Implementation of e-science tools for complex analysis of human-environmental interaction

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Abstract. An e-science approach allows the integration of different data types to develop coherent analyses of past and expected impacts of natural and human caused environmental change and the corresponding impact on human population structures. Demographic analyses have been possible for some time both with and without the aid of computational tools, however, the implementation of e-science tools allow a more dynamic manipulation of scenarios drawing on actual social, economic and demographic data and correlating that with GIS spatial data. The resulting implementation allows us to generate 'snapshots' in time to reconstruct the impact of past events or hypothetical events. In this way, we can test the feasibility of data extraction from diverse data sources produced for different research programs in different disciplines. The research is driven not by an interest in technological development, but rather as one part of a general strategy designed to inform policy decisions in a situation with a number of methodological and practical constraints.

Introduction

The Melanesian island of Papua New Guinea (PNG) and Irian Jaya is home to the largest contiguous block of forest in South East Asia. The consequences of deforestation are both imminent and menacing for the region and the globe. The states on both halves of this large Melanesian island are ill prepared for the full extent of the environmental degradation brought about by mining and logging and the private, non-PNG companies involved in these activities on the PNG side of the island are actively planning their own withdrawal before the full costs of the environmental damages are realised. Papua New Guinea has for the last decade, fallen into political disarray at the national level leaving isolated pockets of the country to govern themselves. The absence of state presence or control and environmental degradation in one of the most important forest resources in that part of the world pose serious problems not only for local people, who must endure them directly, but also for the globe in which that forests play a vital role in the sustainable regulation of the biosphere. There are parts of Papua New Guinea which are difficult to access for both geographical and political reasons. It is currently difficult to

monitor human impact on the environment in large parts of Papua New Guinea and if events pursue their probable course, this is likely to spread. Data collection in these regions will be paramount if the PNG state and global organisations are to have a chance to develop and implement effective management policies. We suggest that an e-social science approach addresses many of these obstacles to data collection as well as substantially enhancing the ways in which human-environmental interaction may be analysed.

An e-social science approach allows the integration of ethnographic documentation and environmental data to construct fine grained representations of the impact of humans on the environment at any given time over the past 150 years. The project synthesises longitudinal data on: culture, social organisation, land use (including agriculture, forest extraction and animal husbandry), economic activities, flora and fauna, climatic variation, natural disasters and geographical information. In addition these tools enable the development of robust methods for working in field environments in which it is desirable to act through local people with minimal training. This may be for ideological purposes as a way of including local people in the research for development purposes, or it may be for pragmatic reasons of inaccessibility. Synthesising disparate data offers realistic ways of conducting interdisciplinary field work and analysis which involves indigenous participants in influential and meaningful roles. The project builds on the work of the authors and their collaborators in the analysis of Papua New Guinea Highland societies, the use of GIS spatial data and in the development of user configurable e-science tools for ethnographic data collection and analysis.

Background to the region

The Was Valley study area, occupied by six kin-group territories (Haenda Suw, Aenda Suw, Ebay Suw, Laerop Suw and Hoboga Suw) is located in the Southern Highlands Province of Papua New Guinea. The New Guinea Highlands comprise a series of mountain ranges occupying the interior of the island. They are physically isolated from the coastal region and were thought by outsiders to be uninhabited until the 1930's. When the population was subsequently surveyed, it transpired that about one-third of the population of New Guinea lives in the intermontane valley basins, hill slopes and plateaux of the highlands region at an altitude of between 1500 - 2200 metres above sea level. The Wola live in the south central highlands of Papua New Guinea. They occupy five valleys in the Southern Highlands Province (the Ak, Was, Nemb, Lai and Mend), north east of Lake Kutubu, between 6Ī 0'/15' south latitude and 143Ī 15'/45' east longitude. The majority of the population lives between 1600 and 2000 metres above sea level. The topography is mountainous, rugged and precipitous, with turbulent rivers flowing along valley floors. The Wola live along the valley sides, leaving the intervening watersheds largely unpopulated. In the valleys, where they have cultivated extensively, there are areas of dense cane grass interspersed with the grassy clearings of fallowed or recently abandoned gardens and the brown soil and green crops of current ones. Lower montane rainforest occurs on the mountains and in the unpopulated parts of river valleys.

Remote Monitoring of Land Use with GPS and Handheld

Computers

Working with local people as remote monitors, the project will develop sustainable mechanisms for monitoring human activity electronically. Handheld computers equipped with GPS devices have been effectively used as part of wildlife conservation management for some time. Existing software packages will be re-configured for the local context and non-literate users will be able to enter data and navigate through the use of appropriate images and icons. Providing local people with handheld computers and training them in how to use them enhances local people's ability to manage their own resources. The handheld devices can communicate with one another using either wireless technologies (802.11b) or USB connections; this allows cooperating resource managers to coordinate efforts and cooperate more easily, as well as easing the central collection of data for the central electronic repository. One device could be used to collate all the data the data could be transferred to a CF card for external transfer.

The handheld computers needed for this project must satisfy the following criteria: 1) They must be robust and able to resist moisture and dirt with long battery life which does not rely on mains power for recharging; 2) they must save to hard disk and not to RAM in case of complete battery discharge; 3) they must have a master USB port that allows data transfer between handhelds or they should have built in 802.11b WiFi technology; 4) they should have some capacity for removable memory; 5) they must support software development for applications which do not rely on literacy of the user. Currently we have identified two examples of handhelds which satisfy most of these criteria. The Sharp Zaurus and the Amida Simputer. Both run versions of the Linux operating system.

GIS data and Satellite imagery

This project builds on a partial Geographic Information System database of the Was Valley funded by the British Academy (see http://www.dur.ac.uk/anthropology.gis/). The GIS organises ethnographic survey data collected from the River Was Valley of PNG, it links cultivation, tenure and kinship data to maps. The result of the GIS is a database that is located within real-world coordinates adapted to the easy inclusion of aerial photographs, remote sensed and satellite imagery as it becomes available. The current project proposes to extend this first-stage study to cover ongoing land-use employing satellite land-cover imagery. Remoteness, cost and political instability make regular maintenance of data problematic in this area. This project is part of an ongoing research programme at Durham focusing on indigenous rights and local understanding of land-use (including large scale mining developments) in the Pacific (Papua New Guinea, Northern Australia, Irian Jaya and the Solomon Islands). In this context, we see the project as partially fulfilling the need to apply technology within a framework of more traditional outreach and participation to begin to understand the information needs of local community groups. The GIS designed for this project allows rapid access to current forest change data. Local knowledge is incorporated thematically into the GIS and interpretation of satellite land-cover data will involve continued collaboration with local people.

Conclusion

Existing e-social science tools, enable applied social scientists to advance the types of research undertaken. Early studies of human-environment interaction were hampered by the abundance of data and difficulties of managing different data types. Rappaport [1968] analysed the role of ritual as a resource management tool and through judicious reduction of variables, demonstrated the power of integrating different data types to demonstrate that environmental variables shape cultural practice and conversely, that cultural practice has an impact on the environment. Similarly, Lansing's [1991] use of computer modelling detailed distributed and centralised cultural mechanisms for controlling rice cultivation in Bali. Environmental anthropologists have successfully demonstrated the complexity of human-environment interactions [Ellen 1982; Netting 1993; Sillitoe 1996; for a summary of such approaches see Moran 2000]; however, they have not managed to cope with very much complexity at any one time, instead opting for artificial delimitation and restriction of the analysis. While anthropologists and cultural ecologists have increasingly relied on computing tools for data collection and analysis, the obstacles to certain kinds of data integration have remained. Accounting for complex variable interaction at the micro level of the household (or indeed within the household) continually through to the level of regional and global patterns of precipitation and heat exchange rapidly exhausts the capacity of conventional software packages as well as the types of computers available to most social scientists up till now. So while many have argued that human ecology should account for these drastically different levels, it has thus far proven impossible to do at one time. Probabilistic models which aggregate and mask individual variation have been used to address some questions while agent oriented models have been used for others. Newly emerging technologies render previously costly or impossible data analysis economical and feasible. This has in turn made it possible to imagine greater democratisation of the ways in which individuals carry out research and make use of the results. In this short paper we have suggested one area in which local people with little or no previous experience may be included in such research.

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