Esri (by author of thesis).

IITA is indicated by the red cross.

IITA is not the only heterotopia. Oil companies like Shell, that in parts have sponsored GIScience laboratories at universities in Nigeria<sup>94</sup> (Figure 45), have their own GIS laboratories where Nigerians and expats work together. Notwithstanding their controversial role in environmental terms, one senior geographer from Ile-Ife hopes that their retired staff can in the future foster ties with universities and help building capacity in departments other than petroleum engineering (Interview 5, 18.03.2016). In Shell's case, researchers perceive that investments are largely focussed on the Niger Delta region, where the company operates and pollutes the environment. One researcher at the department of surveying and geoinformatics indicates why researchers would nevertheless appreciate Shell's involvement in capacity development in GIScience by arguing that it would be narrow-minded to hold Shell accountable for all pollution, such as in cases where pipelines are vandalised by members of the public (Interview 81, 29.03.2016).

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<sup>94</sup> Shell had entered Nigeria's tertiary education around the 1950s by providing scholarships to students from Nigeria. Later, during the 1990s, Shell supported *Shell chairs* (professors) in Nigeria, such as in geology and environmental studies, as well as laboratories for research and teaching (Interview 5, 18.03.2016).

### *The big heterotopian elephant*

Few lecturers and students have the chance to directly become exposed to Shell during sabbaticals or industrial trainings. They might be able to work on a so-called Shell challenge. In this case, Shell benefits in terms of resulting knowledge without having much expenditure in overseas laboratories and researchers benefit in terms of capacity building:

[A local professor of well engineering] was able to create a model for drilling in such areas, the kind of cement to use, the mud to use and stuff like that. He was able to provide the appropriate model to solve that kind of problem. And you may not believe it, that model has succeeded where Shell developed model failed. Because he was able to give a situation. He was able to take into (...) account maybe the local situation (...). (Interview 5, 18.03.2016)

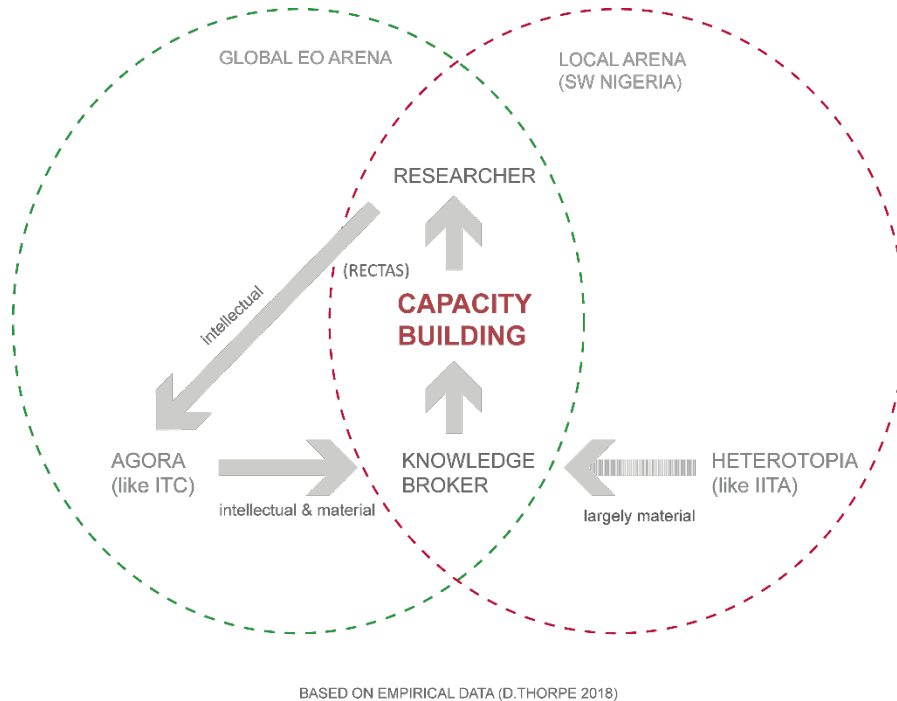
Though this example of a successful model for drilling is not related to GIScience it indirectly points at the big elephant in the GIScience situation. Notwithstanding previous discussions about a researcher's methodological liberation (chapter five), the interpretation of satellite images in most technical terms still often requires specific knowledge of features on ground (chapter two). In the case of West Africa, researchers *from* West Africa have gathered such knowledge since their childhood (chapter five). In the accounts of most researchers this advantageous aspect remains nobly unarticulated. In other words, despite their situation, local GIScientists do not argue that they are potentially better suited to do GIScience in Nigeria than expats in Nigeria's heterotopias. Whilst IITA pays tribute to their 'local knowledge' and remarks that IITA in fact *uses* their knowledge for projects in areas about which they have specific knowledge, this does not alter the material situation of GIScience in Southwest Nigeria:

I mean most of the time, they are the ones that have local knowledge of the area. So, they are the one that (will) help us implementing our projects. (Interview 67, 01.03.2016)

Overall, based on the experience of knowledge brokers in the wider arena, the local GIScience situation is perceived as incomplete, which is further amplified by researchers' occasional experiences with heterotopias. The two regional centres have the potential of being *inclusive temporary* heterotopias with capacity to develop capacity. In the long run, IITA should then be not more than just another local capacity. For now, individual knowledge brokers with their experience of the agora will remain their own heterotopia:

This university will likely be a rich centre for geospatial studies. And you know there is RECTAS there and RECTAS is likely to wake up very soon. (...) And apart from that there is a Federal Centre somewhere on campus, somewhere ARCSSTE-E. (Interview 5, 18.03.2016)

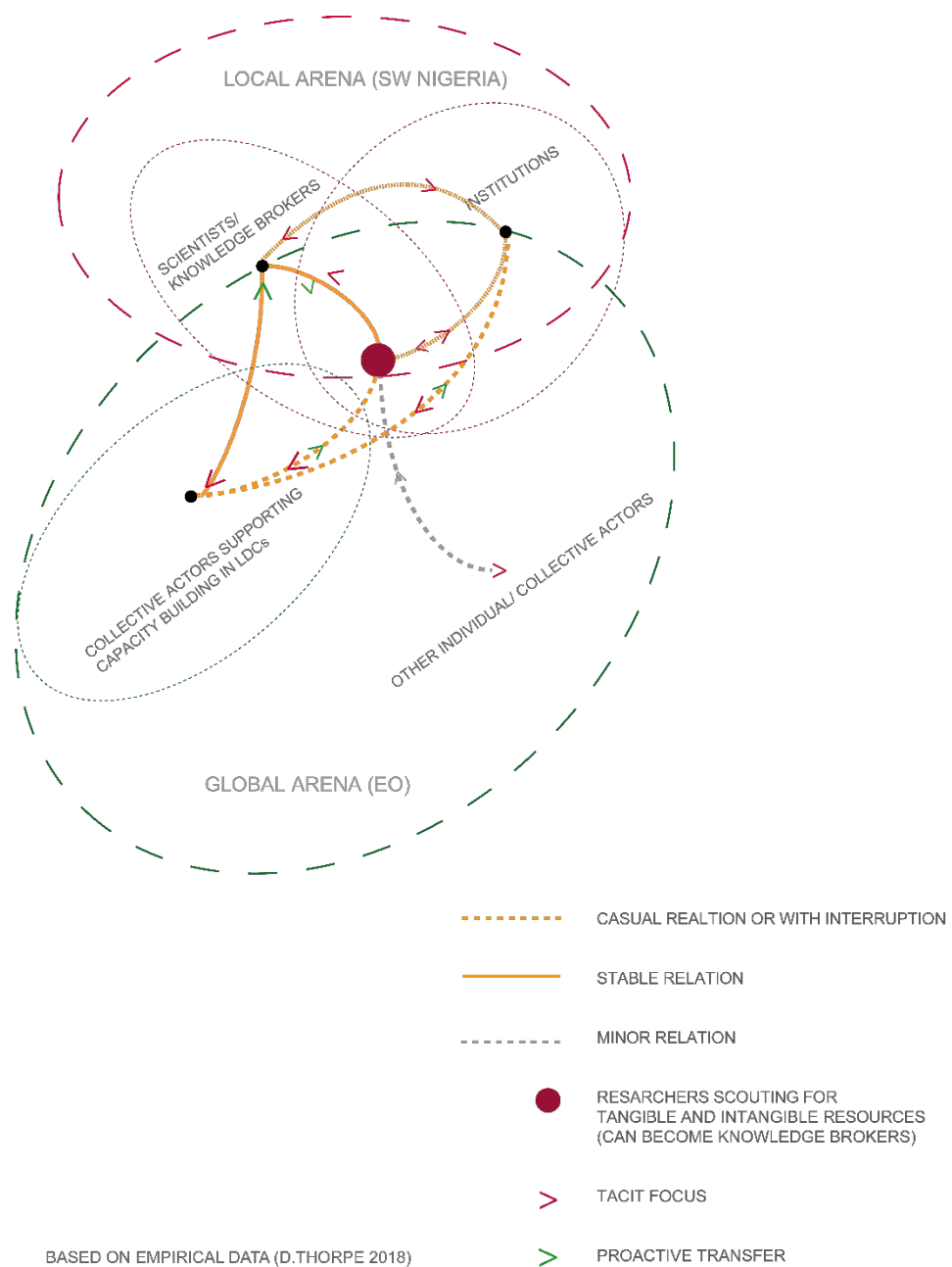
The experience of GIScience in Southwest Nigeria, as related to an international roundabout of capacity development is visualised in Figure 30.



**Figure 30** GIScience in Southwest Nigeria and the international roundabout of capacity building (by author of thesis 2018).

### Scouting Resource Provision (SRP) – a sensitising concept

This sub-chapter has described how researchers experience the wider arena of GIScience, where not only a collective understanding of remote (satellites) and tangible technologies (software and knowledge) is further constructed, but a capacity of using these for problem-oriented and collective knowledge production (agora). Against this background and a knowledge broker’s experience of returning to a situation of scarcity, a sensitising concept, that I refer to as Scouting Resource Provision (SRP), shall illustrate the collective agency of researchers towards maintaining their capacity in relation to a wider arena (Figure 31). Based on their experiences, researchers neither place reliance on political entities nor national or transnational organisations and institutions (including their own) in relation to resources, such as data, knowledge and equipment. Any related prospects are



**Figure 31** Scouting Resource Provision (SRP) (by author thesis 2018).

subordinated to proactive and independent scouting for relevant materials and knowledge. This scouting practice is significantly different from the telic resource provision in a well-funded environment, such as ITC and IITA. Most researchers in the first place pursue a kind of *bricolage*. In this case, bricolage however must not be understood as

a process where any materials in the local situation can become a means – as originally described by Lévi-Strauss (1966) and also considered in appropriation studies (Bellucci et al. 2012). It should rather be understood in the sense of scouting for relevant material resources and knowledge that can trickle in piece by piece from both the local and the wider arena. Whilst specific materials and knowledge are sought, a researcher's agency of *working around* and *tailoring* with available data and software (chapter six) remains a significant aspect of maintaining the momentum of research.

SRP is then characterised by continuous reorientation in relation to the local and wider GIScience arena. Whilst most institutional relations between both arenas are unstable (such as RECTAS and ITC), one constant is that materials are largely sought from collective actors (such as ITC and USGS) and individual actors that display proactive capacity development initiatives *for* the global GIScience arena. Knowledge brokers with stable professional and alumni ties do then also function as reliable brokers for other researchers in Southwest Nigeria. Furthermore, auxiliary non-human elements should be considered as a category of silent actants that support SRP but might at first sight seem irrelevant. Looking at scientific instruments in a historical context of exploration, MacDonald and Withers (2016) point at the challenging definition of 'technologies of exploration'. In line with their contemplations, I suggest that, whether as means of or desired objects within SRP, various technologies that do not seem scientific, are 'used to scientific ends' and hence might constitute a 'technology of exploration' that helps to maintain capacity in GIScience (ibid., 8). In Southwest Nigeria, this can comprise mattresses that are used to take advantage of the internet capacity during night (download data and communication with the wider arena), air conditioning units (cooling offices and laboratories), mobile phones for tethering (downloading data) and generators (power supply).

Overall, in addition to disseminating their research results, most researchers proactively position themselves in transnational social worlds to maintain capacity for their personal and institutional research. Based on their experiences in the wider arena or reports from knowledge brokers, researchers evaluate their own capacity in relation to (affluent) centres of their own research activity. Whilst most researchers from industrialised countries do likewise actively locate themselves in a wider arena of GIScience, in Southwest Nigeria, SRP constitutes an additional intermediate step towards participation in the global arena from the point of incompleteness.

## **‘Down to Earth’ Capacity Building – Preparing the Ground**

I like a space project but if I don’t get it then I look down. (Interview 15, 05.11.2015)

We don’t have data, but do we say we should fold our hands. (...) we have to keep advocating, advocating for people to first of all understand the capability and what it can do. (Interview 26, 16.12.2015)

So my is [sic], learn from them and come back to impact what I have learned. (...) Boy, you have to go back. Africa is missing you, Nigeria is missing you. (Interview 33, 18.01.2016)

In consideration of their situation, researchers do prioritise small-scale developments and applications for the development of a temporary base for capacity building that can be largely independent from institutional infrastructures, as this section will further discuss. Knowledge brokering eventually means to take responsibility for the situation by creating a basis for capacity development that goes beyond scouting (SRP) and that can prepare the ground for the long-term vision of a stable agora. The next sections will describe a situation in which researchers ‘maximise the opportunities they have’. It is a situation in which dependence will remain a factor but in which many small steps with small technologies will allow one to ‘move on’:

They [future generations] may not be able to get independent of funding from overseas, but life does not have to depend on whether those funds come or not. (Interview 5, 18.03.2016)

### **Don’t put the cart before the horse – the NGDI case**

I won’t go to Abuja to get data from them if I can get data from the US right on my table (raps on the table). I can get data from South Africa right on my table. (Interview 58, 24.02.2016)

Many envisaged small-scale developments are suggestions that still relate to larger infrastructures. However, researchers describe a situation in which a new focus on infrastructures on ground intellectually turns the GIScience situation upside down, based on their experiences of being in a situation where SRP accounts for a large part of their daily activities. One geographer from Ibadan, for example, suggests that Nigeria’s space agency (NASRDA) or the Office of the Surveyor General (OSGOF), should invest in ground receiving stations and make agreements with companies that provide high resolution data, instead of launching national satellites, whose data often stay out of reach (chapter six):

Because whether we like it or not, SPOT passes over Nigeria. (...) All we need to do is pay annual subscription for download. Now, given that scenario, we can monitor, we can monitor things like flood. (Interview 58, 24.02.2016)



Many researchers argue that if a West African (ECOWAS) state nevertheless insists on launching EO satellites, a collaboration with regional capacity building institutions and people from other African countries was mandatory, considering that space itself does not have any borders:

Instead of me priming again to go and say okay I may develop my spatial satellite to launch, why can't we integrate and use that common platform. (Interview 24, 07.12.2015)

Here, GIScientists look at countries like Australia that do not operate EO satellites (Woodgate et al. 2017), but would nevertheless make significant use of geospatial data as they valued infrastructures and 'human resources' on ground. Whilst some researchers do not necessarily question the existence of a national space programme, they urge to carefully evaluate related objectives (Interview 22, 27.11.2015).

#### *Spatial Data Infrastructure (SDI) culture*

Researchers envision nothing less than the development of a ground-based culture in relation to data acquisition:

It has to be institutionalised. It has to be seen as a culture. You have to go into that culture. If you cannot/it has been a culture in your own systems. You have the culture of data gathering, but here people can spend occasionally on collecting data. (Interview 22, 27.11.2015)

When my dialogue partner in ecology at OAU suggests that this means institutionalisation, he refers to a development that Areola, a senior geographer, already mentioned as missing in the 1980s (*see* Areola 1986). During his tenure as the director of space applications at Nigeria's space agency, Akinyede eventually began to promote such a culture (awareness of the relevance of geospatial data) in form of a national geospatial data infrastructure (NGDI):

And the space agency will be the host for the geospatial data infrastructure and people will be well-informed on the importance of sharing data/the importance of access to data, the importance of standardisation of data and then to use data as a platform to serve geospatial data for governance as a whole. (Interview 43, 27.01.2016)

Akinyede's colleague in surveying and geoinformatics, who participated in relevant stakeholder meetings, recalls that a related policy had eventually been accepted by the Federal Government, but has never been implemented due to the controversy over the custody of spatial data (from remote sensing data to maps) between OSGOF and NASRDA

(chapter six) (Interview 81, 29.03.2016). Against this background, researchers emphasise their prolonged experience of a tedious process of data gathering and hence their need to pursue SRP (Interview 81, 29.03.2016). Against this background, much GIScience is also accompanied by an implicit concern about research redundancy due to a missing central repository for spatial data and information about existing research. Whilst a monitored policy is on the minds of most researchers, consensus amongst different stakeholders is yet to be negotiated. For example, one of the former Surveyors General of the Federation explains that he had set up a ‘data centre’ in his office, storing auto-photo imagery of 2,5 metre resolution. The related promising policy, however, does not yet represent an unconditional data repository, as envisioned by most researchers:

I will give you the whole [data] of that state. (...) ‘David, I have this, extract the roads, extract all the water bodies, take this token amount. That is just to keep you going and give us back the data, the information you extracted. We will check, if it is good, you receive approval, we allow you to keep [the data]’. That is the kind of thing I am saying that we should have and I did (implement it as surveyor general). If you come to us and you want data, we give you that data but on condition that we are going to get (how you use it). (Interview 84, 31.03.2016)

## **Make things functional on ground – from power generation to CubeSats**

Whilst the implementation of an NGDI is considered dependent on larger structural agreements, researchers have articulated opportunities for auxiliary developments that can increase capacity to build capacity by building on SRP. This section will describe a collective understanding of how their GIScience situation can be made functional through small-scale developments and applications, whilst keeping sight of promoting knowledge transfer with the wider arena.

### *Power supply*

Talking about erratic power supply in Southwest Nigeria, one researcher reminds me: ‘For you, you don’t live here on a permanent basis. (...) It is my reality’ (Interview 15, 05.11.2015). Both this experience and related solutions are entrenched in a larger societal context. One geographer from Ibadan thinks about power supply at his department by looking at his home, where he has been using solar panels for seven years:

At least there is no day, I do not have enough light to power my house over night when I return. (...) To me we can power all the laboratories with solar and it is cheaper, it is cheaper (...). (Interview 58, 24.02.2016)

However, contradictory information about acquisition and maintenance costs as well as politics can sustain expensive, polluting and noisy generators as the prime solution.<sup>95</sup> I have nevertheless met individual researchers who push alternative solutions forward, such as by acquiring UPS units/inverters for their department (Figure 51):

I told the HOD [Head of Department]: ‘we have a local problem. We have electricity problem. We need to put up a system that will be less dependent on generator’. That is how I came about with that inverter. (Interview 33, 18.01.2016)

#### *CubeSats & ground-based sensors*

Knowledge brokers do further appreciate small-scale technological developments that directly relate to the acquisition of data and can be realised in Nigeria to support a collective sense of having an elementary base for independent capacity building. One of my dialogue partners at ARCSSTE-E recalls his ‘eye-opening few weeks in Japan’, where he learned that small CanSats can already achieve a lot, and are even promoted in a country that has the means to build satellites of any size:

They showed me things we could achieve outside of waiting to build a big satellite. It was eye-opening. I attended a programme in Japan on/we worked with CanSats, the small/even highschool students build Cansats now. It is a small device and it has most of what a typical satellite will have. It has communication, it has a power pack, it has sensors that can get data. It has storage maybe. (Interview 15, 05.11.2015)

Looking at such minimalist developments, knowledge brokers appreciate that also a satellite manufacturer like SSTL is a university spin-off, where the company had matured before building bigger EO satellites for Nigeria and other countries. Akinyede considers replicating such a process at FUTA with CanSats or CubeSats as a starting point (Interview 43, 27.01.2016). FUTA now has a MOU-based collaboration with the Kyushu Institute of Technology in Japan. This collaboration is considered part of a ‘technology transfer’ for postgraduate students. The local Centre for Space Research and Applications (CESRA), where Akinyede is the director, functions as a mediator in this respect (Interview 30, 13.01.2016). The MOU further allows to tap into support from UNOOSA, whilst Japan’s space agency JAXA can support the launch of FUTA’s CubeSat (and those of other participating countries) (Interview 43, 27.01.2016). Researchers do not expect this knowledge transfer to be complete, but consider it as laying a foundation for independent developments. The head of the neighbouring department of remote sensing and GIS envisages that FUTA’s future CubeSats will have ‘specific payload’ that can collect data in

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<sup>95</sup> A number of solar panels were installed during my stay at FUTA in 2016.

relation to issues that researchers from Nigeria are concerned with. His department could then function as a relevant mouthpiece:

We are going to come into the building of the payload, so that we will be able to say 'hey this is what we need on the payload' looking at our environment and what we feel will be useful in studying the environment here. (Interview 30, 13.01.2016)

Whilst the CubeSat project exemplifies how the GIScience arena gradually works for their disentanglement from national structures, it also indicates that researchers do not give up hope that relevant national agencies will at some point contribute. Asking Akinyede about the purpose of an antenna next to CESRA's building, he explains that this might be converted to a ground receiving station for the CubeSat but acknowledges that this still requires some support from NASRDA (Interview 43, 27.01.2016). Most small-scale developments still require a basic level of institutional support. CubeSats and ground receiving stations cannot be compared to small investments, such as in power supply. Against this background, a collective appreciation of ground-based developments that require only modest funding, eventually prevails.

This appreciation is further grounded in experiences in the wider space research arena in Nigeria that intersects with GIScience. For example, whilst small-scale technologies have actually been supported by NASRDA, their construction proved challenging. One researcher at ARCSSTE-E recalls how they worked on a payload for a sounding rocket at NASRDA's Centre for Space Transport and Propulsion (CSTP). Their payload consisted of 'off-the-shelf components', whose measurements of the atmosphere were to be compared with those from expensive components that CSTP had bought. However, this project eventually came to a halt due to lack of funding. Researchers from ARCSSTE-E had further been invited to join the HumSat project (humanitarian satellite) by a professor from Spain. As they were unable to afford contributing their own satellite to a 'constellation of small university-built satellites', they decided to find some ground-based use for the constellation. This coincided with a need to know more about desertification:

And the idea was to have sensors and our sensors will communicate the data to the satellite and the data will beam down to a central ground station and we could collect everything over the internet. (Interview 15, 05.11.2015)

The team hence began focussing on ground-based sensors that can support the measurement of desert encroachment, instead of building a small satellite:

That is why rather waiting for thousands and thousands of Dollars for maybe the kind of satellite equipment and staff that we might need, I can buy a microcontroller, 2500

Naira. I'll buy components from (anywhere). I can still afford that (...). You still work, you still show that this is possible. (Interview 15, 05.11.2015)

My dialogue partner describes this approach as 'things that are more down to Earth' and that keep you busy. In their situation it was important to value existing technical knowledge that can at least be implemented 'on Earth' (Interview 15, 05.11.2015). The ground-based sensors, that shall measure the volume of sand, resemble the payload that they had developed for the sounding rocket. Resorting to ground-based sensors was hence a pragmatic issue, whilst the transmission of the recorded data was still a matter of *space*. My dialogue partner describes this process as a necessary translation. It allows to maintain and develop capacity on ground and hence a functional base for future projects:

It is just translating the same kind of work into a more terrestrial environment. (...) It is connected to space because initially the idea is to collect the data [via satellites] from the various stations we have, maybe up to fifty station, in remote desert areas. (Interview 15, 05.11.2015)

However, eventually even these ground-based developments are in danger of being hampered by the situation itself. The sensors need to be calibrated, but due to sustained lack of funding the team was hindered from travelling to the North of Nigeria. Researchers admit that it often is to 'depressing to follow' those transnational projects that they had joined with the most modest aspiration, but eventually had to leave:

I know of a few satellites that were launched. It became to depressing to follow it (...). (Interview 15, 05.11.2015)

### *UAVs*

Notwithstanding CubeSat-related developments, some researchers do directly resort to existing technologies that operate closer to Earth to cover some data needs:

Repetitive coverage, you cannot take that one away from satellites. It will still be an advantage of satellites. But at least for some high resolution mapping, maybe drones will take care of those ones in the (near) future. (Interview 22, 27.11.2015)

During the last weeks of my stay in Nigeria, I was able to attend a drone demonstration. Observing the drone and its payload was indeed somewhat satisfying. The drone was not only visible against the blue sky of Lagos, but the collection of aerial data seemed to finally have a more promising and direct relationship to the ground – to a group of observing researchers and indeed the natural environment (Figure 32). Despite many disadvantages, resolution-related advantages of drones are amplified by the experiences of those, who hardly have access to high-resolution data:

I am sure if you want to buy satellite images [in the UK] now, there is no stress. You just get online and pay for it but from here, it is pretty difficult. But now with the drone, we are going to witness quite a lot of improvement in our research and how it will affect the social life of our people. (Focus Group 10, 30.03.2016).

Similar to knowledge brokers, those who hold UAV-related capacity, do increasingly establish a related network in Southwest Nigeria. Considering their limited access to satellite data, one researcher, who holds a UAV pilot certificate from Germany, states that technologies like UAVs constitute Nigeria's EO future – at least the immediate down-to-Earth future, as she emphasises:

And I know that is the future now in Nigeria also, at least for our small-scale and little, little mapping, not elaborate one. (...) If you don't have access to satellite imageries, especially the high resolution one now, then you can fly, you can fly. (Interview 81, 29.03.2016)

### *Software and Data*

Most small-scale developments and applications still rely on minimal funding and relations to collective actors that initially transfer technologies. This is most visible when researchers share their thoughts on GIS and remote sensing software. Whilst they look for responsibility in the local situation, researchers discern few unnecessary hurdles in the wider EO arena. They envisage more advanced policies that reflect a new sensitivity towards developing countries. Their contemplations on software are usually related to experiences in accessing data, where the 'developed world' is perceived as controlling any related acquisition (Interview 60, 24.02.2016). Whether in relation to software or data,



**Figure 32** Drone demonstration at the University of Lagos (owned and operated by Professor Omojola) (Thorpe 2016).

suggestions regarding access policies are based on promising developments, where researchers repeatedly consider the Landsat programme as the benchmark. They appreciate that under USGS, both the worldwide acquisition and ‘diffusion’ of data seem balanced, which was not the case with most other providers:

In the diffusion theory they tell you that gas moves from place of high concentration to a place of what/lower concentration. (...) Since [the EO satellite] goes round it keeps acquiring so much data base. They have so much stock. The same through all other countries, India all of them, the United States. What the United States have now, is just too much. (...) Particularly that for Africa could actually be provided even if (is going to be) a [minimal] cost. (Interview 26, 16.12.2015)

USGS is particularly praised for providing unbureaucratic access. In a situation that is characterised by a loss of time (such as for SRP), this constitutes a significant alleviation. In the case of software, researchers actually discern missed opportunities in the wider arena, where software developers could provide a ‘lighter edition for Africa’ and would still generate much revenue, whilst tackling the issue of piracy:

Because imagine if we have 1 Million Nigerians using pirated software for GIS, let’s say ArcGIS and ArcGIS, (say) okay they want to do a low edition and that low edition is ten, ten dollars or let’s say hundred, hundred dollars for low edition. Now times (...) one million. You know how much they are going to make in one year. (Interview 26, 16.12.2015)

This continuous orientation towards the wider arena is based on experiences. For example, one alternative would be to programme software in Nigeria. A software for multicriteria analysis has been developed by one of my dialogue partners. However, software becomes another case, where researchers on the one hand pursue independent developments to set a more independent base for capacity building, whilst being aware that technology (software from Nigeria) might be considered inferior in the larger arena:

Some of the programme language you need, some of them are advanced. You also need to get it, need to buy it. Then you also have to get some certain software and see how it works to design yours. (Interview 26, 16.12.2015)

In line with this, in the context of integrating IDRISI software from Clark University at RECTAS, one lecturer at RECTAS argues that mutual benefits of involving ‘local staff’ in the conception of software had yet been largely overlooked. He and his colleagues emphasise that this concern is not about cutting ‘the umbilical link’, but about contributing to the development of software (Interview 24, 07.12.2015, Interview 32, 18.01.2016).

### *Independent development for a long-term good*

Researchers in the first place pursue independent small-scale developments (including the use of alternative technologies like UAVs) to prepare and maintain capacity against the backdrop of erratic institutional support and collaboration with the wider arena. At the same time, they discern at least a basic need for funding and collaboration, whilst keeping an eye on long-term reciprocal relations with the wider arena. They eventually hope for more flexibility on part of a global arena, where academic interests should be the prime criteria for access to data, software and knowledge. Against this background, current independent developments shall primarily address ‘immediate problems’ that lie outside the purview of a researcher’s scientific aspirations in a global GIScience arena and agora:

The money I am going to use in buying calculator is enough to keep me going for the next two weeks. So, I have to use (VBC) to design my own calculator. (...) I could not design it to become scientific in nature, but I was able to use/to solve some (...) immediate problems. (Interview 26, 16.12.2015)

The GIScience arena in Southwest Nigeria eventually promotes as much independent capacity as possible by being ‘pragmatic’ in relation to existing resources. One of my dialogue partners not only describes this process as a *translation* of capacity building goals, but by emphasising that he has never talked about it before, indicates an almost tacit nature of this process:

What can I do so I won’t be idle. Like I said, academic, professional and let me say pragmatic, coming back down. The steps have been due to those factors. Does that make sense (...). I haven’t talked about that before. (Interview 15, 05.11.2015)

### **‘We have many clouds’ – local radar capacity for the world**

And then of course, another problematic issue we have about the satellite is the clouds in Nigeria. (...) The solution to that might be Radar. (Interview 32, 18.01.2016)

Preparing, of necessity, a base for capacity development that is more independent from institutions, coexists with the objective of contributing specific technological/methodological knowledge to the global GIScience arena. The following case of using data from Radar satellites in light of natural restrictions, illustrates how these objectives become interwoven through a focus on *preparing* capacity building, where national attempts have failed. Due to frequent cloud cover, optical data is hardly ever cloud-free for Southwest Nigeria. Active sensors onboard satellites, whose microwave radiation can penetrate



clouds (Radar) are considered a solution. Any relevant developments in relation to Radar capacity in Southwest Nigeria take place against the backdrop of past experiences that for senior researchers constitute another example of disrupted capacity development. They describe a lost capacity in Radar that they partially had in the 1970s. A related publication from 1978 describes a situation that researchers still describe in similar words today – where...

...persistent cloud cover in much of the southern part of the country, have made it extremely difficult to compile recent land use and vegetation maps of the whole country.

The repetitive coverage of the Earth's surface provided by the present generation of LANDSAT earth orbiting satellites offers the possibility of obtaining up-to-date imagery on a 9 or 18-day cycle. However, because the current sensors operate within the visible region of the spectrum, the problem of obtaining cloud free imagery remains (...). (FGN et al. 1978, 3-4)

In 1974, Nigeria's Federal Department of Forestry had suggested to invest in a 'Side-Looking Airborne Radar (SLAR) survey'. A contract was eventually awarded to a 'British firm of consultants' to interpret the images. The related project became known as NI-RAD, was carried out between 1976 and 1978, and produced maps in 1: 250,000 scale (FGN et al. 1978, 1). This success was announced in the Interpretation Phase Report of 1978. Today, the project is considered failed in terms of capacity building. According to Adeniyi, one potential issue has been the past decision to process the data abroad (Interview 94, 20.04.2016). One of his colleagues in Ile-Ife confirms that Nigeria has not been able to 'enhance that capability' (Interview 5, 18.03.2016). The 1978 document already gives further information about the past challenges in building capacity in Radar image interpretation in Nigeria. It states that...

...from the outset the Consultants considered that the training of Nigerian personnel in all phases of SLAR interpretation and ground truth acquisition would be crucial to the long term success of this unique Project. (FGN et al. 1978, 1,11)

Whilst 'suitable candidates' had been selected, the authors regret to acknowledge that the 'heavy commitment' of Nigerian researchers to other existing projects only allowed for a 'partial solution', such as providing training manuals and a short seminar on methodologies and results from the project (FGN et al. 1978, 1,11).<sup>96</sup> Forty years later, knowledge

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<sup>96</sup> One geographer describes how such disruption in developing geospatial capacity dates back to colonial times and provides an explanation for the prominence of surveying in Nigeria, as compared to cartography: 'But the cartography aspect was not well-developed since the maps were not produced here, the missionary, the tools, the equipment were not/for producing the maps were not here. They were in Britain' (Interview 93, 20.04.2016).

brokers in Nigeria seem ready to make another attempt. Akinyede refers to a project that they were about to start during his tenure at NASRDA. The project includes training in the use of Radar imagery from Germany's TerraSAR-X satellite and shall over time lead to the collaborative launch of a Nigerian Radar satellite (Interview 43, 27.01.2016).

However, against the backdrop of past failure in realising such capacity at national institutions, there is a contemporary interest in independently preparing the ground in terms of methodological capacity before related technologies are acquired. One day, the head of one of the local geography departments approached me and asked me whether I might be able to help a PhD researcher in acquiring TerraSAR-X data from Germany. She works on evaluating the use-value of active sensors (Radar) for the extraction of linear features in Nigeria's environment (Interview 21, 13.11.2015). Her supervisor emphasises that this assessment means to 'prepare the mind of people towards this' new and more suitable data (Interview 17, 10.11.2015). In my conversation with her, she refers to challenges in interpreting Radar images, but suggests that instead of waiting for a Nigerian Radar satellite or cloud-free images, Nigerian researchers should 'go ahead of it and take our issues by ourselves'. This means preparing capacity in interpreting Radar images in relation to features on Nigeria's ground, before one day having a Radar satellite without any local capacity to use its data:

Let us see if the Radar can actually give us as much basis for analysis as the optical has done over the years. And if it has been difficult why can't we find a way around it. (Interview 21, 13.11.2015)

The current capacity in Nigeria to develop capacity in Radar, however, remains limited. Few researchers at RECTAS have already used Radar images, and one researcher will at least be able to teach some relevant programming:

Things I look forward to the image, the idea, the technology and programming and having understanding of how the images actually work. It is just that it is not easy to get data. (Interview 21, 13.11.2015)

This training does eventually depend on the availability of data. The PhD researcher had been informed that Airbus Defence and Space, which had implemented TerraSAR-X in cooperation with the German Aerospace Centre (DLR 2004), might be able to provide data and relevant knowledge at reduced or no cost. I hence wrote an email to Airbus on behalf of her, in which I introduced the project and explained that the acquisition of TerraSAR-X data in Nigeria proves difficult. The response email is friendly but resembles

a stock response. It states that a DLR programme provides TerraSAR-X data at reduced costs for scientific purposes (Airbus Defence and Space 2015).

Whilst this response is helpful, it has been eye-opening, considering the research situation in which it was received. The GIScience arena in Southwest Nigeria receives the standardised wording that any researcher in the wider arena will receive. Though the DLR states that ‘a limited amount of TerraSAR-X products will be provided to accepted proposals free of charge and will be delivered electronically’ (DLR 2014, 6), this provision is limited and researchers are faced with complex requirements of the DLR, such as a detailed description of their ‘contribution to the mission objectives’ (DLR 2014), whilst being in a situation in which relevant expertise is only one of many challenges.

At the same time, the PhD researcher’s work is not simply about establishing capacity towards Radar data. She in the long run wants to see a situation in which Nigerian researchers contribute knowledge to the global GIScience arena in terms of relevant methods. Whilst such methods shall relate to Nigerian issues (features on ground), they are meant to be universally applicable as part of a reciprocal knowledge transfer:

I am looking forward to a time that methods, techniques will be originating from Nigeria, from Ife. You know we always have this dichotomy of developing and developed world. We are always the one following. So, we are looking forward to/I am looking forward to a time that we will be the one in front, leader in the front and then others begin to follow, not we always being the followers. (Interview 21, 13.11.2015)

Whilst she argues that any such developments would in the long run ideally involve a national Radar satellite (notwithstanding the experiences with NigeriaSats), this should be understood in the context of capacity to build capacity. Having a ‘voice in the field’ eventually is the major collective objective that however will always depend on access to the most fundamental element in GIScience – data:

I look forward to a time like that we will have a voice in the field, developing the methods and (...) not just being the users. (Interview 21, 13.11.2015)

Having a voice is about ‘adding values to solve problems’, as her colleague in Lagos reminds. And Radar imagery would have various application areas in Nigeria (Interview 81, 29.03.2016). It is not about reinventing the wheel, but about adding value, as also their colleague at RECTAS argues. Participation in the wider arena means to use Radar data in relation to specific ground-based features, and to hence contribute to the development of technologies, such as sensors:

When we are using something that has no restriction [EO satellites], why are we restricting ourselves in sharing that knowledge in associating. It can be done between

Africa, Europe, USA, because we are using, we are all benefiting from the same things. (...). We can also contribute to develop it. (Interview 24, 07.12.2015)

Overall, the following objectives of the German aerospace centre are in line with those of researchers in Nigeria. However, the true value of TerraSAR-X data for researchers in Southwest Nigeria can indeed only be found in their GIScience situation:

In particular the use of TSX data shall help to extend the range of parameters observed and therewith to increase the knowledge of the factors determining the behavior of the environment. (...) Both application and technological development shall aim at a further improvement of the Earth observation services. (DLR 2014, 5)

### **Being a broker of knowledge – responsibility for a ‘mini technological transfer’**

The most fundamental aspect of supporting a base for capacity building, however, is that of everyday knowledge brokering. Researchers who have been abroad appreciate their responsibility of sharing whatever they can share. Their central objective is to develop capacity to build capacity as part of a sustainable ‘mini technological transfer’ (Interview 33, 18.01.2016). Whilst knowledge brokers consider the amount of transferable knowledge limited, its relevance is deemed extensive. One researcher from Ife states that those who ‘have seen a little light really have to work hard’ to maximise their knowledge for the benefit of local capacity (Interview 22, 27.11.2015). His colleague realised his responsibility, when he observed that many of his peers lack in-depth knowledge about geospatial technologies and software, and hence learned to appreciate that knowledge brokers must also introduce the ‘science behind’ technologies (Interview 26, 16.12.2015). They thus organise relevant tutorials, such as on basic computer knowledge, to promote a sound base for training in remote sensing and GIS (Focus Group 9, 07.03.2016).

#### *Capacity to manage capacity*

Efforts of teaching fundamental knowledge are of particular importance in the given situation, as researchers illustrate. Staff in surveying and geoinformatics (Lagos) explain that one reason for teaching analogue techniques, such as related to astronomy, is based on potential ‘failure in the modern system’, such as GPS:

The basic principles are actually/they are fingertips which they can actually use at any time. (...)

People here have not been studying astronomy for any social enlightenment. Those who study astronomy in our own profession they are those who want to use it as an alternative positioning tool. (Focus Group 10, 04.04.2016)

In this situation, having related foundational knowledge also means to have further capacity in assessing one's actual needs:

And now lack of this knowledge has even made it more difficult in our own context. (...) Like somebody just called me now that he wants to use hyperspectral data. (...) But where are you going to get hyperspectral data? (Interview 26, 16.12.2015)

In line with this understanding, the idea of appropriate knowledge as a tailored choice of knowledge in relation to a research problem (as taught at ITC) eventually ties in with appropriate technology – though from a knowledge point of view. For example, one staff from ITC explains that it is not in the interest of ITC to dissuade Nigerian researchers from obtaining commercial software, but to communicate that in-depth knowledge in GIScience entails additional agency towards software. The technology is not made appropriate for Nigeria, but appropriate knowledge allows to use software more efficiently. This approach is also based on the experience that also ITC staff usually only use a fragment of a software's functionality:

What we try to teach them is that they have to analyse the problems that they are working on, so that they use the level of technology and the level of, say analysis and research that is required to solve the problems without any overkill. (Interview 97, 08.09.2016)

Recalling the aim of contributing to software development, increasing local capacity to manage capacity can not only promote a new focus on open source software, but also on ITC's in-house software ILWIS, that allows users to contribute to the development of the software, based on their needs (Interview 97, 08.09.2016).

#### *Apostles of technology – capacity to build capacity*

Overall, knowledge brokers describe how any little knowledge that they can transfer eventually enhances collective capacity to build capacity. This in the first place means to return to Nigeria to lay the foundation for GIScience by allowing other people to 'acquire' their knowledge:

When you travel out of Nigeria to study in ITC that is capacity building. But when you can stay here within the country and develop people to have the skill to work that is capacity to build capacity. (Interview 53, 17.02.2016)

Teaching the science behind GIScience means to develop a ‘critical mass’ that values capacity development, as one researcher explains (Interview 22, 27.11.2015). At the same time, knowledge brokers emphasise that any recognition of their capacity is primarily based on being in a situation where capacity is restricted in the first place (Interview 13, 29.10.2015). Here, a knowledge broker’s capacity is in danger of being overused, which makes the development of collective capacity to build capacity a matter of priority, as their colleague explains with the analogy of a ‘one-eyed man in the land of the blind’, who ‘is going to suffer a lot’ as ‘he wants to see for everybody’. Building capacity was hence a matter of small steps, such as teaching individual researchers ‘how to georeference’, digitise maps, and analyse data. It means to train ‘apostles of technology’, similar to alumni from regional centres, who go back to their countries and share their new capacity (Interview 26, 16.12.2015). One lecturer at RECTAS argues that knowledge brokers need to understand that communicating knowledge will often only show tangible results after years, but that the only way of creating a collective base for capacity building is by appreciating the latter:

But when confronted to other that have been trained in other institutions, [former trainees] found that they gain a lot. (...) when you start expanding your tentacles into the system, at least the philosophy you imparted into them, will now germinate. (Interview 24, 07.12.2015)

Considering their situation, a researcher’s commitment to their capacity to build capacity is not something that must be taken for granted, as one geographer in Ile-Ife reminds. When somebody asked him why he did not just stay ‘in London and just disappear’, he answered that he would ‘betray’ Nigeria: ‘Let me come back and contribute. I still have positive mind that things will get better’ (Interview 3, 15.10.2015). In this context, experienced knowledge brokers also publish their own text books on GIS and remote sensing with local publishers to overcome shortage of expensive literature from abroad. GIScience-related text books (manuals) have, for example, been published by Ayeni (2010), Uluocha (2015), (2007) and Salami and Adepoju (2011b) and can be bought in the bookshops of local universities.

### **(Regional) collaboration – the next step**

Researchers emphasise that the long-term success of capacity building eventually depends on infrastructures that only governments or larger international bodies can provide. In this context, the West African region becomes a prime locale of envisaged collaboration.

Researchers do not only understand related ground as unbounded in environmental and developmental concerns, but technologies that sense the ground are appreciated for literally operating beyond national 'sovereignty' (except for ownership) (Stuart 2009). This section will discuss how transdisciplinary research as a capacity in GIScience in Southwest Nigeria constitutes a potential fundament for regional collaboration. In Southwest Nigeria, GIScience has been constructed as a social world that does not belong to any specific discipline, such as geography, geology, ecology, surveying and geoinformatics and indeed remote sensing and GIS (Clarke et al. 2015, 174). Knowledge brokers gradually develop their own agora in relation to research interests, technologies, knowledge and methodologies:

We [in surveying and geoinformatics] have cordial and intimate relationship with other departments, cognate departments in the whole of Southwest (...) Because, we are all working within the spatial environment and there is no way we will not interact. Our work overlaps by more than 90 percent. (Focus Group 10, 30.03.2016)

Collaboration already takes place in various research areas, such as on environmental issues that relate to the artificial peninsula Eko Atlantic City in Lagos State. I first learned about Eko Atlantic City at the department of surveying and geoinformatics and eventually visited it as part of a conference of Nigerian geographers. The construction of this peninsula entails many environmental concerns that are not only shared by researchers from both disciplines, but can be assessed through their collective appreciation of remote sensing and GIS:

They used what we call hard engineering solution, using huge rocks which they dropped into the deep Atlantic to block the waves. So, the current that is normally supposed to come and go gently has been interrupted and then there is a feedback loop that is generating and that feedback loop is now going to cause erosion, serious erosion on the Eastern part the Nigerian coast. A lot of villages are already lost, many coconut trees have already fallen inside the water, been carried away, villagers have had to be relocated (...). (Focus Group 10, 04.04.2016)

The GIScience layer that allows to look at coastal erosion over a wide area, for most researchers constitutes a direct bridge to other disciplines that only differed in few aspects, such as in the case of surveying and geoinformatics and geography:

Anybody can use GPS. We use the same software and the statistical analysis in geography, everything now is coming into surveying also, because of the geoinformatics that we (are in). What I will think is that what we have done so far, is that we have just taken part of geography and put into surveying (laughs). (Interview 81, 29.03.2016)

However, whilst several researchers appreciate the idea of a GIScience agora, much collaboration is still articulated in future. When Nigeria's former surveyor general argues that some research should indeed only be done in collaboration, his statement is exemplary of the complexity of the situation in which political debates over the custody of spatial data must not be confound with the stance of individual GIScience researchers in the disciplines of surveying and geography. It merely indicates that social worlds are maintained, emerging and merging at the same time, and that only time will tell where GIScience in Southwest Nigeria is heading in terms of an agora:

For example, we had mounted a programme on geoinformation technology and geography mounted a programme on GIS. I believe we are talking almost the same thing and so we should have worked together and had a stronger programme (...). (Interview 84, 31.03.2016)

A focus group discussion at the Federal School of Surveying further emphasises the indetermination of this dynamic process between policy-related (surveying as a profession) and more research-driven pursuits:

Some of the old surveyors are even coming back to learn the GIS and remote sensing, because that is the in-thing now. (Focus Group 9, 07.03.2016)

#### *GIScience as a well-equipped agora*

Many knowledge brokers envision nothing less than GIScience becoming part of a well-equipped agora, respectively in strict institutional terms, temporary inclusive heterotopias, where Nigeria's Earth sciences could directly associate in symbiosis to build GIScience capacity in addressing issues that individually hold them back on ground. My dialogue partner in surveying and geoinformatics recalls her relevant experience at the Lancaster Environment Centre (LEC):

(...) I am looking forward to a centre [in Nigeria or University of Lagos], maybe environment centre, where you have your geographers, you have your town planners, you have your/everybody and then you work seamlessly. (...) You can say I am into geoinformatics or I am a geomatics expert or things like that. (Interview 81, 29.03.2016)

Where such centres can be established, debates, such as about location-related expertise, will take place amongst various actors that become involved at different stages:

The university [Lagos] has an innovation unit and that innovation unit plans to set up centres. (...) You can bring people from sciences who are doing something on plants, animals, our environment. We have environmental management in science. Now the surveyor in terms of positioning in the environment is key. (Interview 84, 31.03.2016)



This further illustrates how the construction of GIScience has also become an issue of either GIScience-centrism or Earth science focus. For example, in the case of RECTAS, GIScience-related capacity building dominates over disciplinary variety (Interview 24, 07.12.2015). However, with researchers and students from various disciplinary backgrounds and geographic regions, it can constitute one platform for a local GIScience agora.

### **The own lab – do it yourself institutions**

Few knowledge brokers also work on what one may call a small DIY agora. They shall pool the strengths of scouting (SRP) and knowledge brokering for small-scale capacity building. In the case of the Space Application and Environmental Science Laboratory (SPAEL) at OAU, national funding from Nigeria's space agency has initially played a role. However, the founder of SPAEL primarily describes this as a window of opportunity to establish an independent institution to build 'capacity from within' without relying on occasional unidirectional research collaborations with foreign partners. His window of opportunity was the launch of NigeriaSat-1:

And when it was launched I was commissioned by the Federal Government of Nigeria to validate that satellite for the forestry sector and it was that challenge that led me to/that motivated me to establish [SPAEL] (...). And after I trained [assistants] I then took them to the field for the work and that proved to be a very effective approach. (Interview 53, 17.02.2016)

SPAEL now autonomously collaborates with transnational organisation, such as the European MESA programme, and has received grants from different national and regional institutions. Part of SPAEL's capacity to build capacity is a challenge for postgraduate students that is set by collaborating organisations. As already mentioned in the case of Shell, such challenges are considered a win-win situation, where students gain capacity, whilst programmes like UNEP get scientific results. However, this time it takes place at an institution that has developed in the local GIScience situation (Interview 53, 17.02.2016). SPAEL shall hence in the long run lead to an extended network that holds further capacity to build capacity (Interview 22, 27.11.2015). Though SPAEL is a relatively small laboratory, it allows for collective SRP and capacity building, which many individual knowledge brokers find yet difficult to achieve. For example, part of their collaboration with MESA comprises the implementation of E-stations that allow to download timely processed EO-derived environmental data (Interview 53, 17.02.2016). I was invited to

participate in a related workshop that was attended by researchers from participating institutions across West Africa. In the context of such capacity to build capacity, one of the involved researchers from Ile-Ife contrasts the level of freedom that SPAEL enjoys to other local institutions, whose policies often hold back capacity building (as discussed):

He [the founder of SPAEL] has some level of freedom to decide who works with him (...). People can give him suggestions and advice, but the other is like/is in geography, ARCSSTE-E, is very complex environment : makes things difficult. (Interview 22, 27.11.2015)

In terms of capacity building, having ‘little’ but being independent is by many researchers considered more beneficial than being held back by structural dilemmas that affect various institutions. When one researcher at RECTAS envisages his own laboratory and acknowledges some potential dependence, this dependence relates to SRP, where organisations from abroad might be able to provide some of their ‘outdated equipment’, data and books (Interview 24, 07.12.2015). Building capacity in GIScience will always require a certain level of successful SRP, as he reminds. He emphasises that their special relation to the field on ground is eventually based on high technologies in outer space. Teaching the practice of ground truthing would hence only be convincing if one has complementary technologies in the field:

For example, I want to go to the field. I am teaching remote sensing, the electromagnetic wavelengths and I do not have radiometre. So, it will be a little bit hard or difficult for that trainee to grab it, when now I am saying that there is radiometre at seven-hundred kilometre above my head that is recording something and converting it into digital values that you can display as an image. (Interview 24, 07.12.2015)

### *Consultancy*

Others become independent by establishing their own GIScience-related consultancy services. Though commercial, they are part of capacity building. The company of one emeritus professor, for example, ‘specialises in economic and environmental research’ and distributes ‘high-end equipment’ to institutions across Nigeria, such as imported printers and digitisers. Furthermore, some researchers from universities are involved in his consultancy, extending the network of knowledge and eventually capital brokering in GIScience in Southwest Nigeria (Interview 65, 29.02.2016). Some researchers would appreciate if more commercial capacity can be transferred to their non-commercial research institutions – in exchange for a coffee – as one geographer in Ile-Ife states with a touch of gallows humour (Interview 5, 18.03.2016).

## The existential dialogue – research, the public and spatial literacy

Researchers eventually consider any capacity development only of long-term value if Nigeria's society and policymakers will at some point appreciate this capacity and will set a climate that allows for more stable relations with the global GIScience arena. They are not only aware of their own conflicting experiences with the use-value of expensive satellites (chapter six) but appreciate a need to communicate their research to the public. They do not consider the public short of knowledge about remote sensing and GIS (deficit model) (Sismondo 2010, 174-179), but most researchers see their social world short of the public. One researcher at one of the regional institutions tells me about their weekly radio programme *Space Talk* that they broadcasted via a local radio station in 2013/2014 to talk about their work:

I wish it was on now. I could have invited you to come over, but you know. But we did that for good two years and it really helped a lot to (distribute) information on what the technology could do. (Interview 26, 16.12.2015)

Whilst researchers use the verb 'enlighten' in this context, they aim at bringing the public on board rather than imposing their applications. For example, his colleague explains that the programme was also used to inform the public and other scientists where they can gain spatial knowledge and scan maps:

You can go in the entire land of this small time and not find a place to get a scanner to scan an A0 sized map, but we have here. (Interview 51, 08.02.2016)

Advocating GIScience is about communicating technologies that have certain capabilities in addressing societal issues. To build their own capacity in advocating GIScience and space research, knowledge brokers emphasise that they regularly expose themselves to transnational platforms, such as ISPRS and the International Astronautical Congress, though only few have means to attend their conferences abroad.

### *Establish dialogues*

Bringing the wider public and local governments on board also means to establish dialogues between those who provide spatial products and those who shall see value in them:

The only thing is now at the end of the research there is need for us to dialogue with the border patrol or the security people and let them see the value of that kind of research. (Interview 58, 24.02.2016)

(...) [Pipelines] pass through gutter and you have this gutter where people's waste also flows. (...) When we are able to produce maps to show all these anomalies it will be a way to getting government to be alive to its responsibilities (...) /we are making the society to feel the impact of our research. (Focus Group 10, 30.03.2016)

Environmental conservation in particular is considered an area where the benefits of GIScience can be demonstrated through dialogue. For example, in the context of the UN-REDD programme (chapter one), GIScience is perceived as a potential basis that allows researchers to show local communities how they can economically benefit from their forests (Interview 22, 27.11.2015). Remote sensing and GIS shall become part of a dialogue that can revive the value of Nigeria's natural heritage for those, who in the eyes of many researchers have lost much appreciation of their forests (Adeyoju 1981, Oyediran 2004, Oyelaran 2011). However, for this envisaged capacity, GIScience as a social world that is well-integrated in different Earth sciences and vice versa, is probably a prerequisite. Some senior researchers doubt that this has already been achieved. Demonstrating GIScience from below, hence also means to widen the GIScience base that can support dialogues with society. Social media begins to play a role in this respect. One younger knowledge broker runs his own advocacy group for remote sensing and GIS on Facebook. He emphasises his independence from Africa's EO associations, that in his eyes do not reach the future GIScience generation (Interview 26, 16.12.2015).

### *Society's spatial literacy*

Many researchers emphasise that GIScience can only be a means to re-establish the relevance of spatial data in national decision making if capacity building includes the promotion of *spatial literacy* from an early age onwards (Interview 65, 29.02.2016). A significant number of researches suggest that any sustainable path for GIScience in Nigeria begins at school:

If your interest is in waste management, I will package an application that/even if you are in secondary school, you will understand the value of geospatial science. (Interview 58, 24.02.2016)

One book that is used in Nigeria's secondary schools does already include a 'GIS section', as one of the co-authors explains<sup>97</sup>. He suggests promoting spatial awareness even earlier, in elementary schools. It could then dovetail with related capabilities that we all possess since our early childhood, as he beautifully reminds:

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<sup>97</sup> For example Areola et al.'s (2014) book *Comprehensive Certificate Geography* for schools in Nigeria includes a brief 'Introduction to GIS'.

When you are young you move around, you crawl around the house, you trace your back and forth. Now that is where the idea of geoinformation started. (Interview 60, 24.02.2016)

When researchers envisage a society that is 'literate' in geoinformation, they refer to the future of GIScience in relation to 'societal benefits'. Whether GIScience in Nigeria has a future in this context might depend on nothing less than the collective appreciation of our position in a universe of spatial vastness and complexity:

Even among the educated elite. That knowledge [that] ['we are just a component of what we call space'] is not there. (...) But when we get to a point where governments and research institutions like our own begin to educate people on the social (application) of understanding space in general, then we can hope to be making impact on the society along that line. (Focus Group 10, 04.04.2016)

In other words, the future of GIScience in Nigeria is considered in relation to society's appreciation of spatial literacy for any guided development, as they shall benefit from remote sensing and GIS in the first place. This includes the army that as of early 2016 had not been able to locate the over two hundred schoolgirls that had been kidnapped in Northeast Nigeria in 2014 (Ross 2014), as one geographer emphasises:

That is why everybody in this country must be geoinformatics literate. (...) What will be the advantage if I locate my activities there or there? (...) (Interview 60, 24.02.2016).

Whilst this position might in parts be evocative of the deficit model (Sismondo 2010), researchers are aware that they appreciate GIScience-related societal benefits in the first place. Notwithstanding discourses on political failure in Nigeria and missing institutional appreciation of GIScience (which seems to paradoxically affect Nigeria's own space agency; chapter six), most researchers will eventually look for responsibility amongst themselves:

We need to understand why we should spend money on outer space. (...) Several times I have organised seminars for Nigerian legislators, senate, house of reps, the committees on science and technology, just to let them know why this is good. They are politicians, they might not be scientists, and even if they are, we might need to remind them. (Interview 15, 06.11.2015)

GIScientists eventually point at an inclusive project that encompasses the whole society – perhaps the biggest agora of all.

## Conclusion

GIScience in Southwest Nigeria is not only constructed through a collective transdisciplinary understanding of how a global GIScience arena looks like, but what this arena constitutes in relation to a researcher's local agency towards remote sensing and GIS. This has further led to a collective appreciation of how medium-term capacity building can look like in Southwest Nigeria beyond any macro-comparative perspectives (chapter two) that have not yet yielded the suggested capacity (chapter six).

Based on their training at institutions in the wider arena, individual researchers have not only become knowledge brokers, but exercise a unique responsibility in transferring and integrating knowledge upon returning to Southwest Nigeria – as 'capacity to build capacity'. The ground-based scarcity in GIScience, as experienced by returning knowledge brokers and any other researcher in the situation (chapter six), sets the framework for envisioned capacity building. Knowledge brokers constitute the main sustained links, as institutional relationships with the wider arena are often disrupted by virtue of the local GIScience situation itself. Capacity building then first of all means to maintain capacity by working for a routine in relation to the wider arena. What I refer to as Scouting Resource Provision (SRP), is a central practice of maintaining capacity, where researchers actively scout for relevant elements along experienced networks:

I was asking her [a colleague] the progress of her work. It was yesterday and she said she needed some imagery without which she will not be able to advance in her work. (...). And you know there are some of us that have a way of getting around our problems, perhaps, maybe some of this high resolution imagery that you will actually need to do your work, when you look at the challenges of acquiring them, you find a way of looking for alternatives. (Interview 14, 04.11.2015)

Against this background, the actual capacity building follows a 'down to Earth' approach that builds on SRP. It, in the first instance, is oriented towards making GIScience functional by building capacity to build capacity through largely independent knowledge brokering, small-scale technological developments and the use of any *adequate* technologies that are available (such as UAVs). Knowledge brokering then means to take responsibility for the situation by creating a basis for capacity development that goes beyond SRP and collaborative problem-oriented knowledge production – the experienced long-term vision of knowledge brokers. At the same time, they experience at least a basic need of funding and collaboration with the wider arena, and likewise keep an eye on working for related *reciprocal* relations. Their current focus on more independent small-scale developments

and applications primarily is a pragmatic ‘down-to-Earth’ approach that does not live up to a researcher’s long-term scientific aspirations in a wider GIScience arena.

#### *Existing remote sensing data – the heart of capacity building*

The case of Radar image interpretation indicates that the objective of preparing the ground for capacity towards GIScience technologies, can be embedded in coexisting objectives of eventually participating in the global arena by means of specific knowledge-related contributions. Researchers are aware of their situational limitations and first of all aim at adding use-value to existing data. Adding value to existing remote sensing data has for most researchers become the prime objective in medium-term capacity building, supported by collective calls for spatial data infrastructures. In other words, capacity building means to prepare local ground for *participation* in the wider arena through increased research outputs and method development (Radar).

#### *The agora shall triumph*

At the same time, such goals are considered in need of collective efforts. GIScience in Southwest Nigeria has not only been constructed as a social world that has epistemically disentangled itself from an ever-complex ground, but that has much potential of being further integrated into Earth sciences and vice versa. Researchers envision centres that can bring together different disciplines and allow GIScience to become a common ‘liberatory’ ground in relation to urgent developmental questions (Hollick 1982). They seem envisioned as temporary *inclusive heterotopias* – as opposed to what some researchers (including myself) have experienced as exclusive heterotopias, where international organisations like IITA have realised their own well-equipped research utopia in Southwest Nigeria (Foucault [1967] 1986). At the same time, these centres shall develop in accord with what knowledge brokers have experienced as an *agora* during their training abroad. The centres shall at some point lose their status as heterotopias – once the agora has triumphed in terms of societal impact and societal participation (the long-term objective).

Here, the construction of GIScience in Southwest Nigeria is neither tied to a geographical location, nor to a specific group-related identity but should be considered in relation to an amalgam of experienced places that create their own spatial references to the wider GIScience arena – whether in Enschede, Ibadan or Ile-Ife. Whilst one place that has played a significant role for capacity building in Southwest Nigeria, is physically located in Europe (ITC in Enschede), it is not simply a capacity building institution in a

developed country. It is a place, where learning knowledge brokers experienced how scientists from all over the world join a productive *agora*. In this agora knowledge production is not only appreciated as a collective and constructive process in relation to various developmental and environmental issues in different places on Earth (Nowotny et al. 2003), but EO satellites have become a shared liberatory medium in this respect, that fades away the dichotomy of developed/developing – at least for a moment. This institution (ITC) has their own related vision of an ‘ideal situation’ for a global GIScience arena:

The ideal situation in terms of capacity development I think would be when people don’t need us anymore, when we have trained so many people that they can do it by themselves. (Interview 97, 08.09.2016)<sup>98</sup>

The long-term capacity building objective of returning knowledge brokers indeed is the construction of GIScience in Southwest Nigeria as a stable *agora*. Here, the envisioned centres are not only well-equipped *locales* (temporary inclusive heterotopias) in a developing GIScience/Earth science agora but are perhaps situated between different ‘truth spots’ that Gieryn describes as places ‘of provenance’ in relation to ‘putatively universal claims of science’. Truth spots are geographically, architecturally and rhetorically constructed, allowing for the ‘passage from place-saturated contingent claims to place-less transcendent truths’ (Gieryn 2002, 113). The envisioned centres resemble Gieryn’s second truth spot. Gieryn describes the works of Albert and Gabrielle Howard at the Indore Institute of Plant Industry in India in the early 20th century, where they had implemented their ‘holistic theories of agriculture and inclusive science’ by bringing together scientists from different disciplines as well as cultivators. Disciplinary boundaries had been economically broken down into a seamless ‘place of display, demonstration and performance’, such as in relation to composting. In this truth spot knowledge is made credible by being observable to visitors (Gieryn 2002). My dialogue partners have collectively argued that the future of GIScience will eventually further depend on how society can be included through dialogues, where the arena must not wait for society to appreciate GIScience:

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<sup>98</sup> Looking at increasing local capacity in many developing countries, ITC intends to eventually cease basic training programmes (such as technical diploma) in the Netherlands and focus on developing advanced capacity in new technological developments, which they expect to be beyond the capacity of most emerging economies in the foreseeable future.

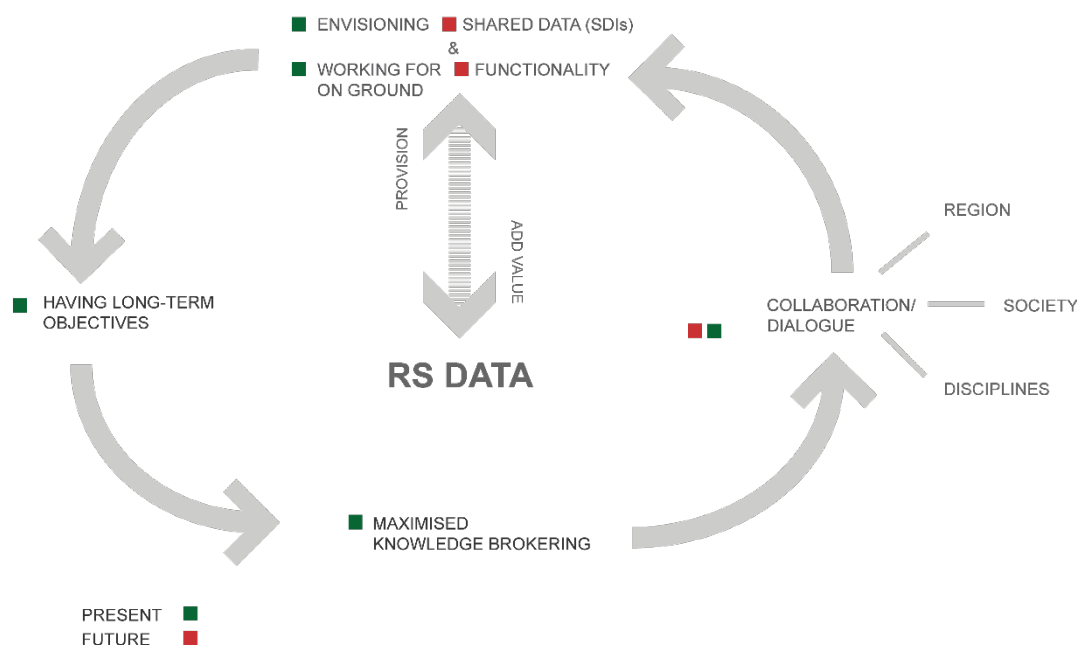


We are not just interested in acquiring knowledge for the sake of acquiring knowledge but how will this knowledge (impart) on people positively, especially in this part of the world. (Interview 93, 20.04.2016)

Only time will tell whether the envisioned centres can eventually be created as open and publicly observable places of GIScience practices that together can constitute a GIScience/Earth science agora in Nigeria (also in consideration of contemplations on how indigenous knowledge can be integrated; chapter five). For now, any envisioned collective capacity follows Scouting Resource Provision, small-scale technological developments and applications, as well as maximised knowledge brokering to further prepare the ground for capacity building, as capacity to build capacity. This focus becomes a cycle of *appropriate action* that has been constructed in relation to collective experiences between GIScience in Southwest Nigeria and the wider arena. Here, adding value to remote sensing data is the short- to medium term primary objective. This cycle can be illustrated as follows (Figure 33). The concluding chapter (eight) will further discuss this capacity building situation

### TAKING APPROPRIATE ACTION - A MICRO LEVEL PERSPECTIVE FROM SWN

CAPACITY BUILDING IN GISCIENCE IN SW NIGERIA  
BASED ON EMPIRICAL DATA/ D.THORPE 2018



**Figure 33** Taking appropriate action – capacity building in GIScience in SW Nigeria (by author of thesis 2018).

in relation to theories of development and modernisation. In addition to theoretical implications, it will also discuss ethical and practical implications that go beyond the global GIScience arena.



# Chapter Eight

## Discussion: *Ground Truthing* of Space-based Earth Observation Activities in a Postcolonial World

The only thing is that within our planet, there is gonna be the survival of the fittest. But the world claims that it wants everybody to go together. (...) If our planet is going to be helped, a lot more of scientific research studies will have to be encouraged. (...) Our centre for example, is supposed to be an international organisation, one will expect that some people would have come and say, 'please can you help us work in this area'. (Interview 9, 22.10.2015)

Much is at stake between low Earth orbit and Earth's ground in terms of social and scientific values. This concluding chapter discusses the theoretical and practical outcomes of this research to further address this relationship. GIScience in Southwest Nigeria has been constructed as a distinct social world in all its multi-sited and un-sited facets. Remote sensing and GIS is appreciated as a shared liberatory language that my dialogue partners have encountered in different places and have learned to appreciate in relation to personal and science-related experiences at the intersection of their social and natural environments. It allows them to regain responsibility for uncontrolled developments on local ground. The remotely sensed environments amongst others are places where my dialogue partners have grown up and have been doing research. Remote sensing and GIS have set these places in relation to other places and spaces of knowledge production, and for me to related discourses on science and technology in a postcolonial world (chapter three and four). Before discussing the empirical data of this research in relation to (post)-development theory and postcolonial science and technology studies, the first part of this concluding chapter will focus on the practical implications of this research.

The first section reflects on chapter five, on how the field on ground in Southwest Nigeria constitutes a base for the integration of remote sensing and GIS that is distinct from any modernisation narratives and the mere proclamation of an advantageous point of view from space. It looks at the policy positions that underlie the transfer and implementation of GIScience by recalling how GIScience researchers situate themselves against other actors and understand their role in relation to society (sub-research questions one and two). This includes a discussion of how remote sensing and GIS does not simply disconnect researchers from the (alleged indigenous) field, but how researchers use these technologies to reconfigure their ailing relationship with the field. In the second section, I will reflect on researchers' related agency and discuss how this situation might constitute

a paradox in relation to capacity in GIScience (chapter six and seven). This will be followed by discussing the value of a heightened awareness of this paradox. In analogy to the practice of ground truthing in GIScience, I suggest that appreciating the lived experiences of researchers on ground in a more systematic way may constitute an opportunity to figuratively calibrate the use-value of distant EO satellites. In a metaphorical sense, this calibration should be understood in relation to specific social *truths* on ground that constitute GIScience in Southwest Nigeria as well as other relevant social worlds. In other words, I suggest to work on additional tools that can assess the actual use-value of EO missions and can help in guiding relevant policy decisions in EO research beyond institutional and business reports in a yet often uncoordinated and bureaucratic EO and space science environment (Neil 2017). Finally, the second part of this chapter will discuss this situation in relation to post-development theory and PCSTS. I will answer whether such a calibration, might be implicitly impeded by some theory and social scientific methodologies towards science and technology in a postcolonial world. For this discussion, I will focus on an extended agency in the GIScience situation (chapter seven) by taking a second look at how researchers address resources that they use to support their objectives and formulate additional positions towards capacity building. Based on this, the final section will argue that GIScience is located between the poles of different determinist methodological and theoretical perspectives that all are valuable in relation to various cases, but cannot directly account for the actors, policy positions and agency in GIScience in Southwest Nigeria.

## The Field as a Base for Space-based Remote Sensing

The implementation of remote sensing and GIS in Southwest Nigeria has been all but a linear and determinist process. Neither can the beginnings of GIScience be related to a national space agenda, which in the 1970s did not yet exist, nor can it be contextualised in frameworks, such as the space technology ladder or any other linear explanations that now exist in literature on space science and EO in developing countries (Wood et al. 2012). The integration of GIScience into Earth science disciplines in Southwest Nigeria has its foundation in long-term experiences of individuals that by most younger researchers are valued as their ‘pioneers’. These pioneers had first encountered remote sensing in a wider global arena and have eventually promoted the use of an aerial and space-based perspective in Nigeria through personal relationships with institutions and researchers abroad. This integration has not only taken place despite various institutional barriers, but up until today the pioneers of this integration continue to play a central role as knowledge brokers in capacity building. Though RECTAS did likewise promote an aerial perspective

from 1972 (Ogunlami 1993), this UNECA-backed regional capacity building centre has not played a decisive role in first integrating GIScience in Earth sciences.

Furthermore, any initial appreciation of remote sensing and GIS by researchers who currently use these technologies, builds on individual interests and encounters that eventually introduce remote sensing and GIS as a choice. This choice usually only becomes meaningful in relation to a researcher's experience with Nigeria's social and natural environment. Based on this, researchers developed a collective understanding of what these technologies mean in relation to their disciplines and interests. This goes beyond a simple appreciation of GIS as a transferred 'research tool' (Goodchild 1995). Remote sensing in combination with GIS, is appreciated as a tool that allows researchers to occupy an elevated perspective. However, it is not simply an aerial vantage point, as it is occasionally described in literature. The appreciation of this perspective is based on individual experiences with 'conventional' methods of data collection and analysis in relation to unbridled processes at the intersection of Nigeria's natural and social environment. In this situation, not only the complexity of processes that have to be analysed does increase, but also the financial and physical burdens of going to the field. Researchers have described the tedious work of physically accessing rural areas due to missing infrastructural development and environmental depletion, which in turn promotes social conflicts and insecurity (Omeje 2006). Furthermore, the new vantage point is also appreciated in a historical context, where missing data on urban planning in a perceived unplanned environment can be partially accommodated by remote sensing data. Whilst topographic maps themselves constitute an important element in GIScience, the majority of maps date back to the 1960s and 1970s (Soneye et al. 2013, Ogedegbe 2014). Overall, those researchers, who eventually had the chance to use remote sensing data, have described EO satellites as technologies that allow them to regain responsibility for Nigeria's environment. GIScience has eventually become a tool that has the potential of ending a vicious circle in which a researcher's agency through conventional methods is deeply thwarted by the disorder on ground (as described by my dialogue partners) that most researchers intend to address.

Any potential post-development critique as related to a determinist understanding of technology transfer therefore does not do justice to social processes that support the integration of remote sensing and GIS as a choice (chapter five). However, at the stage of integration, a related critique at first sight holds true at an ethical level. In the 1990s, when the implications of GIScience became a discourse in industrialised countries, Curry argues that the huge amount of data that is generated, processed and accompanied by claims of universalisability, does lead to positivist assumptions and promotes an alienation of those who are the subjects of research – making people in the field the 'other'. The 'cartesian space and technical, chronological time', that Curry sees as the new dominant, could then

be paralleled to much of Nigeria's urban and rural environment that would benefit from an aerial perspective. According to Curry, the inhabitants of these environments are in danger of being reduced to powerless objects (1995, 78-79). Curry's related concerns about the potential neglect of what he calls the 'lived space, or place, and human or narrative time' (ibid.), eventually bring us back to the *locale* and indigenous, where the collective promotion of remote sensing data to primary data has been critically discussed by one geographer at the University of Lagos. However, also in his case, GIScience primarily is scrutinised in relation to its conditions of use. His reference to indigenous knowledge only signifies what in Curry's case is the *other*, which might be left out if the appreciation of remote sensing and GIS is carried too far. It is a reminder to not lose sight of environmental and social knowledge on the ground that remains invisible to any sensors onboard satellites. Only a new sensitivity to this knowledge could mitigate some of the challenges that researchers encounter on ground, such as the suspicion by villagers and missing historical data – which can induce any resort to remote sensing data in the first place (Interview 93, 20.04.2016).

All this means that remote sensing might not be as much a 'liberatory technology' as it seems to be (Hollick 1982). Whilst these concerns should be kept in mind, GIScience-related *liberation* is not simply a transferred narrative. In the case of Southwest Nigeria, any potential GIScience-related 'disenfranchisement' of humans on ground (Curry 1995) should be understood in relation to a researcher's specific encounters with the ground. Here, liberation is different from any implicit claims of superior 'expertise' that might be understood as supporting a deficit model, where GIScience researchers would consider themselves more literate about the environment than those who live in it (Sismondo 2010, 174-179). For example, when general literature on GIScience refers to potential difficulties in collecting primary and ground truthing data and hence suggests different methods of data classification (chapter two), these difficulties are considered contingent. In the case of Southwest Nigeria, challenges of data collection however are entrenched in the research object (such as urban areas) and objectives (controlled development) and hence in their appreciation of GIScience. In this case, difficulties in data collection and analysis cannot be reduced to temporal and economic aspects (de By et al. 2012, 262). In other words, in Southwest Nigeria, liberation must not be understood as mere improvement of methods and methodologies, such as in terms of quantity, precision and efficiency, as GIS has for long been promoted in industrialised countries (Pickles 1995, 6, 20-23). It neither simply relates to 'more and better information' for decision-making (ibid., 11). In Southwest Nigeria, this liberation is also not a mere modernist and positivist 'switch from knowledge to information', as Pickles phrases (ibid., 12, 18-22), and it neither reflects an 'unreflective GIS advocacy and an almost evangelical need to proselytize about the

geographical nature of GIS', that he criticises (ibid., 22). Though many researchers have a general interest in science, computers, astronomy and space, that has supported their engagement in remote sensing and GIS, these technologies in the first instance are appreciated for liberating researchers from Nigeria's ground-based intricacies, and for simultaneously allowing them to keep track of those uncontrolled developments that restrain their own capacity and guided policies in relation to Nigeria's environments.

## **Bring Earth Observation Back Down to Earth**

Any liberation is eventually diminished by the scope of restraining developments on ground. The words 'in this part of the world' have become a locational denominator for a collective experience of scarcity in GIScience, such as with regard to data, software and power supply. This experience is entrenched through a collective ambiguous experience with data from Nigeria's federal EO satellites. This situation is then further constructed through discourses on a lost institutional basis for research capacity in GIScience, eroded by societal and political values that had developed during post-independence military rule. In this situation, one may discern a paradox that affects the wider global EO arena.

### **The paradox of ground truthing in GIScience in Southwest Nigeria**

Remote sensing is appreciated in relation to ground-based methodological constraints that directly relate to Nigeria's urban and rural geography. In other words, EO satellites gain some of their legitimacy through the collective experience of GIScience researchers from Southwest Nigeria. At the same time, their access to remote sensing data is entrenched in those intricacies that have promoted their appreciation of remote sensing. This creates a double scarcity in relation to data from both the field and EO satellites. This paradox becomes more visible if one considers an ideal GIScience situation as it is reflected in the actual GIScience-related capacity that researchers have acquired and appreciated during their training. Though to a smaller extent, this situation still requires trips to the field to collect relevant primary data (de By et al. 2012) and data that relates to the practice of ground truthing (Bakx, Janssen, et al. 2012). This paradox is particularly visible when researchers from abroad, with their additional costs, such as for translators, nevertheless have sufficient means to access both the field in Nigeria and relevant satellite data, whilst those who have long-term relations to the field, usually do not. Whilst most researchers will nevertheless manage to meet both requirements, it will be a tedious process of carefully allocating resources and working with what is available in terms of data. The liberation is rather more theoretical than realised in a daily research context, and



constantly in danger, if the means to control relevant technologies seem limited (Hollick 1982). However, I suggest that an extended appreciation of the GIScience situations on ground can further put liberation into context and hold a mirror to a global EO community that aims at addressing global environmental issues. Liberation is a collective effort and GIScience in Southwest Nigeria has provided some valuable insights on how it can be achieved.

### **Ground truthing with the ground truthing paradox – policy recommendations**

In analogy to the practice of ground truthing, I suggest that we should likewise ground-truth the operation of EO satellites in relation to a research situation as it has been described in this thesis. Here, indigenous in the end has been a revealing notion. In chapter two, I had originally discerned the literature-based use of the term in relation to few constituent parts of GIScience, such as engineering and contributory knowledge. Though the ambiguous use of the term cannot be further explained, it remains useful as a sensitising concept. In Southwest Nigeria, researchers from various disciplines and social backgrounds share experiences with the field on ground, understand what EO satellites can do in this respect and share daily experiences in relation to both. Indigenous as a sensitising concept then helps to consider these experiences as empirical ground-based *truths*. They appear as lived experiences in a social world that aims at regaining responsibility for Nigeria's environment (Blumer 1954, in Bowen 2006, 2-3). In a relational understanding of indigenous (Kenrick et al. 2004, 9), these lived experiences can then actually become a knowledge base to improve the use-value of space-based EO missions. I thus suggest to take the paradox of ground truthing as a basis to argue that EO satellites, regardless of their commercial or national ownership, should be ground truthed in relation to what is simultaneously on ground in terms of relevant human agency towards the remotely sensed environment.

This means to pay closer attention to scientists' 'external conditions' ('working conditions') and their 'inward conditions' ('motivations') that Erickson (2002, 36-37) discusses with reference to Max Weber's (1948) lecture *Science as a Vocation* and his own research on science in the UK. Erickson contemplates on the yet missing appreciation of an understanding of how 'scientific work relationships' are constructed 'in the context of a workplace environment that reproduces key instabilities, and key imperatives, of contemporary capitalism' (2002, 53). Looking at GIScience in Nigeria, researchers experience limited institutional support (material base, including missing salaries), but nevertheless promote the transdisciplinary implementation of remote sensing and GIS through SRP and careful knowledge brokering. Here, the association of external postcolonial

conditions and inward conditions is yet largely overlooked in the wider EO policy arena, where capacity building is primarily considered through macro-comparative frameworks and institutional policies (chapter two). Erickson emphasises Weber's concern with 'tensions' in relation to the 'external constraints' that affect an 'individual' and their 'inner motivations' that deal with these conditions. These might be social and material constraints that thanks to their 'motivations' do not preclude scientists from practicing science (Weber 1949, 26-27, 1989, 3-4, in Erickson 2002, 37). I suggest that these tensions should become a focus of policymakers in EO to guide their policies in relation to capacity building. Despite the complex historical conditions, 'some major positive benefits' that incite GIScientists 'to persist in their work' (inward conditions), such as methodological liberation (chapter five) (Erickson 2002, 45), should be considered in relation to particular local situations. When Erickson refers to Weber's restricted understanding of a scientist's 'single-minded devotion' towards their work (*ibid.*), we find an experience-based devotion that drives GIScience in Southwest Nigeria. Borrowing Erickson's words, researchers 'make sense of what science [here GIScience] is by reference to their own work and motivations towards it' (*ibid.*, 48). These motivations comprise wider external conditions, such as policymakers' yet limited appreciation of spatial data – contributing to the 'character' of capacity building in GIScience in Southwest Nigeria (*ibid.*, 53).

Approaching indigenous knowledge from this angle, seems useful for the following reasons. Based on lived experiences in local GIScience, social and natural environments enter space research from a perspective that often seems overlooked when agencies, organisations, policymakers and academics talk about how EO can contribute to social and economic development once certain institutional requirements are fulfilled (see chapter two). Different collective experiences of agency towards those GIScience elements that researchers have described as essential for their liberation from ground-based methodological constraints, should be taken more seriously. This includes scouting resource provision (SRP), down-to-Earth capacity development and underlying social processes. This sensitivity could then be used in transnational negotiations over data policies and technological developments. For example, based on communication, such as in the context of SRP, conferences and publications, some actors in the wider EO arena will be aware that researchers in GIScience in Southwest Nigeria are increasingly interested in active sensors (Radar) and related local method development (Interview 21, 13.11.2015). However, a sensitivity for the situational context, in terms of how capacity building is envisaged and on which grounds, is yet missing. Whilst it is difficult to understand individual data distribution policies without further research, providers of Radar and other remote sensing data, do appear to distribute data based on hard-edged economic terms and in a hardly coordinated manner (Neil 2017). The reasons do actually not matter as in GIScience in

Southwest Nigeria, that has largely transcended any reliance on institutions, access matters.

Notwithstanding the agendas of various EO organisations and initiatives, such as AfriGEOSS, the prosaic economic reality of EO has become visible to me at conferences. First of all, observations and conversations have confirmed that any means that could capture the lived experiences of researchers in a structured way and render this information useful for the design of EO agendas, such as satellite missions, spatial data infrastructures, software development and capacity building, are largely missing. Only few channels of communication, such as publications and those of SRP, exist. Much communication with the wider GIScience arena is disrupted by virtue of the situation itself. For example, I had the chance to attend both the 2014 and the 2016 conferences of the African Association of Remote Sensing of the Environment. Whilst this is an important and valuable forum, where EO actors from Africa and other parts of the world come together, it remains exclusive. The founder of AARSE himself critically addresses the limited member base, and hence means to communicate collective positions and interact with policy-makers (Interview 94, 20.04.2016). Notwithstanding that membership amongst my dialogue partners is limited in the first place, most members from Nigeria were unable to attend AARSE 2016 in Uganda for economic reasons. Overall, this important association is yet limited in representing GIScience on the African continent. Furthermore, some African countries are completely unrepresented in the association and this was critically discussed at the latest conference. This seems a shared concern amongst EO organisations and initiatives on the continent. A geomatics expo in Uganda that was scheduled for 2018 is postponed to 2019 due to a low response rate, as I was informed via email.

Furthermore, whilst these conferences are a good platform to share research results, policy-related issues are still often discussed in a macro-comparative way, where major EO actors, such as Airbus and ISPRS, have the most visible platform. A plenary presentation by Airbus Defence and Space eventually showed me how naïve my policy-related suggestions might be. Listening to the presentation, I was reminded of the standardised response that I had received after my enquiry about TerraSar-X data for a local method development project. ‘Space is business, space is business’ were the words of the representative of Airbus after one conference participant had the chance to raise a concern about the costs of data. I felt caught up in a whirlwind of promotions of ever-new space technologies and programmes for Africa’s social and economic development, that remain largely disconnected from agency on ground. During a plenary session, one audience member made no pretence of his concern that all these EO programmes, that have been mushrooming for years, had so far largely failed. In an earlier interview at ITC I had told one of my dialogue partners about my related feeling that many global EO initiatives, such

as GEOSS, AfriGEOSS, ISPRS, MESA and those at UN-level, seem yet often uncoordinated, whilst making no visible impact at the micro-level – at least in Southwest Nigeria. My dialogue partner, a widely travelled researcher, confirmed my impression, as does Neil (2017) in relation to data. Neil argues that despite a ‘new level of claimed international cooperation in EO’ the management and distribution of ‘millions of data sets’ remains yet largely uncoordinated and ineffective. The UN’s (1986) thirty year old suggestion to grant developing countries access to EO data on their territories under reasonable conditions, to respond to disasters and prevent disasters, remains unfulfilled in the lives of most GIScientists in Southwest Nigeria. It does not matter that NASRDA operates EO satellites or indeed might have access to foreign commercial data, the end users of remote sensing data, who hardly have access, remain disconnected from any international agendas that yet often focus on institutional capacity and coordination through a macro-comparative lens, respectively framework, that aims at joining various stakeholder at different levels (AfriGEOSS 2018). Despite their value, these can neither account for the many social processes between individual actors and technologies (such as SRP), nor for discourses about capacity building (such as in relation to society) and my dialogue partners’ experiences of brokering. One overlooked experience that seems fundamental in relation to any EO agendas is mistrust.

During conferences I have learned what my dialogue partners mean by mistrust that they perceive on part of the wider EO arena. This mistrust has much to do with the lived experience of researchers, who in light of their time-consuming SRP face difficulties in meeting deadlines and in finding adequate data and licensed software. This threatens their credibility in the wider EO arena (Hwang 2008) and creates a vicious circle, where most collaboration is evaluated in quantitative terms. The more important it is to promote a new sensitivity towards agency in local GIScience arenas. Since Gall’s suggestion to critically assess the transfer of space science and technologies to developing countries, including her own country Mexico, any wider appreciation of local GIScience-related agency is yet often reduced to technical issues, such as research output, and institutional capacities. I argue that Gall’s following statement from 1983 reflects a wider perspective on capacity in GIScience in developing countries that is still common. Notwithstanding Gall’s accurate critique that the transfer of remote sensing and GIS does not automatically lead to social and economic development, and that the voices of the users of these technologies often go unheeded in policy-related decision making, I do not agree that this is based on a local ‘lack of insight into the relevance of the space technology’, neither can it be simply understood in terms of a ‘lack of local human and physical infrastructure’, as Gall implies (1983, 7). On the contrary, this research suggests that it is rather based on implicit ‘post-colonial arrogance’ (Ellen 2002, 246) on parts of a wider EO policy arena that often

reduces GIScience to developmental narratives and institutional issues, whilst overlooking not only the careful and experience-based integration of GIScience in Earth sciences, but also the independent agency of knowledge brokering, SRP and down-to-Earth capacity building. In other words, classifying Nigeria as climbing the space ladder, space pyramid or space tiers (Harding 2013, Wood et al. 2012), thanks to national EO satellites, does not have any meaning in the GIScience situation.

In summary, much valuable global EO research looks at people's environments for global development. From the perspective of GIScience in Southwest Nigeria, this yet involves an uncoordinated patchwork of researchers, programmes and institutions that in the case of IITA can even appear as exclusive heterotopias next door (chapter seven). The critical interface of GIScience researchers, the field and data from space, is still neglected in many ways. It is caught up in a whirlwind of space businesses, agencies and associations that are involved in EO research (chapter two). Relevant policymakers should be encouraged to find ways of further democratising EO. This should include communication, participation, equitable data policies and selective capacity development. A few global EO actors do already support free data, remote sensing and GIS software and promote online webinars (Turner et al. 2015). However, when global actors begin talking about the 'the role of norms of behaviour in African Outer Space activities' (UNIDIR 2013b) or indigenous space capabilities, they should make sure that they establish a dialogue with those people from Africa who have much to say about the EO-related future of outer space. High-profile conferences where these issues are usually negotiated should not remain the only platform. Furthermore, commercial satellite data providers could be encouraged to further extend their grants and run capacity development programmes.

Overall, in analogy to down-to-earth capacity building in Southwest Nigeria, this research suggests that EO satellites should be figuratively brought back down to Earth. EO data should gain value by looking at the particular in terms relevant agency on ground (Abu-Lughod 1991). One of the biggest challenges for a more efficient and democratic EO arena can then be found in the literature review of this thesis. Most relevant literature still refers to space science as an all-encompassing unit. Furthermore, having attended two conferences of AARSE, I have learned how EO is always just part of a wider African space arena. For example, AARSE appreciates that 'Africa is making major strides in space science and technology development' through national space programmes and EO satellite ownership and recognises that an 'African space coordinating mechanism is needed' (AARSE 2014a). Though I am likewise enthusiastic for space science in general, and even became involved in astronomy outreach during my stay in Nigeria, this research empirically indicates that policymakers might be well-advised to carefully disentangle EO from space science in a political and scientific context. Whilst for some researchers an interest

in space exploration has paved their way into GIScience or vice versa, they have eventually constructed a collective and independent understanding of remote sensing and GIS. Space becomes an advantageous geography (MacDonald 2007) to study both the beauty of and capitalist scars on Nigeria's ground and not the Martian polar caps. I hence suggest that *Earth* observation activities should neither be blindly set in relation to space activities in policy-relevant literature. For example, whilst the space ladder is a straightforward concept, it considers EO as just one milestone of space activities towards presumed socio-economic development (Wood et al. 2012). If EO is primarily treated as part of space science in the context of technology and knowledge transfer, it might indeed be not more than a modernisation narrative that is disguised by 'development jargon' – indigenous (Sillitoe 2002a, 109).

An all-encompassing understanding of space science seems too big for the current anthropogenic environmental destruction that this planet faces. Looking at the 'dynamic of interest in space technologies', promising EO initiatives, such as GEOSS, have not yet managed to spin off the development of global collective space-based environmental agency towards system Earth (Neil 2017). I do not say that Nigeria or any other country should not focus on other space sciences – on the contrary – but that for scientific purposes, EO should be institutionally emancipated as much as possible to pool capacity to build capacity. I do not talk about technological aspects but a clear and honest position by relevant actors towards their investments in EO missions. The case of GIScience in Southwest Nigeria does eventually point at potential up-stream and down-stream related policy confusions in a wider space science arena, where more and more EO satellites congest and eventually pollute low Earth orbit (MacDonald 2007), whilst not showing sufficient complementary *collective* human agency on ground to tackle environmental destruction.

### **The social worlds that can help calibrating EO for developing countries**

At this stage it is worth making some suggestions for further research. Based on situational analysis, various social worlds that intersect with the GIScience arena in Southwest Nigeria indicate that additional micro-level studies can be designed to guide policy decisions that can support bottom-up capacity development. A draft map of the most relevant social worlds and arenas that this research describes, can be found in the appendix (Figure 34). Most social worlds, such as EO data providers, are directly involved with GIScience, whilst others will hardly be aware of their related relevance. For example, multinational IT companies that produce equipment like plotters and manufacturers of energy-

generating technologies, like solar panels, will not be directly aware of their (latent) relation to GIScience in Southwest Nigeria.

Whilst researchers have developed their independent foundations for capacity maintenance and capacity building (chapter seven), the case of power supply remains intricate and should be studied in more detail. Nigeria's collective entrenched experiences of daily power outages seem to relate to feelings of impuissance. This is perhaps best reflected in Barros et al.'s statement, concerning Nigeria's 'vast supply of gas, coal, as well as solar and hydro resources', and yet constant shortage of power. According to Barros et al. this power situation has not improved for a decade despite various political measures (2014, 65). Whilst the potential of solar energy is increasingly discussed amongst Nigerian scholars (Oji et al. 2012), researchers explained to me that polluting generators remain the prime alternative to the grid in light of conflicting information about the costs of solar technologies, institutional opposition and a general societal distrust in solar technologies.

Another intersection that deserves additional attention is the following. Many researchers have argued that the future of GIScience eventually depends on how the public can be brought on board. This position provides many opportunities for research, such as from a public engagement perspective, where the valuable thoughts of one of my dialogue partners deserve more attention. Contemplating the methodological liberation through EO satellites, he suggests to nevertheless pay close attention to 'indigenous' knowledge as a source of information that should be integrated in GIScience. This could not only build people's trust in EO technologies, but eventually also ease a researcher's social access to the field (chapter five). Overall, all social worlds that I have mapped play their explicit or implicit role in maintaining and building capacity in GIScience. In line with this, they do likewise all relate to Scouting Resource Provision (SRP), where one of the most important resources is moral support from families and faith communities. In the end, they are all important in the process of ground truthing EO satellites from a social perspective, and hence in calibrating the ethical values of EO research in general and in increasing the use-value and legitimacy of EO satellites in a congested low Earth orbit that is dominated by satellites from industrialised states (UNIDIR 2013b, MacDonald 2007).

## A Universe of Postcolonial & (Post)-Development Orientations – African Science and GIScience in Southwest Nigeria

This discussion about a more ethical and balanced relationship between EO satellites in space and relevant agency on ground, will be followed by a discussion about whether some contemporary perspectives on high technologies and science in a postcolonial world inadvertently construct barriers in this respect – at least in theory.

### *PCSTS and the dangers of over-provincialisation*

With his idea of ‘provincializing Europe’, Chakrabarty (2000) has provided some valuable thoughts on how the challenging legacy of ‘European thought and history’, as embodied in various concepts, such as ‘the state’ and ‘scientific rationality’, can be reconsidered. Whilst Chakrabarty does not suggest that we should question these concepts, the notion of everlasting related ‘incompleteness’ in the margins of an imagined and perpetuated European ‘political modernity’, such as in colonial and postcolonial India, is challenged. Chakrabarty suggests emphasising issues of translation rather than transition in relation to a ‘capitalist modernity’, as they, amongst others, became visible in the ‘rebellions’ of peasants in ‘British India’. He thinks of ‘life-worlds’ that in many ways reveal fractures in the alleged universal manifestation of European Enlightenment, highlighting the limitations of supposed universal theories that for a long time have been considered capable of understanding and describing these life-worlds. This recalls Kenrick et al.’s suggestion of a ‘relational’ approach towards *indigenous* to highlight the plurality of both struggles and resilience in a postcolonial world. This plurality co-exists with the idea of modernisation and can primarily mean resistance. It does hence neither represent incompleteness nor developmental delay (Kenrick et al. 2004, Chakrabarty 2000).

As Chakrabarty emphasises, it is neither about questioning concepts like ‘scientific rationality’, nor social scientific concepts and theories that are associated with Western institutions (that Chakrabarty himself uses), but about acknowledging their narrow normative essence. However, as discussed in chapter four, postcolonial science and technology studies (PCSTS) tends to become a challenging reference to the alleged Third World in this respect. A southern standpoint can call attention to resilience and resistance towards a ‘Northern modernity’ (Harding 2008), but can at the same time create problematic dichotomies, such as a global South and global North. Here, understanding science and technology in a postcolonial world through a lens of ‘epistemological pluralism’ (Anderson et al. 2008, 186-187) can mask the messiness of technoscience, including the movement of ‘scientists, knowledges, machines, and techniques’ (Abraham 2006, 210).



Against the backdrop of various discourses that relate to modernisation theory, post-development theory and PCSTS (as an analytical perspective), it has proved valuable to provide an ‘empirical response’ in relation to science in those locations where political and knowledge-related alternatives to a Western modernity exist (Abraham 2006, 217). In the case of GIScience in Southwest Nigeria, positions towards the environment and capacity building, related knowledge, technologies and practices must indeed not be considered in relation to a geographically or geopolitically bound group, but to agency. Borrowing Abraham’s words, this agency is a result of ‘historically situated intersections of the political economy of place and unequal location within transnational circuits of knowledge flow’ (ibid., 211, 217). Whilst Western science and technologies are now often considered as being unidirectionally imposed on global communities, and are hence challenged through a new theoretical focus on indigenous knowledge and technologies, including national science traditions (such as Indian Science), this research highlights how such a perspective might overlook the agency of researchers in integrating individual technologies independent from national and transnational science and technology agendas, but based on experiences. It furthermore overlooks how researchers from the alleged periphery of GIScience contribute to the construction of ‘Western science’ – both actively and passively (ibid., 217). Whenever researchers from Nigeria meet in an agora-like environment abroad, they purposefully engage in problem-oriented and collective knowledge production. At the same time, upon returning as experienced knowledge brokers to Nigeria, they leave parts of the analysis of their environment to researchers from abroad as any realisation of an agora in Nigeria is impeded by the daily need to pursue SRP and down-to-Earth capacity development (chapter seven). Anything *Nigerian*, such as related indigenous space capabilities, might relate to discourses that have much to do with politics but are detached from the GIScience situation on ground (Abraham 2006).

I argue that the valuable idea of provincialising Europe must never lose sight of the postcolonial that manifests beyond the nation state or any geopolitical constellation. It can manifest in relation to a global natural environment that should not be provincialised or decentred. Related experiences and practices have already developed their own agora<sup>99</sup> that cannot be taken into account by any rigid understanding of place and culture (chapter seven). This has much to do with the legacy of colonialism, but points at a new postcolonial reality, that does not always leave space for resistance but can instead be characterised by daily struggles for preserving system Earth and hence resistance against losing control of developments at the intersection of urban and rural spaces. In other words, whilst relevant agency in GIScience in Southwest Nigeria is embedded in postcolonial political

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<sup>99</sup> (Nowotny et al. 2003)

struggles, the foundation of using remote sensing is constructed through individual experiences and encounters that eventually point at postcolonial issues that are implicitly considered too big for dispersed alternative forms of knowledge production and technologies. These are the experiences of those who eventually have encountered a relevant agora abroad (Nowotny et al. 2003), in which various environmental and socioeconomic issues are represented by scientists from all over the world and are translated into a collective appreciation of EO satellites and relevant knowledge exchange. These experiences then indeed become a form of collective resilience that allows researchers in Southwest Nigeria to address ‘their relationships with land, resources and other peoples’ (Kenrick et al. 2004, 9), as they have been described in chapter five.

Overall, whilst provincialising Europe is an important objective, the many different ‘life worlds’ in a postcolonial world are not always easy to locate. ‘Incompleteness’ in many cases indeed is a dangerous understanding that conceals the concerns of groups, such as farmers who are dispossessed of their lands, including direct resilience towards exogenous developments that might be of political nature (Kenrick et al. 2004). However, in GIScience in Southwest Nigeria incompleteness actually is a daily collective experience as related to researchers’ resilience towards postcolonial ecological dislocations. It is constructed through the experience of knowledge brokers who translate between GIScience in Southwest Nigeria and a global GIScience arena in this respect. This, however, requires some further explanation.

#### *Modernity and a pseudo-cognitive divide*

First of all, the following discussion cannot live up to the complexity of discourses on modernity, nor to how my dialogue partners and Nigeria as a political entity, relate to modernity and postcolonial conditions in a larger historical context. At the same time, the GIScience situation in Southwest Nigeria should be tentatively discussed in relation to the ‘standardization projected by capitalist globalization’, that Jameson suggests as one ‘fundamental meaning of modernity’ (2002, 12-13). Whilst a widely discussed ‘African kind’ of modernity, as one of many alternative modernities, should first of all be considered a valuable perspective, it must not distract our attention from the possibility of using a capitalism-related *modernity* for an explanation of standpoints on the African continent (ibid.). This means to go beyond arguments that in alleged non-Western societies, ‘the particular cultural legacies (...) call for different trajectories of modernity than those of Europe and North America’, where an African modernity would indeed appear in a ‘cultural guise’ – ‘fetishiz[ing] difference’ (Dirlik 2013, 7). Though in a different context (development projects), Ellen actually relates social research to this criticism [1] and

articulates one of my conclusions with regard to GIScience and relevant technologies in relation to the theoretical opposition that they face as ‘incoming’ technologies or knowledge practices (Mavhunga 2014) [2]:

[1] We accept there is a discourse and a set of concepts which are sufficiently shared to enable the common pursuit of understanding and the forming of judgements whose standing can be measured against data. [2] Most of us also accept science-driven development for ourselves, so when it comes to ascertaining the correct balance of science and indigenous knowledge in projects in less developed countries, we have to be careful that we do not deny to others what we would accept for ourselves. (Ellen 2002, 249)

In other words, the situation as it is described by GIScience researchers must not be related to *Western* discourses on indigenous capabilities, culturally appropriate technologies, or even to alternative modernities, when neither can be grounded in empirical data. Whilst attributions like ‘here in Africa’, ‘we Africans’, ‘in your country’ and ‘white people’ have been frequently used by my dialogue partners to locate and describe their agency and must be taken seriously as they further point to important issues in postcolonial discourses, they entail interpretation-related dangers on my part. I hence suggest to carefully distinguish between my dialogue partners’ place *in* and standpoint *towards* the global economy and arena of science and technology. Here, mentioned attributions do not necessarily embody the ‘cultural difference’ that they might suggest. The danger is to ‘serve to perpetuate an invidious and pernicious social and pseudo-cognitive divide’ (Ellen 2002, 249) and to give in to an ‘obsession with cultural difference’, where we seem to discern such in our data. This will distract our ‘attention from urgent structural questions of social inequality and political injustice that have been globalized with the globalization of the regime of neoliberal capitalism’, as Dirlik argues (2013, 6). This includes ‘ecological destruction’ (ibid., 8) and paradoxically the experienced *incompleteness* of GIScience in Southwest Nigeria. My dialogue partners do not only address such ‘ecological destruction’ and globalised ‘inequality and political injustice’, but their agency towards remote sensing and GIS is affected by nothing less than the implications of the neoliberal capitalism that they confront. Here, Dirlik reminds that global claims for science and technology must be taken seriously:

Claims to difference notwithstanding, societies cross the globe look to science and technology for the resolution of these contradictions. In other words, despite all the problems with it over the last three centuries, the assumptions of capitalist modernity – *Euro-modernity* – have become integral to the consciousness not only of the Europeans who produced it but the world at large – as is suggested by the claims to alternatives. (Dirlik 2013, 36; emphasis in original)

When GIScience in Southwest Nigeria is constructed through the consequences of Euro-modernity, what then can PCSTS look at and on behalf of whom (chapter four)? PCSTS

has much value if it takes an ethnographic approach towards science and technologies and does not from the outset relate these to specific understandings of socioeconomic and cultural affiliation. This might otherwise conceal places and social worlds of knowledge production that have their own standpoint towards science and technologies in a postcolonial world. This includes places in industrialised states, such as ITC, that are better known in the alleged developing world than in their actual geopolitical location (Europe) (chapter seven). Approaches like Harding's southern standpoint, that is related to a pluralistic understanding of culture, place and knowledge, has much value if resilience and resistance have been clearly located and can be understood from there. The alleged peripheries of science and technologies (Hwang 2008), however, must not be identified as 'Indian', 'African' or 'Nigerian' from the outset, even if notions like indigenous suggest doing so (Abraham 2006).

With reference to the questions that have been posed in chapter four, current perspectives on science and technology in developing countries are indeed often in danger of inadvertent 'postcolonial arrogance' (Ellen 2002, 246). Even where the social foundations of 'Western science' are acknowledged, contrasting the latter to peripheral science or other knowledge practices that take place outside the geopolitical unit of industrialised states, seems indeed dangerous against the backdrop of this research (ibid.). GIScience is a matter of 'inequality and political injustice' that is negotiated with reference to various places in and outside Nigeria, including heterotopias like IITA in Ibadan. In a relational understanding this means that within PCSTS and (post)-development theory, the idea of epistemological pluralism and 'alternative visions' of modernity might from time to time be carried too far, ignoring the own *Western* social scientific (including PCSTS) and developmental work in the first place (ibid., 249). Furthermore, *appropriation* of GIScience technologies and knowledge in Southwest Nigeria, has a different meaning than in much post-development literature, as does the accompanying term appropriate. This will be discussed in more detail in the following.

#### *Post-development and a determinist focus on appropriation*

Most non-human elements in the GIScience situation, such as data, indeed are political. They are not political in the sense of design, where technologies might be purposefully designed to exclude certain groups, but rather in the sense that the 'power of things (...) lies in their associations', as Johnson (pseud.) argues (Winner 1980, Johnson [pseud.] 1988 in, Joerges 1999, 414). This means that in the context of capacity development in Southwest Nigeria, there is a soft-determinist touch that is not easy to overcome in the case of data and technologies (EO satellites, GIS and GPS). The GIScience situation moves much

data out of reach for various reasons, such as missing data infrastructure, power outages and political issues. Any enthusiasm for space-based remote sensing can hence give way to small-scale technologies that operate close to the ground, such as UAVs. Research objectives and methods are then usually adapted ('tailored') to what is available in terms of technologies and data – the point of *incompleteness* as it is constructed in relation to the wider arena. This is in contrast to industrialised countries and heterotopias like IITA, where resources are either already available or can be acquired or produced, as human and financial resources do not need to be spent on elements that are taken for granted in a Western context – including cooled air. In this context, the practice of SRP (chapter seven) describes intermediate steps that are required towards participation in the wider GIScience arena. Their capacity for innovation is then often subordinated to their work for routine.

In line with this, capacity building first of all means to make the ground functional for 'incoming' EO technologies that remain the prime means of addressing our collective 'ecological destruction' and globalised 'inequality and political injustice' (Dirlik 2013). In this context, appropriation is largely limited to semi-local solutions, such as regarding power outages and software. Relevant technologies, such as handheld GPS, spectrometers, scanners and plotters, are in the first place acquired as a blackbox. Capacity building includes the aim of looking inside the blackbox<sup>100</sup> to gain an in-depth understanding of the inner workings of GIScience technologies. This includes knowledge transfer to develop CubeSats and software in Nigeria. At the same time there is no immediate and inherently local solution if these technologies fail, beyond what can possibly be repaired without the original spare parts. For researchers in Nigeria, it is a priority to guarantee that the designed functionality of technologies is maintained and adheres to knowledge and technology-related experiences that have been acquired in a wider GIScience arena.

Whilst valuable research has described how technologies like mobile phones are appropriated and domesticated, 1) how their functionality can be adapted to local social and economic structures, 2) and how broken technologies are innovatively repaired despite missing spare parts, presupposing these practices in developing countries from a social scientific perspective, might distract attention from what is at stake for users of other technologies in other social worlds and arenas. In the first case of appropriation, GIScience technologies, data and knowledge are already considered *appropriate*, to the extent that they are regarded as an amendment to 'traditional' and disciplinary methods for an adequate understanding of their physical environment that has been severely impacted by a capitalist modernity. They are neither considered a replacement for existing

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<sup>100</sup> I do not mean this in the direct sense of STS research, such as SCOT, where we can aim at understanding the social genesis of technologies (Pinch et al. 1984).

technologies, nor are they considered untimely for the Nigerian context, except for Nigeria's own EO programme, as many researchers suggest. In the second case, it is not in the interest of researchers to replace faulty parts of instruments with available but potentially corrupting materials. The use of cracked software is an exception in this case, as long as it does not corrupt the results. Little repairs, such as taping and wiring, should not be understood as appropriation or even bricolage, neither should the programming of software. Capacity building takes place in relation to a larger arena. In a published lecture in 1992 the emeritus geography professor Adeniyi points out that this arena contains 'several developing countries, especially those in Asia and Latin America [that] have successfully adopted the technology and are applying it for their national needs', whilst most African countries had not yet appreciated this 'revolutionary technology' (1992, 1-2). This has become a continuous collective position amongst those who promote GIScience as liberatory for local research with universal applications in mind.<sup>101</sup>

For example, persistent cloud cover in the South of Nigeria is a problematic issue as most accessible data originates from passive sensors that are not able to penetrate clouds. One Nigerian researcher suggests to hence build local capacity regarding Radar satellites and develop relevant methods of data analysis in relation to specific physical features and socioeconomic fingerprints on Nigeria's ground. These can then be transferred to the wider arena. The related long-term objective of leaving behind the role of a mere recipient of technologies, however, is reciprocal in nature. It builds on relevant technology and knowledge transfer from the wider GIScience arena, whilst any *appropriated* method development in relation to Nigeria's environment shall in turn be applicable all over the globe. This means to add value to Radar data, such as from TerraSAR-X, to perhaps even contribute to the development of sensors, and to eventually have a 'voice in the field' (Interview 21, 13.11.2015). Whilst in this case, developments are indeed intended to be locatable in Nigeria, relevant knowledge is considered as universally applicable (Kuukkanen 2012).

I hence refer to Hollick, who more than thirty years ago cautioned against a careless use of the idea of appropriate technologies, which is further promoted through Western middle classes that call for the worldwide use of DIY and 'arts-and-crafts' movements (Hollick 1982). As important as these movements are from an ecological perspective

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<sup>101</sup> This is significantly different from my experience with other technologies, such as automobiles that have indeed been appropriated to socioeconomic aspects (Bellucci et al. 2012). For example, some cars have a button installed. The location of the button is only known to the driver. It needs to be pressed every few kilometres as the engine otherwise stops running. This feature has been developed in order to reduce the number of stolen cars, as my host explained to me. Here, the major difference is that GIScience technologies and knowledge operate in a different framework (arena and social worlds). GIScience technologies can of course at some point be appropriated outside the GIScience situation (once they have become inappropriate in the latter).

(whether in relation to development theory or Western middle classes), they overlook the ecological crisis that some groups want to address with technologies that have already been constructed and constantly observe their lands. In line with this, I follow Hollick when he suggested that...

...[m]aybe the time has come to try to develop a theory of appropriate technology that avoids the worst of these cultural biases and permits a blend of big, small, and middling. Such a theory would have to be built upon a deep understanding of human needs – both individual and social – that could accommodate wide cultural variations. (Hollick 1982, 228)

*Ethical dilemma for EO and post-development theory – question of agency*

Against this background, there are some ethical dangers for the supposed centres of EO and for social sciences. One danger is to not sufficiently acknowledge the agency in the presumed peripheries of GIScience that is directed towards participation in global GIScience. Not only the notion of technological determinism has lasted long in relation to the African continent (Macola 2016), but no other part of the world has been more widely related to the ‘stigma’ of technological and scientific failure, as one staff at ITC added for consideration. He expressed his concern that whilst, from a European perspective, there usually is much confidence in science, technology and innovation (STI) in other parts of the world, sub-Saharan Africa still often is perceived as having not much ground in this respect. This stigma is confirmed by many African scholars (for example Titanji 2001, Mavhunga 2017). The danger for scholarly and developmental work is then perhaps best illustrated by recalling three major perspectives on STI and Africa.

1) Like many of my dialogue partners, several scholars from sub-Saharan Africa argue that they still miss a well-established ‘scientific/technological culture’ on the continent (Titanji 2001, 127). With optimism and occasionally a bit of pessimism, the promotion of such a culture is supported by development-oriented literature, such as on innovation systems (Lundvall et al. 2009). 2) On the other hand, many scholars criticise a modernisation paradigm (even if only latent) and argue for a focus on appropriate technological development and related or independent indigenous knowledge (Dibua 2006, 165). 3) Whilst both perspectives can be found in literature from the African continent and from outside, Mavhunga relates these to a specific appreciation that most social scientists had with regard to STI and Africa. He distinguishes five turns in this respect. The first turn began around 1900, with functionalism and structuralism à la Malinowski and Lévi-Strauss. In the current fifth turn, STS scholars ‘order African empirical evidence’ according to their understanding of STI. Their focus is on scientific and technological ‘inbound forces’ from the West and their biographies on the African continent. With a pinch of

rhetorical irony, Mavhunga argues that the *Western* focus on ‘Western-derived phenomena’ on the African continent nevertheless has value for conversations about that which complicates lives on the African continent. However, if they consider Africa at all, most STS studies and other research would portray Africans as the recipients of technologies, as victims, as appropriators that focus on ‘tinkering’ without ‘initiative or inventing anything’ (2017, 6-8). Mavhunga perhaps refers to bricolage, where Africans would be portrayed as using ‘what is already made’, which Mavhunga deems a Western perspective that supports the ‘lazy narrative’ (Mavhunga 2017, 6-8, Lévi-Strauss 1966). Mavhunga’s aim is to tell a ‘positive African story’ by focussing on dedicated ‘Africans’ with ‘their own philosophies, and alert to the world around and beyond them as a source of things that they render technological’ (2017, 5, 8). This means to neither define technology, science nor innovation too narrowly, and as Mavhunga suggests go beyond STS perspectives with their positivist baggage. Looking at complex colonial encounters Africans should from the outset be understood as ‘coauthors of a knowledge store monopolized through imperialistic power’ (ibid., 1-8).<sup>102</sup>

Mavhunga’s arguments in the first instance provide a good base to articulate some concerns in relation to post-development theory and PCSTS. Based on my discussion in chapter three, I agree that a large amount of literature on present-day STI situations on the African continent is determinist in terms of both a focus on either development focus or appropriation. At the same time Mavhunga’s (2017) critique of appropriation studies remains vague, and he later himself refers to important studies on ICT and mobile phones, where Africans should be portrayed as changing mobile technology rather than the other way around (ibid., 18-19). What do these three perspectives then mean for this research? This research fortunately does not portray GIScience researchers in Southwest Nigeria as victims and has neither applied a lens through which Africa simply appropriates. This directly relates to my second extended argument.

Proactive agency can be found in a situation in which my interview partners have indeed often described themselves as being recipients of technologies and knowledge. The issue is then about how we define agency and ‘initiative’. In GIScience in Southwest Nigeria, agency goes beyond the mere use of technologies or knowledge from abroad. It must be considered in a larger context. SRP shows that the GIScience situation in Southwest Nigeria primarily restrains innovation as much energy is needed for the maintenance of a daily research routine. Researchers, who use transferred technologies, are neither victims in this particular case, nor mere recipients. Furthermore, based on SRP, researchers elaborately build capacity through a ‘down to Earth’ approach to make GIScience

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<sup>102</sup> See also Macola (2016) in *The Gun in Central Africa: A History of Technology and Politics*.



functional by building independent capacity to build capacity. Individual knowledge brokers, who have been trained abroad, actively engage in the transfer of knowledge, in the promotion of small-scale technological developments and in the use of any relevant technologies that are available (such as UAVs). Knowledge brokers take responsibility for the GIScience situation by creating a basis for capacity development that in the long run allows them to collaboratively produce knowledge with the wider GIScience arena (chapter seven).

Mavhunga's perspective and that of some of his colleagues, like Dibua and Macola, takes place at a different important level that relates to a larger historical context. At the same time, such a perspective can neither account for every 'African'. Mavhunga's approach primarily relates to epistemological questions in a pluralist understanding, where Africa is the largest unit. It is not about STI in a wider universal context and neither about what 'STI transferred or diffused to Africa means to Africans', as Mavhunga emphasises. It rather is about alternative African meanings of STI (Mavhunga 2017, 1). However, when Mavhunga calls for a related 'self-determined African path to the future', we should also acknowledge what Mavhunga calls 'elitist' 'bench science', that he describes as having its origins outside the continent, detached from Africa's villages and streets (ibid., 1, 9-10). These villages are eventually affected by the consequences of a capitalist world in which my dialogue partners use existing 'science and technology for the resolution' of all the messiness and 'contradictions' that the 'capitalist modernity' has brought about, including urban sprawl, deforestation and oil spills (Dirlik 2013, 36).

On the one hand Mavhunga poses important question over narrow STI perspectives in African policies, and with reference to the work of his colleague Daniels suggests that Africans should not blindly focus on a Western 'STI and development trajectory', but should find its own (2017, 27). Writing about STI and Africa indeed means *incompleteness*. The danger is to portray STI on the African continent in a narrow way and hence overlook much agency (outwith development-oriented literature that tends to take STI for granted). However, considering Mavhunga's emphasis on 'Africans as intellectual agents and as thinkers, creators, and doers of technology' (ibid., 7) then also means that postcolonial and post-development discourses must not overlook the standpoint of GIScientists. The dangers of falling back to the STI-related 'stigma' of Africa that much postcolonial literature actually wants to avoid, became obvious to me in my own research situation. In the context of situational analysis and a multi-sited ethnography, I could for example have shifted my focus on church communities as a different social world that became most visible during my research. In relation to Mavhunga's concerns, this could even unintentionally have portrayed my interview partners as 'victims' of transferred technologies with an emphasis on 'spiritual comfort', whilst Christianity itself has a complex transcultural

history in Nigeria.<sup>103</sup> Most researchers are members of both social worlds. At the same time enforcing a relation to GIScience would be problematic, and indeed overlook that both social worlds also coexist in industrialised countries (Toumey 1991). Whilst one geographer at the University of Lagos is concerned about the suppression of indigenous knowledge and spiritual beliefs in GIScience in Nigeria, he primarily argues that any beliefs shall be brought back on the side of primary data that can contain useful information to *supplement* remote sensing data:

So, it is very, very possible to integrate indigenous knowledge into GIS, into remote sensing and GIS, especially in this part of the world. (Interview 93, Geography UNILAG, 20.04.2016)

This highlights how PCSTS and post-development theory is incomplete without considering *science* and high-technologies.

## Conclusion – Theoretical Determinism

I want to look at the local problem in this local environment because if I can solve a local problem (...) possibly somebody in the UK may also benefit from it. (Interview 22, 27.11.2015)

Everybody who applies this technology has the passion for it to achieve goals (...). To be able to get to that level where you can be on a par with your contemporaries from advanced communities. It is true. (Interview 51, 08.02.2016)

Looking at PCSTS, all revised perspectives on STI have their strengths, such as in addressing complex questions over the relationship between imperialism and Western science and technology, challenging Western epistemologies, highlighting the impact of local knowledge and technologies on Northern science and technology, questioning development practices, and thinking about alternative STI policies in ‘Third World states’ (Harding 2011). However, as this research shows, pluralist PCSTS perspectives on ‘multiple modernities with their multiple sciences’ (ibid.) can be carried too far and actually distract attention from postcolonial places and spaces in which knowledge is constructed and carefully brokered for particular reasons.

For this research, Abraham’s (2006) call for more research on science in the alleged peripheries of knowledge production has indeed proved the most valuable perspective. It has allowed me to understand the construction of GIScience beyond presumed cultural or group-related ‘homogeneity, coherence and timelessness’ (Abu-Lughod 1991) and beyond deductive theoretical perspectives of determinist modernisation, dependency and

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<sup>103</sup> Dirlik describes spiritual comfort as something that ‘provide[s] identity in a world of consumption that threatens to erase it’ (Dirlik 2013, 36).

alternative developments. This research shows that we should be cautious to not accidentally sustain colonial perspectives whilst aiming at being postcolonial. Whilst an empirical and theoretical focus on alternative forms of knowledge production is valuable, my concern is that with an overly essentialist understanding of Africa, we might lose sight of groups in this alleged non-*West* that produce knowledge and use technologies in a different epistemological arena. GIScience researchers address the long-term social, economic and environmental implications of colonialism, not by opposing related technological and scientific consequences, but by instead participating in them with often unrecognised agency and rationales. At the same time, much theory paradoxically seems in danger of inadvertently denying people in the global South access to wider arenas of science and technology. This is the case whenever the West has been provincialised at too many levels (Chakrabarty 2000). This is not in the interest of my dialogue partners. They see careful participation in a modernity that relates to worldwide capitalism (Jameson 2002) as the most powerful agency to address its severe implications. Instead of resistance towards science and technology, they oppose becoming subalterns in another era of global inequality in which knowledge production and technologies now also relate to spaces that once more are largely under the physical and power-related purview of industrialised countries – low Earth orbit, where most EO satellites operate (MacDonald 2007, UNIDIR 2013b). In other words, the transfer of science and technology must not be theoretically reduced to modernisation agendas. Instead, local agency in relation to experiences with environmental issues that directly relate to a colonial past, should be emphasised.

This research has led to some questions that should be further considered within PCSTS. Whilst events that have led to postcolonial situations need to be reassessed, including postcolonial development agendas (Escobar 2011, 281), I suggest that we should pay equal attention to agency that is directed towards addressing this situation through science and technology. A few authors like Escobar (1991), who are concerned about much development anthropology, argue that large parts of the world implicitly *resist* science and technology (as understood in the West). What, however, happens when scientists in the ‘Third World’ (as Escobar himself generalises) describe their daily environment as incomplete? In Escobar’s words this might be a problematic use of ‘Western standards as the benchmark’ (2011, 274-275) – calling for a provincialisation of GIScience (Chakrabarty 2000). However, this research argues that it would be dangerous to consider the perceived situational scarcity as exemplary for modernisation agendas, with alternative practices as the only solution. The danger is to overlook purposeful agency in relation to transferred STI that has developed in the situation by means of knowledge brokering and against all institutional odds (chapter seven). Postcolonial perspectives are occasionally in

danger of denying large parts of the world this benchmark, which Ellen pointedly describes as ‘postcolonial arrogance’ (2002, 246).

A *Western* benchmark is indeed in many ways problematic. However, when post-development theory implicitly denies people their agency towards this benchmark, in cases where it is constructed as relevant, then the misrepresentation takes place at a different level: the (hard) sciences on the African continent are subordinated, if not ignored, and biased narratives about Africa’s space science (chapter two) are supported as are those on Africa as an STI-detached continent, that Mavhunga and others aim at avoiding (though in a different context). If PCSTS is serious about the impact that Africa and other parts of the world had on science in the West, then it should likewise acknowledge contemporary scientific agency that is directed towards the globe. Calls for emphasising indigenous knowledge to counter collective experiences of the oppressive colonial past should not be considered as a more valuable alternative to the implicated ‘research as we know it’ (science) (Odora Hoppers 2011, 392), but as coexisting means. Indigenous knowledge in GIScience is external knowledge that can be integrated (chapter five), whilst the life-long knowledge of researchers is a social base for their participation in science.

The idea of an agora (chapter seven) (Nowotny et al. 2003) indicates how postcolonial theory is in danger of maintaining a simple centre-periphery model of global science. ITC in the Netherlands, as one of the temporary social worlds, where researchers from Nigeria have become knowledge brokers, has for a long time resisted becoming part of a ‘self-referential system’ of Western science (Hwang 2008, Disco 2010). Furthermore, ITC’s own development as a knowledge-related agora has only been possible through the commitment of researchers from all over the world, who have shared their experiences, such as about environmental concerns. I hence share Hwang’s concerns, who suggests to take into account the mutual relationships between the cores of knowledge production and the alleged peripheries of science, where people maximise their scientific agency, whilst emphasising their limitations (Hwang refers to Korea) (2008, 129). I actually suggest going one step further and questioning the classic understanding of a scientific periphery. In consideration of SRP and down-to-Earth capacity building, the agency in GIScience in Southwest Nigeria goes beyond ‘efforts’. It is characterised by determined capacity maintenance and development, independent from institutional and national structures. Simple accounts of dependency do not live up to the biographies of researchers, who have become knowledge brokers and do not work for any simplified form of GIScience, but for temporary solutions that, in the long run, have a reciprocal relationship with the wider arena. Dependency only holds true if we ignore all the lived experiences of researchers that make GIScience meaningful in the first place.

Against this backdrop, improving the use-value of EO satellites will only work if we take into account ground-based *centres of experience* to overcome the limited sensitivity towards what GIScience means in a global context in a yet largely uncoordinated arena. Who is to blame? – no one. Since the 1960s, EO and GIScience has been implemented at a pace at which developments on ground can unfortunately not catch up in ethical, social and legal terms (Stuart 2009, UNIDIR 2013b). Though most of my dialogue partners are indeed critical of national EO agendas, one researcher, who is more involved in the engineering aspects of space science, told me about his great frustration, when the supposed centres of knowledge production reduce science and technology on the African continent to small-scale developments. Whilst such developments shall set the basis for capacity building, researchers do aim at not losing sight of one day becoming an equitable member of a global GIScience/space arena. He remembers, how on the date of our interview, he read an article by a ‘Western journalist’, who argued that Nigeria could channel resources for development by shrinking their space programme. On the one hand my dialogue partner sees some substance in such arguments, in that...

...it is logical at face value that we do not need a space programme in a country like Nigeria, that it is a luxury, ultimately that it should be the purview of people of lighter skin. (Interview 15, 05.11.2015)

He, however, also expresses how he is tired of the experience that Nigeria must ‘justify every scientific thing’ in terms of socioeconomic impact, whilst showing such impact takes time. He is also tired of hearing that Nigeria is considered repeating what the centres have already provided.

Overall, if we *prima facie* tie knowledge to culture and place, a focus on the local might sometimes paradoxically lead to a neglect of a *particular* – of ‘individuals in time and place’ (Abu-Lughod 1991). One should be cautious of dichotomising the local into a developed local, which can be largely understood by means of *normal* STS research and a developing local, where science and technology is always considered different (Abraham 2006, 214-215). All postcolonial and post-development perspectives are important, but none can account for every individual in the capitalist world, with its natural environments that perish in front of our eyes. In particular scientific and technological contexts, such as presented in this research, related understandings of geography and culture, and Africa in particular, can seem overly static. Researchers come together from various communities, including religious backgrounds and refuse to be isolated from the West for transnational objectives (*ibid.*, 217). *Africa* is not simply Africa, as one of my dialogue partners beautifully reminds, when remembering his capacity building-related trip to Botswana:

My stay in Botswana was an eye-opener for me in terms of/it was a new environment for me/in terms of the culture, their language. (...) I need to really know a lot about their environment and I think all together it really helped me to learn how to relate with people from other/from other ways of other countries. (...) And that is why I really want you to applaud you for coming all the way from your area to Nigeria to come and see actually what is happening in this country. (Interview 56, 23.02.2016)

Against this background, I hope that this research has contributed to, in Abraham's words, further counter the occasional 'provincialism prevailing among western scientific gatekeepers, their sense of the limits of the "normal" scientific community, and their fixed expectations of those who lie beyond it' (2006, 214-215).

### *Post-development*

A critical post-development perspective does of course remain valuable, but should neither be confined to 'small-scale, simple, low-cost and labour-intensive technology' (Dibua 2006, 149), nor to those technologies that are only sustainable if they 'originate from the cultural and ecological realities' of a given society (Dibua 2006, 164). GIScience in Southwest Nigeria uses technologies at a different level with their own 'cultural and ecological' reality. Here, agency is directed towards *access* to distant high-technologies, regardless of their ownership and origins. The incoming technologies are already appropriate as long as they comply with the capacity that researchers have learned to appreciate as knowledge brokers in the wider arena or as their students. In terms of appropriation, only the situation in which the technology is applied, shall be changed by means of down-to-Earth capacity development. The empirical data of this research hence also supports the early positions of some senior knowledge brokers, like Areola, who already in 1986 suggested to focus on 'user-capability', the acquisition and storage of data and 'the creation of a socio-political climate that values and places due emphasis on adequate data collection and evaluation in all aspects of development planning' (1986, 4-5). This down-to-Earth approach should be further acknowledged in the wider GIScience arena without being distracted by Nigeria's official EO programme, which plays a subordinate role for my dialogue partners.

Overall, both modernisation and post-development perspective appear overly determinist in relation to GIScience. On the one hand, GIScience in Southwest Nigeria is confronted with what I call full development determinism. Global EO initiatives often overlook important social processes and agency in relation to the triangle of EO data, researchers and society. Despite bottom-up initiatives (such as workshops), they still lack an appreciation of primary capacity building goals and related networks of agency, where

researchers actively debate one-directional determinist technology transfer/leapfrogging, such as in the case of Nigeria's satellites:

They gave birth to us, they gave us the independence and we want to enter the space era, USA has reached, or France has reached. You cannot jump all those developmental processes in the society. (Interview 24, 07.12.2015)

At the same time, from a post-development perspective, GIScience is confronted with constructivist determinism, when it overlooks experience-based claims<sup>104</sup> for capitalist science and technology, and marginalised GIScience in Southwest Nigeria in relation to Nigeria's physical and social environments as well as global science arenas.

Overall, whilst studies on the local appropriation of different technologies (including ICT) and on indigenous knowledge are important for various reasons, this research calls for a new appreciation of high-technology-based science on the African continent among those, who look at science and technologies from a social scientific perspective that is critical of modernisation. Much critique is justified, but PCSTS and accompanying post-development perspectives are occasionally in danger of entrenching Africa's STI-related 'stigma', whenever they presuppose to find anything but the continent's purposeful participation in *a* global modernity. This is not to say that researchers do not also participate in other arenas and social worlds, where other forms of knowledge play a role. On the contrary, almost all my dialogue partners hold different posts in faith communities. At the same time, they however also spend nights in their offices to participate in a global GIScience arena. Though this is not the symmetry that Mavhunga had in mind,<sup>105</sup> it is the post-colonial symmetry that this empirical research has brought to light, where different places of GIScience in Southwest Nigeria have a collective imprint of agency that is directed towards participation in a global GIScience arena. Through this they want to contribute to nothing less than Oyelaran's (2011) 'hope to preserve the environment' and should hence in relation to local communities be symmetrically appreciated in postcolonial research.

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<sup>104</sup> These claims first of all comprise careful small-scale leapfrogging, such as the integration of a spatial data infrastructure.

<sup>105</sup> SCOT and SSK applied to knowledge *from* the African continent (Mavhunga 2017).

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# Appendix I – Overview Interviews

Interview	Institute/ Organisation	Position	Location	IV Type	Date	Duration hh:mm
1	Department of Geography, Ile-Ife	Senior lecturer	office	semi-structured	13.10.15	01:14
2	ARCSSTE-E, Ile-Ife	Lecturer	office	semi-structured	15.10.15	01:03
3	Department of Geography, Ile-Ife	Lecturer	GIS lab	semi-structured	15.10.15	00:26
4	ARCSSTE-E	Senior scientific officer	office	semi-structured	16.10.15	00:50
5	Department of Geography, Ile-Ife	senior	office	semi-structured	18.03.16	00:30
6	Department of Geography, Ile-Ife	Technical officer	GIS lab	semi-structured	19.10.15	00:57
<b>7 (FG 1)</b>	Space Club OAU	Board members	office	mini focus group	19.10.15	00:45
8	ARCSSTE-E	Staff	office	semi-structured	21.10.15	00:41
9	ARCSSTE-E	Staff	office	semi-structured	22.10.15	00:52
10	Department of Geography, Ile-Ife	PG student	outside	semi-structured	22.10.15	00:52
11	Department of Geography, Ile-Ife	PG student	outside	semi-structured	23.10.15	01:17
12	Department of Geography, Ile-Ife	Lecturer	office	semi-structured	27.10.15	00:34
13	Department of Geography & ARCSSTE-E, Ile-Ife	Lecturer	office	semi-structured	29.10.15	01:36
14	Department of Geography, Ile-Ife	Lecturer	office	semi-structured	04.11.15	01:24
15	ARCSSTE-E	Lecturer	office	semi-structured	05.11.15	01:00
<b>16 (FG 2)</b>	Department of Geography, Ile-Ife	PG students	PG Room	focus group	09.11.15	02:16
17	Geoinformatics, Ile-Ife	Professor	office	semi-structured	10.11.15	01:11
18	COPINE	Staff	corridor	semi-structured	11.11.15	01:12
19	RECTAS	Dean of academics	office	semi-structured	13.11.15	00:27
20	RECTAS	Head of GIS	office	semi-structured	25.11.15	00:56
21	Department of Geography, Ile-Ife	PhD student and lecturer	office	semi-structured	13.11.15	01:03

22	Institute of Ecology and Environmental Studies, Ile-Ife	Lecturer	office	semi-structured	27.11.15	02:21
23	RECTAS	Lecturer	office	semi-structured	03.12.15	01:48
24	RECTAS	Lecturer	office	semi-structured	07.12.15	02:48
25	Institute of Ecology and Environmental Studies, Ile-Ife	PhD student	seminar room	semi-structured	15.12.15	00:49
26	COPINE	Scientific officer	GIS lab	semi-structured	16.12.15	02:04
27	RECTAS	Deputy Director	office	semi-structured	02.01.16	01:56
28	RECTAS	Lecturer	office	semi-structured	06.01.16	01:21
29	Department of Geography	Professor Emeritus	office	semi-structured	07.01.16	Not rec.
30	Department of Remote Sensing & Geoscience Information System FUTA, Akure	Senior lecturer	office	semi-structured	13.01.16	00:43
31	Department of Remote Sensing & Geoscience Information System FUTA, Akure	Lecturer	office	semi-structured	13.01.16	01:18
32	Department of Remote Sensing & Geoscience Information System FUTA, Akure	Technical officer	GIS Lab	semi-structured	18.01.16	00:59
33	Department of Remote Sensing & Geoscience Information System FUTA, Akure	Lecturer	office	semi-structured	18.01.16	01:21
34	Department of Remote Sensing & Geoscience Information System FUTA, Akure	Student	office	semi-structured	18.01.16	00:33
35	ARCSSTE-E	Student	Office at FUTA	semi-structured	19.01.16	00:45
36 (FG3)	Department of Remote Sensing & Geoscience Information System FUTA, Akure	Students	outside	focus group	20.01.16	01:42
37 (FG4)	Space Club, Akure	Students	lecture room	focus group	23.01.16	00:49
38	Department of Remote Sensing & Geoscience Information	Lecturer	office	semi-structured	25.01.16	01:13

	System FUTA, Akure						
<b>39</b>	Department of Remote Sensing & Geoscience Information System FUTA, Akure	Lecturer	office	semi-structured	25.01.16	00:38	
<b>40</b>	Meteorology, Akure	Professor	office	semi-structured	25.01.16	00:49	
<b>41</b>	Space Club/ Meteorology, Akure	President/student	outside	semi-structured	27.01.16	00:28	
<b>42</b>	CESRA/ Physics	Deputy Director Space Applications/ Lecturer	scholars lodge	semi-structured	27.01.16	00:44	
<b>43</b>	CESRA	Director	office	semi-structured	27.01.16	01:22	
<b>44</b>	RECTAS (NCRS)	Students	lecture room	group interview	28.01.16	01:04	
<b>45</b>	RECTAS	Student	GIS lab	semi-structured	29.01.16	00:48	
<b>46 (FG5)</b>	RECTAS (CESRA)	Students	lecture room	focus group	29.01.16	01:37	
<b>47</b>	Meteorology	Lecturer	office	semi-structured	29.01.16	00:47	
<b>48</b>	RECTAS	Lecturer	RECTAS Hostel Restaurant	semi-structured	26.01.16	01:22	
<b>49</b>	Former student DoG at OAU and GIS Consultant	GIS consultant	office	semi-structured	08.02.16	01:35	
<b>50 (FG6)</b>	COPINE	Staff	Lecture room Mathematics	focus group	08.02.16	01:06	
<b>51</b>	COPINE	Staff	GIS Lab	semi-structured	08.02.16	00:30	
<b>52</b>	Department of Geography, Ilorin	Professor	office	semi-structured	11.02.16	00:21	
<b>53</b>	DVC OAU/ SPAEL	Professor	office	semi-structured	17.02.16	00:25	
<b>54</b>	ARCSSTE-E	Staff	office	semi-structured	20.02.16	01:26	
<b>55</b>	CRIN (Cocoa Research Institute of Nigeria)	Analyst	library	semi-structured	23.02.16	00:49	
<b>56</b>	Department of Geography, Ibadan	Lecturer	office	semi-structured	23.02.16	00:26	
<b>57</b>	Department of Geography, Ibadan	Student	office	semi-structured	23.02.16	00:18	
<b>58</b>	Department of Geography, Ibadan	Lecturer	office	semi-structured	24.02.16	01:10	
<b>59 (FG7)</b>	Department of Geography, Ibadan	Students	GIS lab	focus group	24.02.16	01:01	
<b>60</b>	Department of Geography, Ibadan	Lecturer	office	semi-structured	24.02.16	01:01	

<b>61</b>	Department of Geography, Ibadan	Staff	office	semi-structured	25.02.16	00:57
<b>62</b>	Department of Geography, Ibadan	Lecturer	office	semi-structured	26.02.16	00:39
<b>63 (FG8)</b>	Forestry Research Institute of Nigeria FRIN, Ibadan	Staff	GIS lab	focus group	25.02.16	01:00
<b>64</b>	Faculty of Veterinary Medicine, Ibadan	Senior lecturer	office	semi-structured	29.02.16	01:11
<b>65</b>	Department of Geography, Ibadan	Emeritus professor	office	semi-structured	29.02.16	01:14
<b>66</b>	Department of Geography, Ibadan	Student	office	semi-structured	01.03.16	00:30
<b>67</b>	International Institute of Tropical Agriculture IITA, Ibadan	Staff	GIS lab	semi-structured	01.03.16	01:11
<b>68</b>	Department of Forestry, Ibadan	Lecturer	GIS lab	semi-structured	02.03.16	00:59
<b>69</b>	Department of Geology, Ibadan	Lecturer	office	semi-structured	02.03.16	00:44
<b>70</b>	Department of Geography, Ibadan	Lecturer	office	semi-structured	03.03.16	00:59
<b>71 (FG9)</b>	Federal School of Surveying, Oyo	Staff	office	focus group	07.03.16	00:49
<b>72</b>	Department of Geography, Ibadan	Lecturer	GIS lab	semi-structured	07.03.16	00:30
<b>73</b>	RECTAS	Staff	office	semi-structured	15.03.16	00:57
<b>74</b>	RECTAS	Staff	office	semi-structured	17.03.16	00:47
<b>75</b>	Department of Geography, Ile-Ife	Staff	office	semi-structured	21.03.16	01:13
<b>76</b>	NASRDA	Staff	hostel room RECTAS	semi-structured	21.03.16	01:03
<b>77</b>	Department of Geography UNILAG, Lagos	Lecturer	office	semi-structured	24.03.16	01:28
<b>78</b>	Department of Geography UNILAG, Lagos	Lecturer	physical lab	semi-structured	25.03.16	00:36
<b>79</b>	Department of Geography UNILAG, Lagos	Lecturer	office	semi-structured	25.02.16	00:39
<b>80</b>	GISKonsult	CEO	Guest house UNILAG	semi-structured	28.03.16	01:22
<b>81</b>	Department of Surveying and Geoinformatics UNILAG, Lagos	Lecturer	office	semi-structured	29.03.16	01:34
<b>82 (FG10)</b>	Department of Surveying and	Staff	office	focus group	30.03.16/ 04.04.16	02:09

	Geoinformatics UNILAG, Lagos						
<b>83</b>	Department of Geography UNILAG, Lagos	Lecturer	office	semi- structured	30.03.16	00:54	
<b>84</b>	Department of Surveying and Geoinformatics UNILAG, Lagos	Professor	office	semi- structured	31.03.16	00:35	
<b>85</b>	Department of Geography UNILAG, Lagos	Lecturer	office	semi- structured	31.03.16	00:28	
<b>86 (FG11)</b>	Department of Geography UNILAG, Lagos	Students	class room	focus group	02.04.16	00:50	
<b>87</b>	Department of Surveying and Geoinformatics UNILAG, Lagos	Lecturer	HOD office	semi- structured	05.04.16	00:36	
<b>88 (FG12)</b>	Department of Geography UNILAG, Lagos	Students	GIS lab	focus group	06.04.16	01:20	
<b>89</b>	Department of Surveying and Geoinformatics UNILAG, Lagos	Lecturer and Sub-Dean	office	semi- structured	07.04.16	01:10	
<b>90</b>	Department of Geography UNILAG, Lagos	Professor	office HOD	semi- structured	05.04.16	01:05	
<b>91</b>	Department of Geography UNILAG, Lagos	Lecturer	office	semi- structured	08.04.16	00:56	
<b>92</b>	ESRI	Staff	outside	semi- structured	15.04.16	00:52	
<b>93</b>	Department of Geography UNILAG, Lagos	Lecturer	office	semi- structured	20.04.16	01:57	
<b>94</b>	Department of Geography UNILAG, Lagos	Emeritus pro- fessor	office	semi- structured	20.04.16	01:42	
<b>95</b>	Department of Geography UNILAG, Lagos	Professor	office	semi- structured	21.04.16	00:48	
<b>96</b>	ITC, Nether- lands	Academic staff	office	semi- structured	07.09.16	Not rec.	
<b>97</b>	ITC, Nether- lands	Academic staff & coordinator	office	semi- structured	08.09.16	00:37	
<b>98</b>	ITC, Nether- lands	Academic staff	Cafe-teria	semi- structured	09.09.16	Not rec.	
<b>99</b>	ITC, Nether- lands	Academic staff	office	semi- structured	09.09.16	Not rec.	
<b>100</b>	ITC, Nether- lands	Academic staff	office	semi- structured	12.09.16	Not rec.	
<b>101</b>	ITC, Nether- lands	Academic staff	office	semi- structured	13.09.16	Not rec.	
<b>102</b>	ITC, Nether- lands	Academic staff	office	semi- structured	15.09.16	Not rec.	
<b>103</b>	ITC, Nether- lands	Academic staff	office	semi- structured	16.09.16	Not rec.	

**Table 3** Overview Interviews.



## Appendix II – Invitation to Participate in Research

# Invitation to participate in my PhD research (Daniel Thorpe)

## Science and Technology Studies

The University of Edinburgh

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### **Purpose of research:**

In the context of my PhD studies I aim at learning about the implementation of (space-related) geospatial information science research in Southwest Nigeria to, inter alia, promote more equitable discourses on the development of a sustainable, collaborative and future-oriented global Earth-observation community. This research also aims at further developing and reviewing theories and methods in science and technology studies (social science).

### **What is involved in participating?**

I am pleased to invite you to participate in my research. I would be delighted to ask you some questions about your work and/or studies and to also hear about other aspects in your life that are important to you. Please respond in a way that is most convenient to you, and please feel free to also ask me any questions you may have. If you wish, I will anonymise your name, your age and any other identifiers (personal information).

### **Withdrawal from participation:**

You may at any time withdraw from my PhD research. You do not need to give me any reason.

### **Use of interview data:**

I will use the data to write my PhD thesis. I shall also provide researchers from Southwest Nigeria with analyses upon request.

Attached please find a **consent form**. Here, I will ask you (1) whether you allow me to audio-record the interview, (2) whether I shall anonymise the interview, and (3) whether the data may be shared with other genuine researchers or not.

The data will only be used for academic purposes.

### **Details of research:**

My research is supported by the UK's *Economic and Social Research Council (ESRC)*.

My project is supervised by *Dr Lawrence Dritsas* and *Dr Eugénia Rodrigues*.

### **Please send any complaints to me:**

Daniel Thorpe (M.A., MSc by Research), Doctoral Student

Science, Technology & Innovation Studies

The University of Edinburgh  
Chrystal Macmillan Building  
15a George Square  
Edinburgh EH8 9LD  
Scotland/ United Kingdom

e-mail: [D.Thorpe@ed.ac.uk](mailto:D.Thorpe@ed.ac.uk)

Yours faithfully,

Daniel Thorpe

This invitation is based on a template by the UK Data Service.

## Appendix III – Consent Form

# CONSENT FORM

## PhD Research by Daniel Thorpe

Daniel Thorpe (M.A., MSc by Research), Doctoral Student  
Science, Technology & Innovation Studies  
The University of Edinburgh  
Chrystal Macmillan Building  
15a George Square  
Edinburgh EH8 9LD  
Scotland/ United Kingdom  
e-mail: [D.Thorpe@ed.ac.uk](mailto:D.Thorpe@ed.ac.uk)

Please initial box

1. I confirm that I understand Daniel's invitation to participate in his PhD research and that I have had the opportunity to ask questions.
2. I understand that my participation in Daniel's PhD research is voluntary and that I am free to withdraw at any time, without giving reason.
3. I understand my personal details will not be revealed to people outside the PhD project.
4. I agree to take part in the above research.

Please initial box

- |   | Yes                      | No                       |
|---|--------------------------|--------------------------|
| 5. I agree to the interview being audio recorded.   | <input type="checkbox"/> | <input type="checkbox"/> |
| 6. I agree that my words may be quoted in Daniel Thorpe's PhD thesis and possible publications:   | <input type="checkbox"/> | <input type="checkbox"/> |
| 6.1 Daniel may use my name and other personal information, such as gender, age and institutional affiliation in his PhD thesis and potential publications.                    | <input type="checkbox"/> | <input type="checkbox"/> |
| <b>or</b>   |                          |                          |
| 6.2 Daniel may only use <b>anonymised</b> quotes (my words) in his PhD thesis and potential publications.   | <input type="checkbox"/> | <input type="checkbox"/> |
| 7. I agree that <b>anonymised</b> transcripts of the interview may be stored in a specialist data centre and may be used for future research.                                 | <input type="checkbox"/> | <input type="checkbox"/> |
| 8. I understand that other genuine researchers will have access to this data only if they agree to preserve the confidentiality of the information as requested in this form. | <input type="checkbox"/> | <input type="checkbox"/> |
| 9. Please feel free to add any additional suggestions for Daniel on the reverse side of this document.  |                          |                          |

_____	_____	_____
Name of Participant	Date	Signature
_____	_____	_____
Name of Researcher	Date	Signature

This consent form is based on a template by the Oxford Brookes University and by the UK Data Archive.

## Appendix IV – Interview Questions

The three subsidiary research questions have been addressed by asking the following questions during semi-structured interviews (depended on interviews).

### Question I

- How would you describe your area of interest?
- How would you describe your area of work/studies?
- How have you got involved with your work/studies?
- Who has been important for your current work?
- Who is important for your current work?
- How have other people accompanied your work?
- What else do you consider relevant for your work?
- What affects your work?
- What contributes to your work?

### Question II

- What are important aspects for you in our contemporary world?
- How would you describe work and research in general?
- What are important aspects of your work?
- What makes your work/research meaningful to you?
- Why do you do this kind of research?
- What research would you like to do in the future?
- How would you like to do your research?
- Who should be part of your research?
- What changes would you like to see in the future with regard to your research?
- What development would you like to see for your personal academic life?
- (Why is this aspect of your work important to you?)
- (How have your personal (non-academic) experiences influenced your work?)
- (How have your ideas and aims been influenced?)

### Question III

- How would you describe your working routine?
- How would you describe your working environment as related to your research aims and ideas?
- What is most important for you in order to achieve your ideas?
- What are your wishes for the future with regard to your working routines?
- How do you perceive your working environment in the future?

## Appendix V – West Africa Land Use/Land Cover Data, 1975-2013

Land cover classes	1975		2000		2013	
	Area (km <sup>2</sup> )	Percent of total area	Area (km <sup>2</sup> )	Percent of total area	Area (km <sup>2</sup> )	Percent of total area
Agriculture	192.948	21,09	298.084	32,59	379.628	41,50
Agriculture in shallows and recession	8.992	0,98	11.376	1,24	11.900	1,30
Bare soil	772	0,08	812	0,09	844	0,09
Bowe	224	0,02	224	0,02	224	0,02
Cropland and fallow with oil palms	1.628	0,18	1.888	0,21	1.820	0,20
Degraded forest	47.896	5,24	40.728	4,45	38.544	4,21
Forest	20.756	2,27	15.492	1,69	11.216	1,23
Gallery forest and riparian forest	30.184	3,30	26.148	2,86	23.312	2,55
Herbaceous savanna	3.504	0,38	4.480	0,49	3.372	0,37
Irrigated agriculture	1.384	0,15	2.820	0,31	4.620	0,51
Mangrove	9.716	1,06	9.648	1,05	9.348	1,02
Open Mine	108	0,01	112	0,01	228	0,02
Plantation	1.628	0,18	3.024	0,33	3.920	0,43
Rocky land	2.276	0,25	2.276	0,25	2.256	0,25
Sahelian short grass savanna	113.648	12,42	88.400	9,66	75.260	8,23
Sandy Area	476	0,05	500	0,05	488	0,05
Savanna	336.724	36,81	279.208	30,52	219.284	23,97
Settlements	7.252	0,79	11.940	1,31	18.520	2,02
Steppe	22.348	2,44	20.796	2,27	20.008	2,19
Swamp Forest	17.496	1,91	16.460	1,80	14.152	1,55
Thicket	2.180	0,24	2.300	0,25	2.736	0,30
Water Bodies	13.164	1,44	11.096	1,21	11.256	1,23
Wetland - floodplain	21.740	2,38	22.780	2,49	21.968	2,40
Woodland	57.712	6,31	44.164	4,83	39.852	4,36
Total mapped area (km <sup>2</sup> )	914.756		914.756		914.756	

**Table 4** West Africa Land Use Land Cover Time Series 1975-2013: U.S. Geological Survey data release (Tappan et al. 2016).

## Appendix VI – Utilisation of Landsat 8 Bands

<b>Band</b>	<b>Wavelength</b>	<b>Useful for mapping</b>
Band 1 – Coastal Aerosol	0.435 - 0.451	Coastal and aerosol studies
Band 2 – Blue	0.452 - 0.512	Bathymetric mapping, distinguishing soil from vegetation, and deciduous from coniferous vegetation
Band 3 – Green	0.533 - 0.590	Emphasizes peak vegetation, which is useful for assessing plant vigor
Band 4 – Red	0.636 - 0.673	Discriminates vegetation slopes
Band 5 - Near Infrared (NIR)	0.851 - 0.879	Emphasizes biomass content and shorelines
Band 6 - Short-wave Infrared (SWIR) 1	1.566 - 1.651	Discriminates moisture content of soil and vegetation; penetrates thin clouds
Band 7 - Short-wave Infrared (SWIR) 2	2.107 - 2.294	Improved moisture content of soil and vegetation and thin cloud penetration
Band 8 - Panchromatic	0.503 - 0.676	15 meter resolution, sharper image definition
Band 9 – Cirrus	1.363 - 1.384	Improved detection of cirrus cloud contamination
Band 10 – TIRS 1	10.60 – 11.19	100 meter resolution, thermal mapping and estimated soil moisture
Band 11 – TIRS 2	11.50 - 12.51	100 meter resolution, Improved thermal mapping and estimated soil moisture

**Table 5** Utilisation of bands on board Landsat 8; retrieved from U.S. Geological Survey (2018c).

(see also Barsi et al. 2014)

## Appendix VII – Actors Involved in Promoting EO/GIScience on the African Continent

(non-exhaustive and excluding national space agencies)

<b>Organisations from the African continent</b>	<b>Founded</b>	<b>Objectives</b>	<b>Partnerships/observer</b>	<b>Geopolitical focus</b>	<b>References</b>
African Association of Remote Sensing of the Environment (AARSE)	1993/ 1994	Be a facilitator of EO/GIScience on the African continent for national and continent-wide social and economic development; promote African space coordinating system; biennial conference (...).	ISPRS, ESA, UNECA, AU, COPUOS and others	Africa	(AARSE 2014b, a, 2016c)
African Leadership Conference on Space Science and Technology for Sustainable Development (ALC)	2004	Improve communication of space activities amongst African countries; biennial meeting (...).	COPUOS and others	Africa	(Martinez 2012)
Islamic Network on Space Sciences and Technology (ISNET)	1987	Platform to share 'experiences, research studies and developments in space sciences and applications' amongst member states; includes training programmes (...).	COPUOS and others	Organisation of Islamic Cooperation (OIC) members, including Egypt, Libya, Morocco, Niger, Senegal Sudan and Tunisia	(ISNET 2018)
African Organization of Cartography and Remote Sensing (AOCRS)	1988	Coordination between African mapping organisations/agencies in the area of remote sensing and space science activities (...).	COPUOS, AU, UNECA, regional organisations and others	Africa	(COPUOS 2016)
EIS-Africa	2000 (origins in the late 1980s)	Coordination of GIScience and technologies to 'support sustainable development in Africa'; capacity building, networking, contribute to policy strategies, build fundamental geospatial datasets; biennial conference (Africa GIS) (...).	GEO, ISPRS, UNECA, CGIM, UNEP, FAO and others	Africa	(EIS-Africa 2014a, b, Geospatial World 2014)



<b>International partnerships (non-exhaustive)</b>	<b>Part of</b>	<b>Objectives</b>	<b>Supporting actors</b>	<b>Geopolitical relation</b>	<b>References</b>
Global Monitoring for Environment and Security (GMES) and Africa	Africa – EU strategic partnership	Strengthen space-based and in-situ Earth observation capabilities of 'African users'. (...).	EU, ESA, EUMETSAT, African Union Commission, African Union, African Development Bank, UNECA RECs, Africa's space agencies, technical institutions (such as RECTAS, ACMAD, Agrhymet, UN programmes, such as FAO and SPIDER, and others	Africa – EU	(Giannopoulos 2011, Eumetsat 2014)
MESA Monitoring for Environment and Security in Africa (part of Africa – EU strategic partnership)	European Union	Support mandate of GMES and Africa through EO and in-situ data, promote 'capacity in information management, decision making and planning of African continental, regional and national institutions mandated for environment, climate and food security.' (...)	EUMETSAT and others	Africa – EU	(MESA 2016a, b)
Digital Belt and Road (DBAR)	China's Belt and Road Initiative	Address common developmental challenges by means of remote sensing in countries of Asia, Europe and East-Africa.	N/A	China – Africa and Eurasia	(Song 2016)
AfriGEOSS	Group on Earth Observations (GEO)	Build a 'coordination framework' that brings together all relevant EO 'stakeholders' (production, management and use), provide the 'linkage country-region-continent'; strengthen the role of existing EO institutions in Africa (...).	African states	Africa – global	(AfriGEOSS 2018)

<b>Multilateral African Partnerships (non-exhaustive)</b>	<b>Established</b>	<b>Objectives</b>	<b>Supporting actors</b>	<b>Geopolitical relation</b>	<b>References</b>
African Resource Management (ARM)	2006	Constellation of EO satellites; operate 'space technologies in the areas of disaster management, resource identification, land use, and public health' (...).	Nigeria, South Africa, Algeria and Kenya	Africa	(Harding 2013, Mostert 2008)
African Space Policy and Strategy	Adopted 2016	Build 'indigenous space capability, in both the private and the public sectors, for a coordinated, effective and innovative African-led space programme' (...)	African Union	Africa	(African Union 2017, 2016)

**Table 6** Actors involved in promoting EO/GIScience on the African continent (non-exhaustive).

# Appendix VIII – Ordered Situational Map: GIScience Capacity Situation in Southwest Nigeria (Chapter Six)

## Individual Human Elements/Actors

- GIScience researchers (different disciplines)
- Students
- Surveyors
- Politicians/policymakers (national/international)
- ‘Traditional’ rulers

## Collective Human Elements/Actors

- NASA/USGS/GLCF (Landsat programme, ASTER/MODIS data)
- Other space programmes, such as ISRO (India).
- Commercial data providers (Digital Globe et cetera)
- NASRDA
- Remote sensing/GIS institutes (ARCSSTE-E, RECTAS, CESRA, FSoS)
- Remote sensing/GIS departments
- GIScience institutions abroad
- Former NEPA (National Electric Power Authority)
- Commercial software developers (ESRI et cetera)
- Open source software developers
- Shell
- Google
- ‘Africa’
- Nigerian civil society

## Discursive Construction(s) of Human Actors

- Politicians as not interested in development
- Politicians as corrupt
- Traditional rulers as inhibiting structural change
- Surveyors as inhibiting wider appreciation of RS/GIS
- NASA/USGS/GLCF as a saviour
- Landsat as the tried and trusted
- ‘Africans’ as users
- Nigeria as derailed
- NEPA as ‘never expect power always’

## Nonhuman Elements/Actors

- EO satellites
- Remote sensing data
- Software (GIS/remote sensing)
- Textbooks (GIS/remote sensing)
- Hardware (notebooks, handheld GPS, spectrometers, plotter, scanners, workstations, servers et cetera)
- Electricity
- Fuel/Gas
- Oil
- Money
- Other data (topographic/base maps, weather data et cetera)
- RS/GIS laboratories

## Implicated/Silent Actors/ Actants

- Other power suppliers
- Transport providers

## Discursive Construction of Nonhuman Actants

- Commercial data (high-resolution) as a chimera
- Free data as saviour
- Any free data as the new desirable
- Databases as exclusive
- NigeriaSats as dubious objects in space
- NigeriaSats as data producers
- NigeriaSats as bearers of independence
- NigeriaSats as the (white) elephants in the situation
- Software as a tool that can be cracked
- Cracked software as makeshift
- Cracked software as producing botched work
- Licensed software as norm
- Open source software as valuable makeshift
- Electricity as defective/missing (‘there is no light’)
- Electricity as human and technological capacity
- Work around missing data
- Any working equipment as precious
- Oil as a curse
- NigeriaSat’s data as ‘our’ data

- Google (Earth) as a resort
- NASRDA as a white elephant
- NASRDA as a bearer of hope
- Students/future generations as victims

### Political/Economic Elements

- Costs of commercial satellite data
- Access to funding
- Missing salaries
- Federalism Nigeria
- Nepotism/corruption
- Patrimonial political culture
- Boundary work
- Institutional gridlock
- Dependence on foreign actors
- Loss of physical/human capacity
- Scarce elements as more valuable
- Maximise use of available elements
- 'Forget' what you can't get
- Invest own funds in equipment
- Keep going with little improvements
- Investing hopes and losing them
- Need to stay confident
- Space technologies for prestige
- Buying instead of producing
- Losing at the 'bargaining table'

### Temporal Elements

- Feeling of being back in time in terms of power supply
- Feeling of being thrown back in time
- Feeling that many things have not been updated since the 1970s
- No updated maps since 1970s
- Crawling whilst others are running
- Lost institutions and technologies
- No or slow internet
- Losing time when looking for data
- Losing time when accessing data
- Losing time when downloading RS data
- Losing time when acquiring software in this part of the world
- Losing time when looking for cracked software
- Frequent strikes
- Losing time when teaching/demonstrating

### Sociocultural/Symbolic Elements

- Individualistic attitudes/communitarianism
- Disorder (planning)
- Rurality
- Underdevelopment
- Group politics
- Oil
- Certificates and titles
- Entrenched traditional ways of doing things
- Postcolonial developments (military rule)
- Dependency
- Awareness of own capacity
- Stay confident
- 'this part of the world'
- 'there is no light'
- Limited knowledge about own (Africa's) resources in comparison to non-African countries (former colonial powers).

### Spatial Elements

- Look for data depositories all over SW Nigeria
- 'This part of the world' to designate elements in the research situation
- 'Here' (developing countries) and 'there' (developed countries)
- (Spatial) disorder in cities
- Evidence/data
- Technologies as imported from the North
- Missing knowledge about Nigeria's resources
- Nigeria as partly excluded from remote sensing data backup
- Nigeria as excluded from some databases abroad
- Use of maps with outdated information
- Office space
- Being in a place that is not in the loop of technological development
- Outside the loop of ICT
- No or slow access to the World Wide Web
- Power supply as essential in other parts of the world
- Not able to show knowledge capacity to the rest of the world

### Related Discourses (Narrative and/or Visual)

- Future in Nigeria
- General role of institutions/government

- Need to repair IT
- Prepare for failure (e.g. power)
- Use time when things work (e.g. power)
- Distraction by sound of generators
- Heat/sweating (reducing physical capacity)
- Time gaps in satellite data regarding research aim
- Post-independence decline
- Postcolonial disruption
- No institutional continuity after change of management
- Not able to meet own capacity (work below capacity)
- Premature upstream EO programme in Nigeria/leapfrogging
- Being out of the loop of technological development
- Losing momentum
- Losing achievements of the past
- Technological innovation/developments/ maintenance in Nigeria
- Capacity needs
- Capacity building goals
- Policies/legal basis
- Planning in Nigeria
- Standards
- Education
- Data distribution
- Political culture
- Corruption
- Norms/values
- Nigeria's institutions
- Nigeria's military past/'derailing'
- Developed/ developing

### Major Issues/Debates (Usually Contested)

- Data access/sharing
- Data policies
- Technological development
- Sequence of developments in national EO programme (upstream/downstream)
- Management of data
- Access to 'federal data' from Nigeria's satellites
- Role of NASRDA and its institutions
- Relevance of Nigeria's EO/space programme
- Satellite missions (Radar)
- Role of policymakers
- Use-value of free medium resolution data
- Spatial Data Infrastructures
- Data custody
- Role of surveyors
- Data accuracy
- State of equipment
- EO policies
- Environmental Impact Assessments (EIA)
- Spatial evidence for planning
- Commercial use of EO data
- Working environment
- Research capacity
- Self-dependence
- Improvising ('not be able to do the real thing')

**Table 7** Ordered situational map: GIScience capacity situation in Southwest Nigeria (chapter six); produced by author, based on Clarke et al. (2015, 106).

## Appendix IX – Sample of Use of Remote Sensing Data and Software at Geography, OAU

- PhD and MSc research in Remote Sensing and GIS (respective theses are archived at the Department of Geography at OAU).
- Itemisation of relevant satellite data products and providers, as well as software products are listed below the following tables (see codes).

Researcher	Researched issue in Nigeria	Year	Satellite data	Maps	GPS	GIS/ software	Mentioned Issues	other technologies used
I	Dumpsites	2012	6.1.5	NA	Geographic definition of waste dumpsites in Osogbo (legal and illegal) by taking coordinates with handheld GPS (2m accuracy).	3	NA	HP Laptop DV7, HP Deskjet 1280 Printer (A3 Printer), Handheld GPS

2		Researcher
Change in Vegetation		Researched issue in Nigeria
2015		Year
2.1.1	2.2.1	2.4.1
		2.5.1
		2.6.1
Satellite data		
Maps		
Base map of Ife South, scale 1:150,000, (from Osun State Ministry of Land and Survey).		
GPS		
Handheld GPS, used coordinates for georeferencing of satellite images and ground truthing.		
3	9	10
		7
GIS/ software		
Mentioned Issues		
scanner for base map (raster)		
other technologies used		

3		Researcher
Land Use Change		Researched issue in Nigeria
2012		Year
2.3.1	2.7.1	Satellite data
	1.1.3	
Nigeria Admin Map, 2011, 1:150000		Maps
		GPS
		Handheld GPS, used coordinates for georeferencing of satellite images and ground truthing.
1	2	GIS/ software
	3	
	4	
NA		Mentioned Issues
		other technologies used



4	Researcher	
Land Use Dynamics	Researched issue in Nigeria	
2008	Year	
2.5.99	Satellite data	4.2.99
Topographic map from 1966 (1:50000)	Maps	
NA	GPS	
NA	GIS/ software	
Initially planned to use Landsat 1978 and those of 1980s, but due to atmospheric noise had to use data from 1994; the topographic map is outdated (1966); for primary data the costs of fieldwork also became a challenge; recommends to set up a remote sensing centre for matter of data acquisition and analysis of land use change; recommends software development (classification algorithms); recommends human training in GIS and remote sensing; argues that Nigerians should be able to acquire data from their national EO satellites for environmental and other research.	Mentioned Issues	
NA	other technologies used	

5		Researcher
Deforestation and Land Use Dynamics		Researched issue in Nigeria
2007		Year
2.1.4	4.2.4	4.1.2
		1.1.12
Used a topographic map from 1968 (produced and published by Federal Survey Nigeria, 1:100000), obtained from Federal Ministry of Work and Housing (Survey Department Lagos).		Maps
NA		GPS
1	3	6
8		7
Problems in accessing remote sensing data; states that NigeriaSat-1 data was only made available two years after launch (2005) due to technical issues; refers to issues with spatial resolution due to the high costs of acquiring high resolution satellite images (KONOS and QUICKBIRD), refers to limitations in using ILWIS software; refers to social challenges during focus group discussions.		Mentioned Issues
cassette player; Sanner HP ScanJet 4C; Printer Deskjet 845c		other technologies used



7	Researcher	
Shelterbelts	Researched issue in Nigeria	
2012	Year	
2.10.1	Satellite data	8.1.7
NA	Maps	
Handheld GPS	GPS	
3	GIS/ software	
NA	Mentioned Issues	
NA	other technologies used	

8	Researcher	
Environmental Change	Researched issue in Nigeria	
2008	Year	
2.11.99	2.12.99	2.13.99
		2.14.99
		9.1.99
Different	Satellite data	Maps
NA	GPS	
1	GIS/ software	3
Acknowledges one Professor, who had encouraged him to finish his work despite uncondusive conditions.		
NA	Mentioned Issues	other technologies used

9	Researcher
Malaria	Researched issue in Nigeria
2012	Year
6.1.11	Satellite data
NA	Maps
Handheld GPS to record locations of healthcare facilities and mosquitoes' breeding sites.	GPS
7	GIS/ software
11	3
4	4
NA	Mentioned Issues
NA	other technologies used

10	Researcher
Learning Facilities	Researched issue in Nigeria
2015	Year
3.1.99	Satellite data
Administrative map of Ife East local government area as base map.	Maps
Handheld GPS to record coordinates of public secondary schools.	GPS
3	GIS/ software
7	12
NA	Mentioned Issues
Laptop (500GB, Core 3); handheld GPS (Garmin eTrex vista); HP Laser Jet Printer	other technologies used

11		Researcher
Urban gullies		Researched issue in Nigeria
2012		Year
5.1.99		Satellite data
NA		Maps
GPS		GPS
4	13	7
Mentions gully studies-related qualities and value of high resolution data from IKONOS and Quickbird, but regrets that Nigerian researchers are not able to use them due to the high costs.		Mentioned Issues
GPS and total station		other technologies used



12		Researcher
Oil spillage		Researched issue in Nigeria
2014		Year
2.15.1	2.16.1	2.17.1
Administrative map to guide the study (from Survey Department of Ministry of Land and Housing, Ondo State).		Satellite data
Handheld GPS to obtain coordinates for georeferencing of satellite images.		Maps
1	3	4
14		12
NA		GIS/ software
		Mentioned Issues
Computer; handheld GPS (Garmin); Digital Scanner Mercury I200u for rasterising of admin map; Printer (HP Laserjet 2050); Digital Camera (Sony)		other technologies used

Landsat ETM+ 2005	Landsat TM 1986	Landsat ETM+ 2000	Landsat OLI 2014	Landsat ETM+ 2002	Landsat TM 1994	Landsat TM 1990	Landsat TM 1984	Landsat MSS 1978	NigeriaSat-1	Satellite/ Source
2.9.1	2.8.1	2.7.1	2.6.1	2.5.1	2.4.1	2.3.1	2.2.1	2.1.1	1.1.1	GLCF
2.9.2	2.8.2	2.7.2	2.6.2	2.5.2	2.4.2	2.3.2	2.2.2	2.1.2	1.1.2	RECTAS
2.9.3	2.8.3	2.7.3	2.6.3	2.5.3	2.4.3	2.3.3	2.2.3	2.1.3	1.1.3	COPINE (NASRDA)
2.9.4	2.8.4	2.7.4	2.6.4	2.5.4	2.4.4	2.3.4	2.2.4	2.1.4	1.1.4	FORMECU
2.9.5	2.8.5	2.7.5	2.6.5	2.5.5	2.4.5	2.3.5	2.2.5	2.1.5	1.1.5	Digital Globe via Google Earth
2.9.6	2.8.6	2.7.6	2.6.6	2.5.6	2.4.6	2.3.6	2.2.6	2.1.6	1.1.6	EROS
2.9.7	2.8.7	2.7.7	2.6.7	2.5.7	2.4.7	2.3.7	2.2.7	2.1.7	1.1.7	ITC Netherlands
2.9.8	2.8.8	2.7.8	2.6.8	2.5.8	2.4.8	2.3.8	2.2.8	2.1.8	1.1.8	NCRS
2.9.9	2.8.9	2.7.9	2.6.9	2.5.9	2.4.9	2.3.9	2.2.9	2.1.9	1.1.9	USGS
2.9.10	2.8.10	2.7.10	2.6.10	2.5.10	2.4.10	2.3.10	2.2.10	2.1.10	1.1.10	LCBC Lake Chad Basin Commission
2.9.11	2.8.11	2.7.11	2.6.11	2.5.11	2.4.11	2.3.11	2.2.11	2.1.11	1.1.11	Ministry of Land and Survey Sokoto
2.9.12	2.8.12	2.7.12	2.6.12	2.5.12	2.4.12	2.3.12	2.2.12	2.1.12	1.1.12	NASRDA
2.9.99	2.8.99	2.7.99	2.6.99	2.5.99	2.4.99	2.3.99	2.2.99	2.1.99	1.1.99	unknown

SPOT XS 1994	SPOT XS 1986	World View	Landsat ETM+ 2011	Landsat ETM+ 2001	Landsat TM 1991	Landsat ETM+ 2003	Landsat ETM+ 1999	Landsat TM 1987	Landsat MSS 1975	Landsat MSS 1972
4.2.1	4.1.1	3.1.1	2.17.1	2.16.1	2.15.1	2.14.1	2.13.1	2.12.1	2.11.1	2.10.1
4.2.2	4.1.2	3.1.2	2.17.2	2.16.2	2.15.2	2.14.2	2.13.2	2.12.2	2.11.2	2.10.2
4.2.3	4.1.3	3.1.3	2.17.3	2.16.3	2.15.3	2.14.3	2.13.3	2.12.3	2.11.3	2.10.3
4.2.4	4.1.4	3.1.4	2.17.4	2.16.4	2.15.4	2.14.4	2.13.4	2.12.4	2.11.4	2.10.4
4.2.5	4.1.5	3.1.5	2.17.5	2.16.5	2.15.5	2.14.5	2.13.5	2.12.5	2.11.5	2.10.5
4.2.6	4.1.6	3.1.6				2.14.6	2.13.6	2.12.6	2.11.6	2.10.6
4.2.7	4.1.7	3.1.7				2.14.7	2.13.7	2.12.7	2.11.7	2.10.7
4.2.8	4.1.8	3.1.8				2.14.8	2.13.8	2.12.8	2.11.8	2.10.8
4.2.9	4.1.9	3.1.9				2.14.9	2.13.9	2.12.9	2.11.9	2.10.9
4.2.10	4.1.10	3.1.10				2.14.10	2.13.10	2.12.10	2.11.10	2.10.10
4.2.11	4.1.11	3.1.11				2.14.11	2.13.11	2.12.11	2.11.11	2.10.11
4.2.12	4.1.12	3.1.12	3	3	3	2.14.12	2.13.12	2.12.12	2.11.12	2.10.12
4.2.99	4.1.99	3.1.99	2.17.99	2.16.99	2.15.99	2.14.99	2.13.99	2.12.99	2.11.99	2.10.99

Corona (aerial photo- graphs) 1963	ASTER 2007	IKONOS 2009	QUICK- BIRD	Google Earth (via google sat- ellite maps downloader)
9.1.1	8.1.1	7.1.1	6.1.1	5.1.1
9.1.2	8.1.2	7.1.2	6.1.2	
9.1.3	8.1.3	7.1.3	6.1.3	
9.1.4	8.1.4	7.1.4	6.1.4	
9.1.5	8.1.5	7.1.5	6.1.5	5.1.5
9.1.6	8.1.6	7.1.6	6.1.6	5.1.6
9.1.7	8.1.7	7.1.7	6.1.7	5.1.7
9.1.8	8.1.8	7.1.8	6.1.8	5.1.8
9.1.9	8.1.9	7.1.9	6.1.9	5.1.9
9.1.10	8.1.10	7.1.10	6.1.10	5.1.10
9.1.11	8.1.11	7.1.11	6.1.11	5.1.11
9.1.12	8.1.12	7.1.12	6.1.12	5.1.12
9.1.99	8.1.99	7.1.99	6.1.99	5.1.99

Software	Number
ILWIS	1
IDRISI TAIGA	2
ARC(view)GIS	3
MS Office Excel	4
ERDAS (Imagine)	5
Corel Photo Paint	6
SPSS	7
Anova	8
ArcMap	9
IDRISI Selva	10
EPI-Data	11
Microsoft Access	12
AutoCAD Land Development	13
Microsoft Power Point	14
QGIS	15

**Table 8** Sample of Use of Remote Sensing Data and Software (Geography, OAU).

# Appendix X – Social Worlds/Arena Map (Fieldwork Draft)

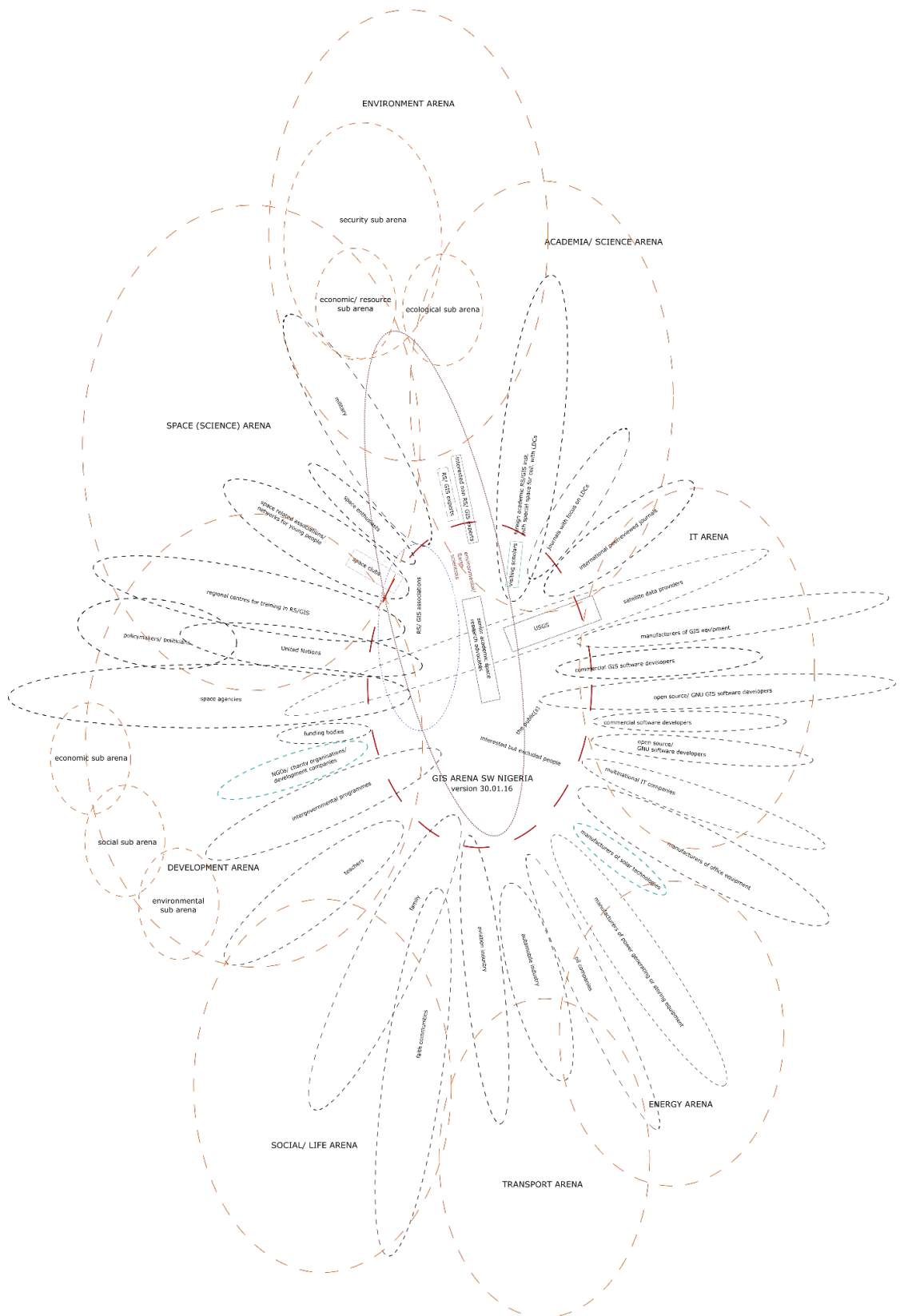


Figure 34 Social Worlds/Arena Map by author (fieldwork draft by author of thesis, 2016).

# Appendix XI – Photographs & Scanned Documents

## Institutions



**Figure 36** Obafemi Awolowo University (OAU) in Ile-Ife (Thorpe 2015).



**Figure 35** New space museum on campus of OAU, Ile-Ife (Thorpe 2015).



Figure 38 Welcome billboard of CESRA at FUTA (Thorpe 2016).

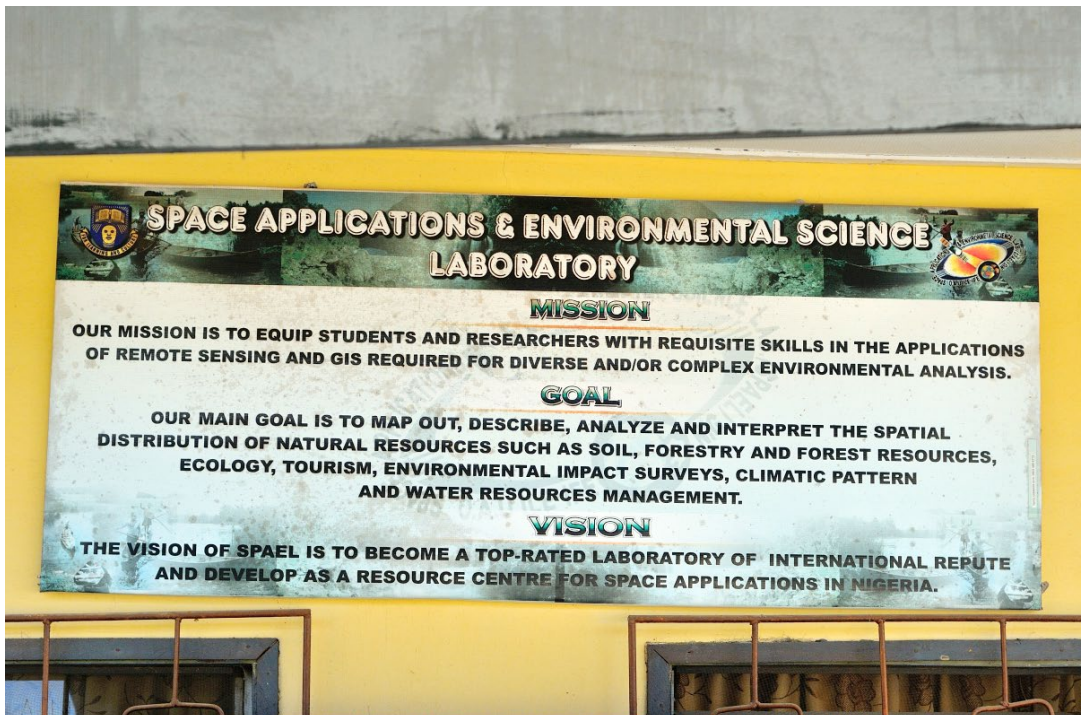


Figure 37 Declaration of SPAEL's mission, goals and vision at OAU (Thorpe 2015).



## Natural environment



**Figure 40** Rainforest between Ile-Ife and Akure (Thorpe 2015).



**Figure 39** Canopy walkway at Lekki Conservation Centre, Lekki, Lagos State (Thorpe 2016).

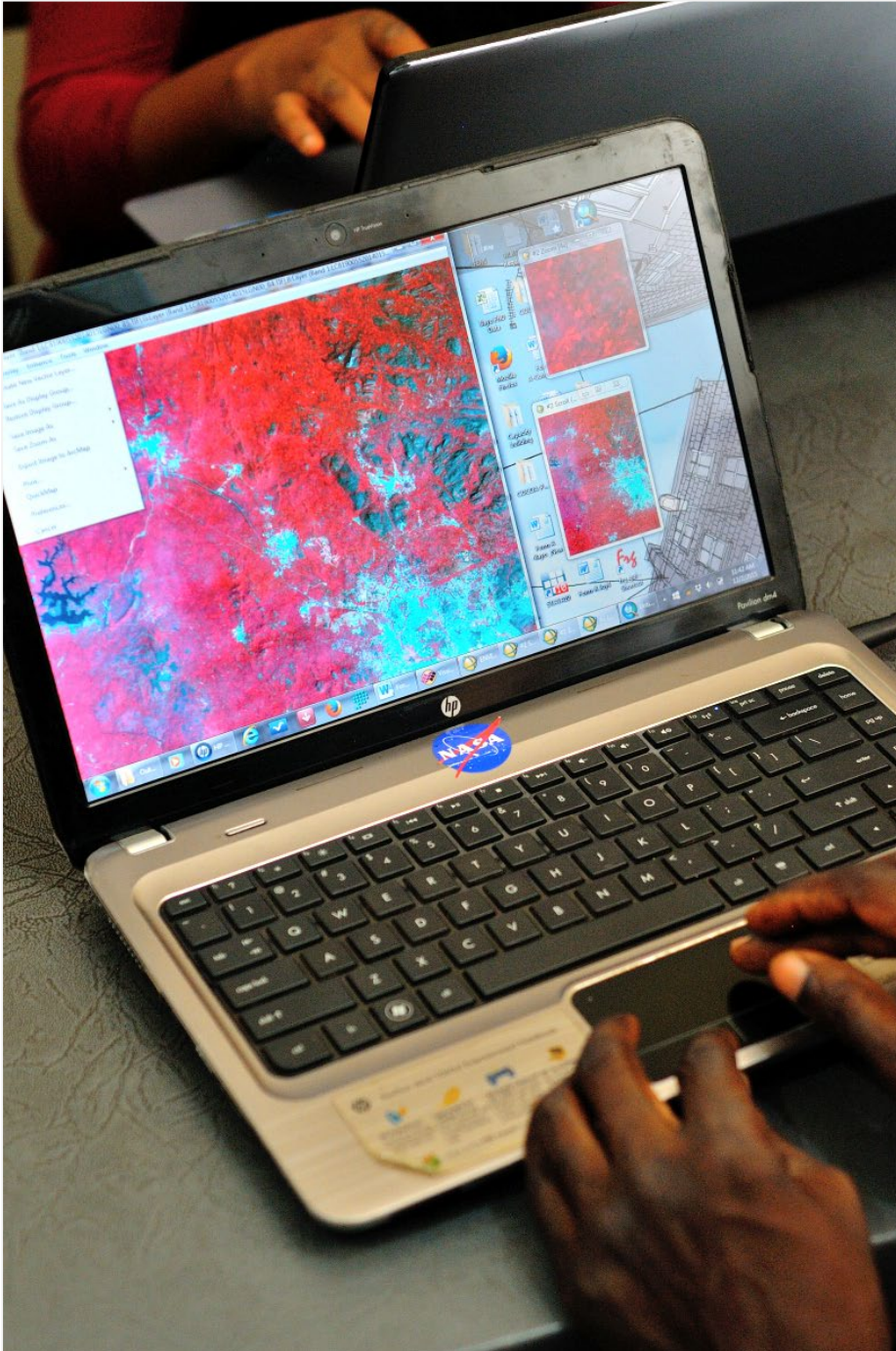


**Figure 42** Cleared vegetation between Ibadan and Ile Ife (Thorpe 2016).



**Figure 41** Sawmill in Ile-Ife (Thorpe 2016).

## GIScience technologies



**Figure 43** Working with remote sensing data on a personal notebook (Thorpe 2016).



**Figure 44** RS/GIS laboratory, Department of Geography, OAU (Thorpe 2016).



**Figure 45** Shell-sponsored workstations, RS/GIS laboratory, Department of Geography, OAU (Thorpe 2016).



**Figure 46** Remote sensing laboratory, RECTAS (Thorpe 2016).



**Figure 47** Taped handheld GPS receiver (Garmin GPSMAP 76S) during student training in Ile-Ife (Thorpe 2016).



**Figure 48** Head of RS/GIS laboratory at CESRA shows A3 plotter HP I30NR and map cabinet (Thorpe 2016).



**Figure 49** Colortrac SmartLF SC36 Scanner, Department of Remote Sensing and GIS, FUTA, Akure (Thorpe 2016).



**Figure 50** Shell Map, RS/GIS laboratory, Department of Geography, OAU (Thorpe 2016).



**Figure 52** Drawing board/digitiser, RS/GIS laboratory, Department of Geography, OAU (Thorpe 2016).



**Figure 51** UPS unit and batteries, department of Remote Sensing and GIS at FUTA (Thorpe 2016).





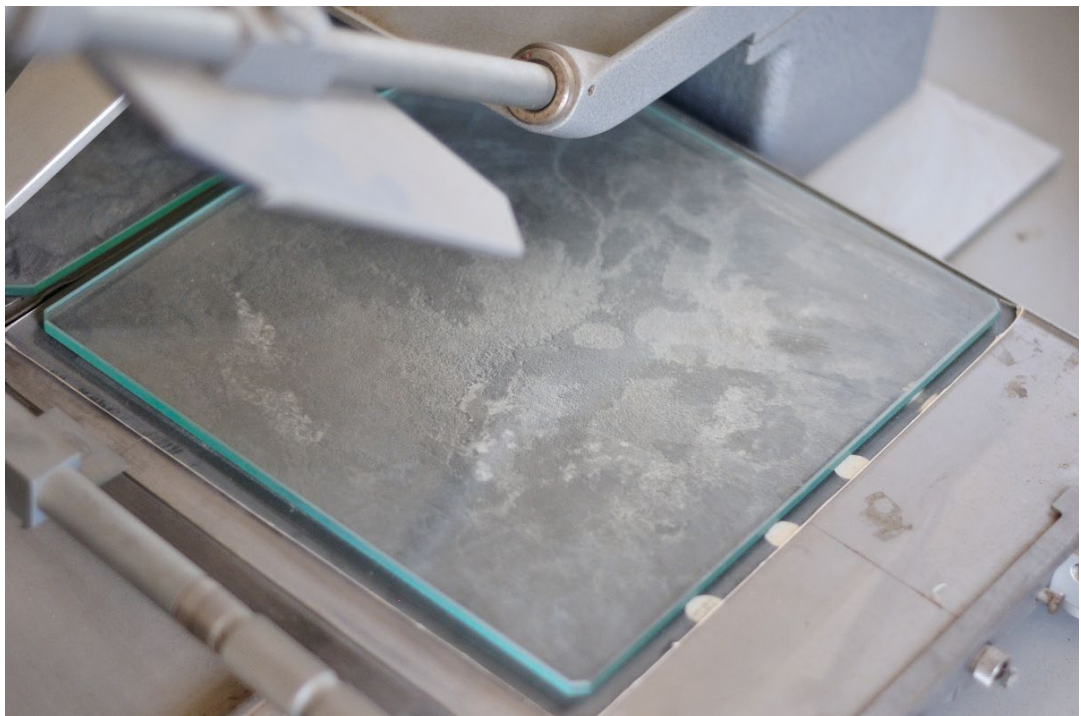
**Figure 54** Large generators for power supply at RECTAS, OAU, Ile-Ife (Thorpe 2016).



**Figure 53** AC unit (Samsung), Department of Geography, OAU, Ile-Ife (Thorpe 2016).



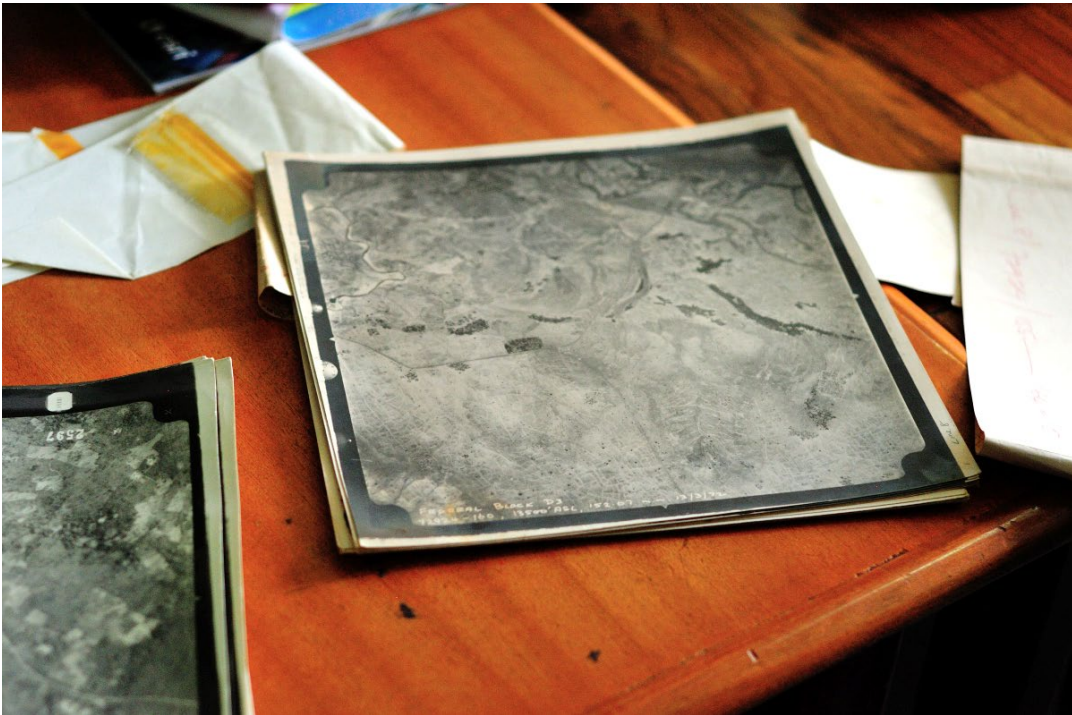
**Figure 55** Aerial photographs (Federal Surveys, 1973) and maps at RECTAS (Thorpe 2016).



**Figure 56** Aerial photograph at RECTAS (Thorpe 2016).

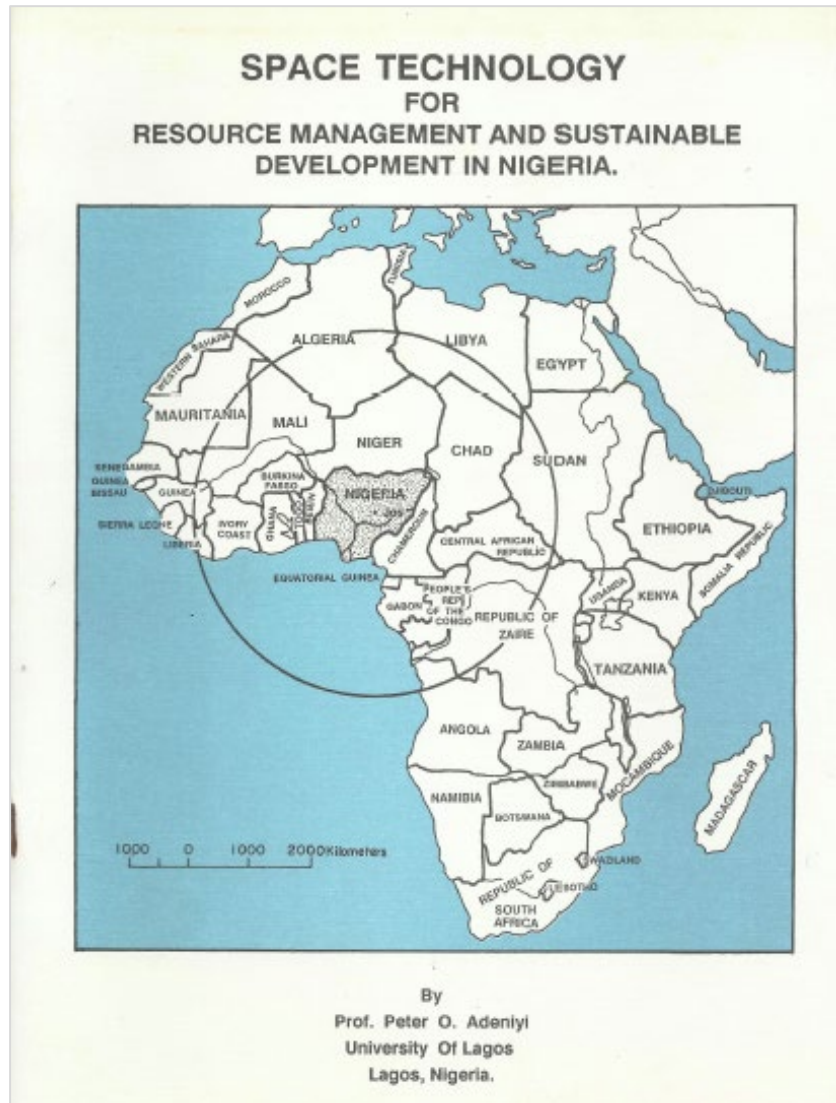


**Figure 57** Stereoplotter documents at RECTAS (n.d) (Thorpe 2016).



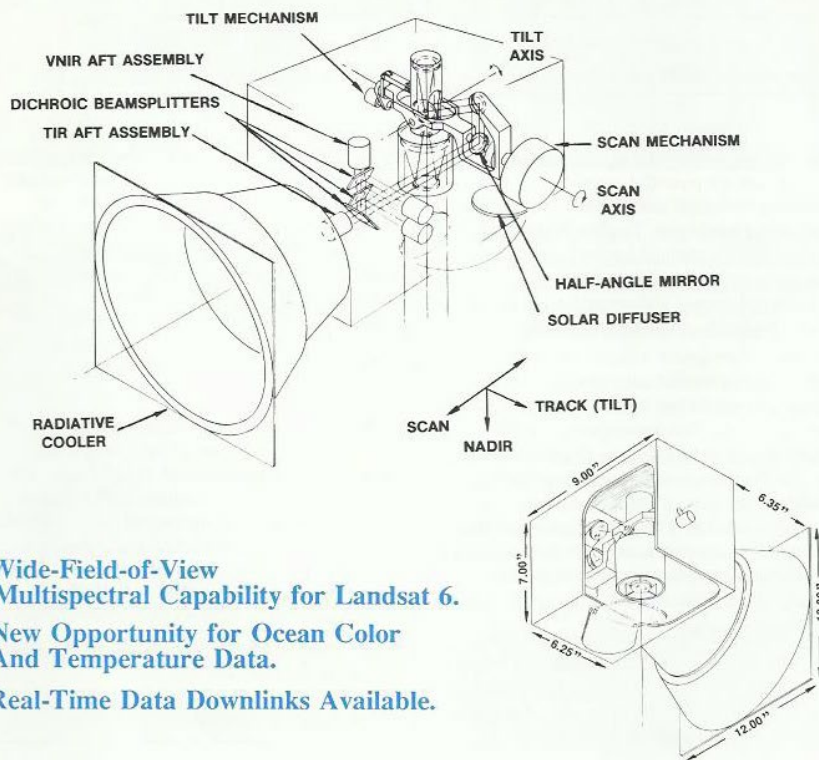
**Figure 58** Aerial photographs (Federal Surveys 1972) at Department of Geography, University of Lagos (Thorpe 2016).

## Policy and technical documents (1970s – 1990s)



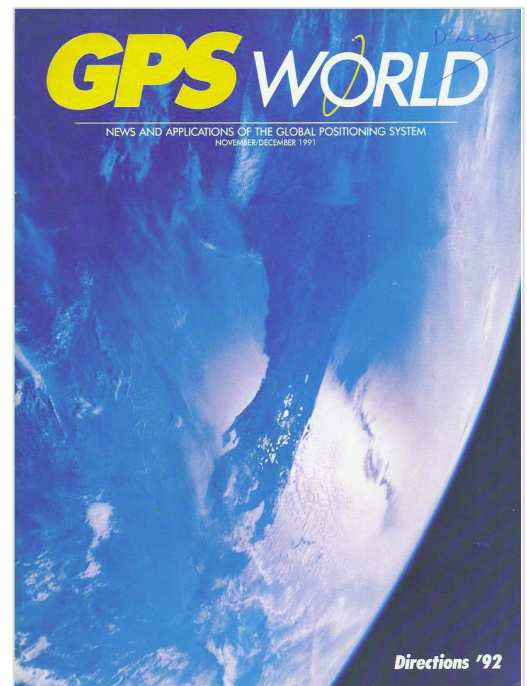
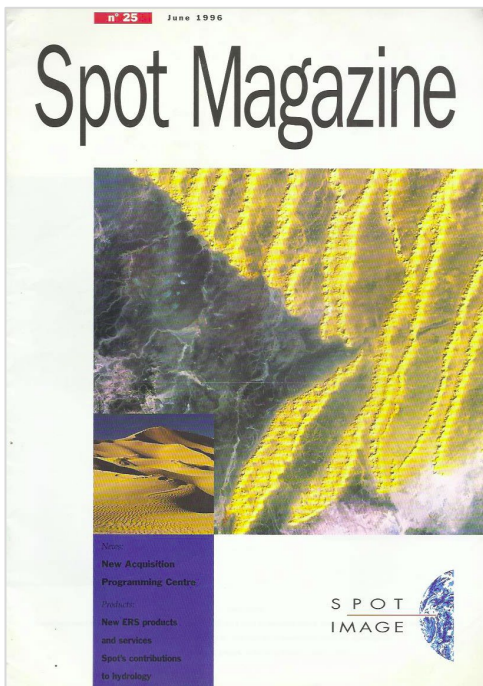
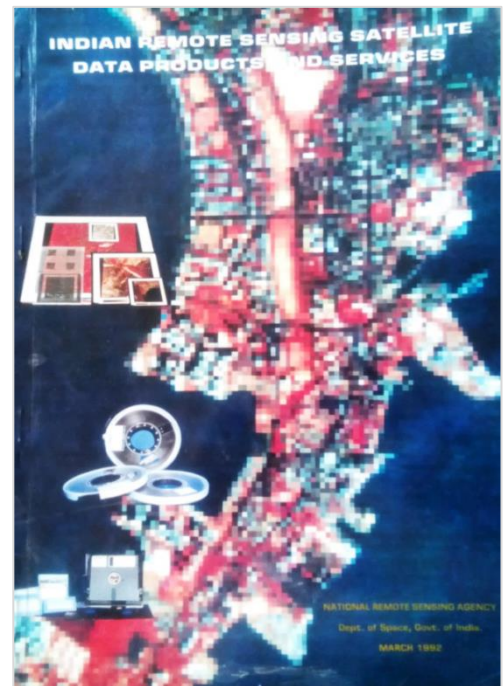
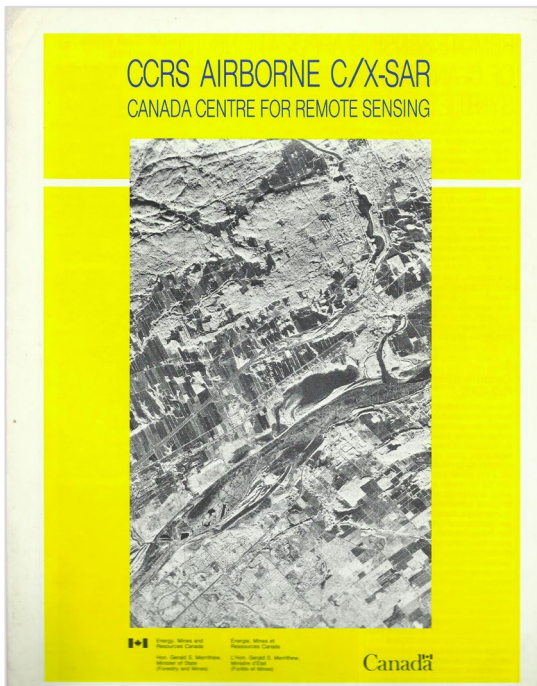
**Figure 59** Publication by Adeniyi (1992), found in RS/GIS laboratory, Department of Geography, University of Lagos (scan by author of thesis 2016).

## SEA WIDE FIELD SENSOR

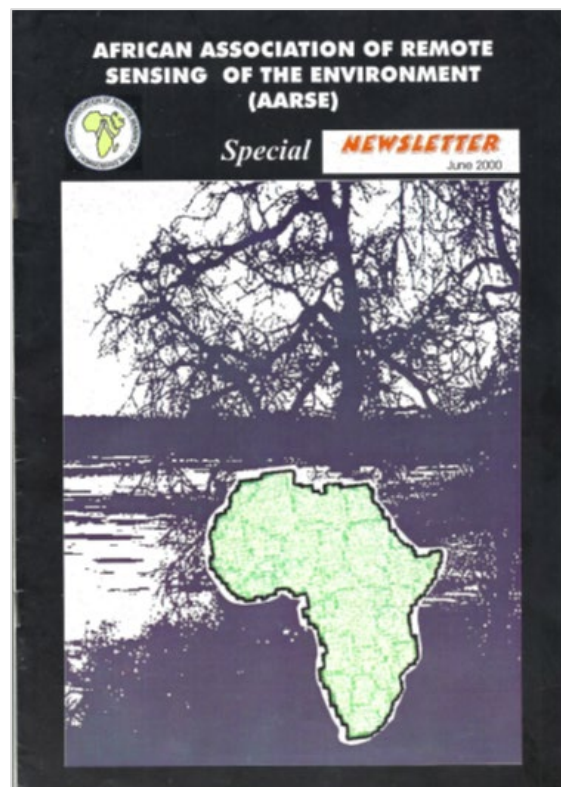


- \* Wide-Field-of-View  
Multispectral Capability for Landsat 6.
- \* New Opportunity for Ocean Color  
And Temperature Data.
- \* Real-Time Data Downlinks Available.

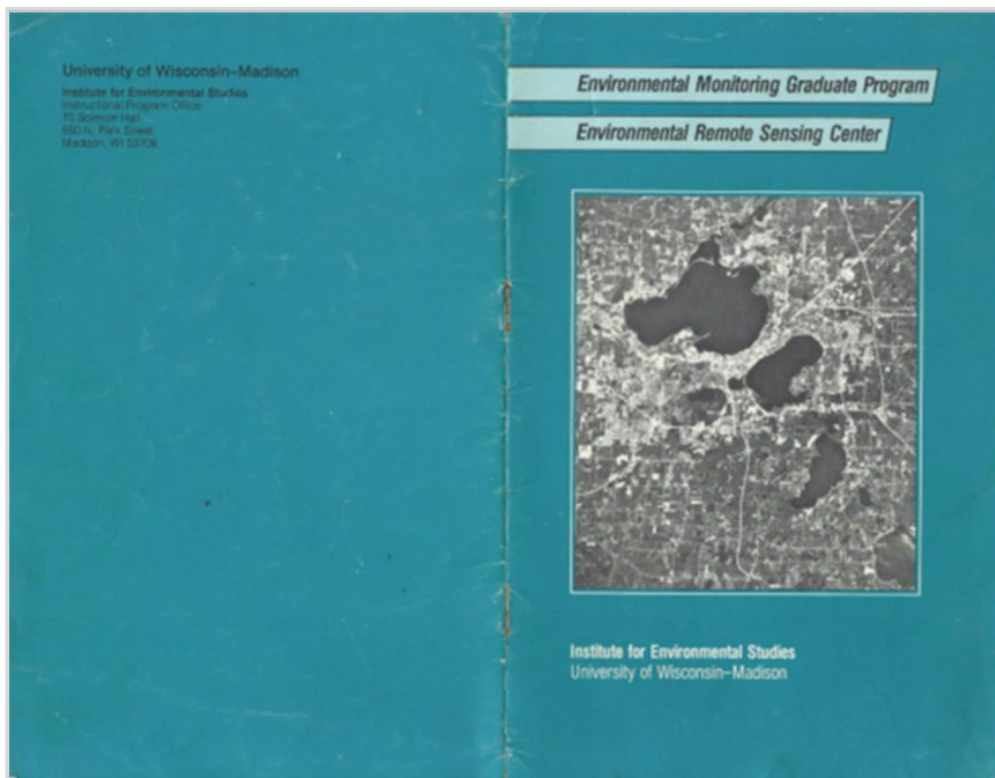
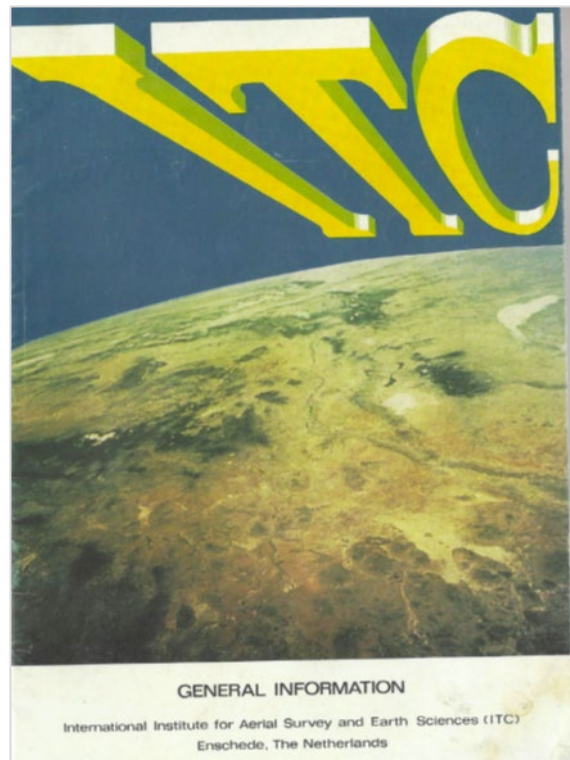
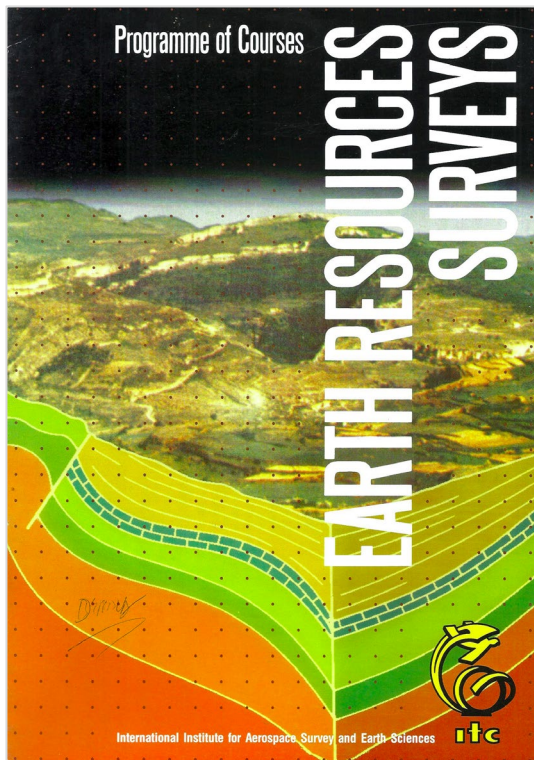
**Figure 60** 'Landsat Technical Notes' (1987), found in RS/GIS laboratory, Department of Geography, University of Lagos (scan by author of thesis 2016).



**Figure 61** Information brochures/magazines on GIScience products & applications (1980s -1990s), found in RS/GIS laboratory, Department of Geography, University of Lagos (scan by author of thesis 2016).

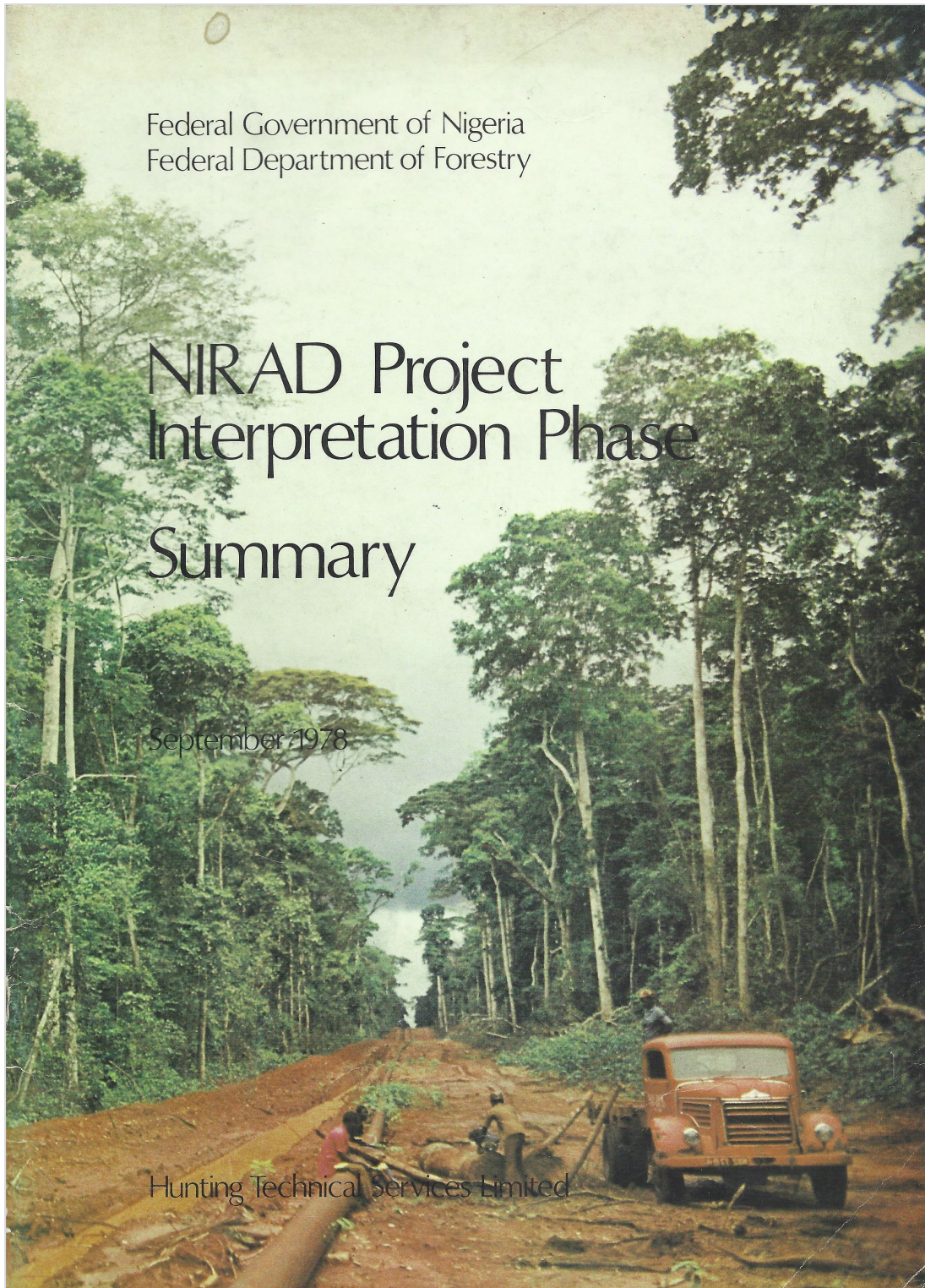


**Figure 62** Newsletters, found in RS/GIS laboratory, Department of Geography, University of Lagos (scan by author of thesis 2016).



**Figure 63** Training programme brochures from international institutions, found in RS/GIS laboratory, Department of Geography, University of Lagos (scan by author of thesis 2016).





**Figure 64** Report (1978) on the 1970s Nigerian Radar (NIRAD) project, found in RS/GIS laboratory, Department of Geography, University of Lagos (scan by author of thesis 2016).

