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MUKUND RAO
V S RAMAMURTHY
BALDEV RAJ

STANDARDS, SPATIAL FRAMEWORK AND TECHNOLOGIES FOR NATIONAL GIS

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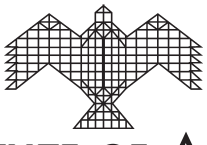
NATIONAL INSTITUTE OF ADVANCED STUDIES
Bangalore, India

Standards, Spatial framework and Technologies for National gis

MUKUND RAO, V S RAMAMURTHY & BALDEV RAJ

(RESEARCH TEAM: R SHILPA, VILAS CHAVAN AND DIKSHA BANDIL)



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DST SPONSORED PROJECT ON STANDARDS, FOUNDATION DATASET AND TECHNOLOGIES FOR NATIONAL GIS

Advise:

Dr Ashutosh Sharma, Secretary, DST (secydst@nic.in)
Dr T Ramasami, Former Secretary, DST (samisrisailam@gmail.com)
Dr Vijay Raghavan, Secretary, DBT & Formerly Secretary, DST (secydst@nic.in)
Dr Shailesh Nayak, Secretary, MoES (secretary@moes.nic.in)

Expert Panel:

Dr R Sivakumar, Former CEO, NSDI (rachapudi.sivakumar@gmail.com)
Dr Bhoop Singh, Head, NRDMS (bhoopsingh@nic.in)
Dr RL Nanda, SOI (nandarn@yahoo.com)
Dr P G Diwakar, NRSC/ISRO (pgdiwakar@nrsc.gov.in)
Dr Vandana Sharma, NIC (sharma.vandana@nic.in)
Mr TP Singh, DG, BISAG (info@bisag.gujarat.gov.in)
Dr NL Sarda, IIT-B (nls@cse.iitb.ac.in)

NIAS Project and Research Team:

Dr Mukund Rao, Principal Investigator
(mukund@nias.iisc.ernet.in; mukund.k.rao@gmail.com)
(Late) Mr J Premnath Singh, Project Team Member
Ms R Shilpa, Research Associate (shilpa.r1585@gmail.com)
Mr Vilas Chavan, GIS Analyst (chavanvilash@gmail.com)
Ms Diksha Bandil, Junior Research Fellow (diksha.rsgis@gmail.com)

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For any further information, please contact Dr Mukund Rao, Principal Investigator, DST Project on National GI Policy at NIAS (mukund.k.rao@gmail.com; mukund@nias.iisc.ernet.in) OR Dr Bhoop Singh, Head NRDMS, DST (bhoopsingh@nic.in)

GI (Geographic Information) .....

.....refers to any information that has a geographical or location context. The GI includes satellite images, aerial images/data, maps – topographic and thematic, ground survey data, positioning data, geo-tagged attributes/tables etc and also the derivatives from their integrated processing – all of which are amenable to visual display, integration and processing and serving/ querying as maps/images.

STANDARDS.....

..... ensure that materials, processes, products, and services fit into a consistent open use regime .....

....In the GIS context, Standards ensure that geographical data are consistent and open to sharing, increase interoperability across platforms and enable uniform services for wide range of applications ..... in the national context, GIS standardisation brings systematization into the gamut of processes of generating, storing, accessing and using GIS data ....

SPATIAL FRAMEWORK

.....provides a common geographic referenced GIS foundation spatial data on which assembly and maintenance of a seamless coverage of the best available, most current, authoritative GIS data can be oragnised and which would be standardised and quality controlled uniformly and authoritatively .....

NATIONAL INSTITUTE OF ADVANCED STUDIES
Indian Institute of Science Campus, Bangalore - 560 012 India

S Ramadorai
Chairman, NIAS Council

FOREWORD

In an age of global mobility, the inherent spatiality of information assumes great significance. Life in 21st Century is buoyed by ubiquitous spatial awareness. Our economy highly dependent on images and maps. Governance in the country can be improved through widespread use of geographically annotated information and databases. It is therefore of utmost importance that the National Institute of Advanced Studies (NIAS) has undertaken this study on "Standards, Spatial Framework and Technologies for National GIS".

Standardisation is important to bring together a variety of spatial data in different formats to a common framework. In a sense, a geo-spatial framework is like a "foundation of the nation" and - on this foundation various layers can be added and built upon to make an exhaustive database, grounded, as it were, in geographic truth. I am delighted to see that this study has systematically established the definition of National GIS Standards. It is also heartening to see the reflection of the cumulative wisdom from multiple earlier geospatial initiatives – especially, Natural Resources Information System (NRIS); National Natural Resources Management Systems (NNRMS); National Spatial Data Infrastructure (NSDI); National Urban Information System (NUIS) and the Natural Resources Repository (NRR).

Consultations held in NIAS in September, 2013 included experts from number of agencies in government, private sector and academia. These experts considered a draft of this report that NIAS provided, important inputs were obtained and later incorporated by the NIAS team – this is an excellent approach of NIAS in inclusive scientific consultation and widening the inputs-base.

NIAS has completed this important study and will be submitting the report to DST. It is clear that, in past few years, NIAS has developed considerable knowledge and capability in Remote Sensing and GIS related scientific and policy studies. I think NIAS is opening a new chapter for its future and entering into the "advanced studies" related to Remote Sensing, Mapping and GIS – with direct relevance to society and government. This new chapter at NIAS will be important for it to further develop scientific and policy analysis capabilities in advanced technology areas. As a spin off, NIAS should be able to undertake specific studies on ICT, Big Data, Super-computing, Data Analytics, Data Mining and also look at ways of facilitating the incorporation of emerging UAV based platforms for remotes sensing and GIS.

I am also delighted that NIAS adopts an inclusive approach and involves all relevant stakeholders including innovators and researchers. This spirit of inclusiveness and association with one-and-all is an important character for NIAS to bear upon – for it is only through open discussions, dialogue and critique that one can excel and realise impact of results. I am sure that NIAS will continue to adopt this important character and play a larger role to bring to the nation an external 'think-tank" inputs and ideations in various areas.

Finally, I sincerely hope that National geo-spatial framework will support myriads of decisions that government needs to take that will require fusion of disparate data sets of images, maps, statistics, measurements etc – be it for farmers, citizens, Infrastructure, Smart Cities, Railways, Energy, Health, environment and any other societal activity.

I congratulate the authors and also commend the young research team for the excellent work done relating to an important study. I take this opportunity to wish them the very best and hope that their knowledge and experience will further contribute in a more significant manner for national mandates in the future.

S. Ramadorai

(S Ramadorai)
e-mail: ramadorai.office@tcs.com
June 9, 2015

Preface

Realizing the importance and relevance of GIS and also to cover the existing gaps in GIS, Government of India (GOI) is implementing a NATIONAL GIS - a new information regime supporting governance, sustainable development and citizen empowerment through GIS Decision Support services and by maintaining a nation-wide, standardized, seamless and most current GIS Asset for the nation.

NIAS has undertaken a study sponsored by Department of Science and Technology (DST) to define a suite of technical standards and protocols that will allow easy GI data creation and organisation; GIS database organisation; publishing services of GI in National GIS DSS services; sharing and inter-operability of GI data in the larger context of National GIS. These standards procedures and protocols should ultimately enable government, private and individuals to "contribute" to GIS Asset, for GIS Asset to be properly and systematically created/maintained, to develop and provide effective GIS applications services and also for easy usage/access of National GIS for decision support.

This report is an outcome of exhaustive analysis and assessments – we have studied various international efforts in GIS standards, looked to national efforts in GIS and evaluated various GIS Portals. NIAS also organised a Consultation meeting of Experts on National GIS Standards in September, 2014 and obtained important inputs. All of these have helped define the key issues/perspectives and parameters for National GIS Standards – ultimately, we have defined key GIS standard parameters and values for National GIS.

Chapter- 1 is an Introduction that provides the background to the study and the scope – in the context of what DST wanted NIAS to study.

Chapter – 2 covers detailed description of international scenario of GIS standards – covering US FGDC, ISO, OGC, Europe-Inspire and China. The chapter describes the efforts and coverage of each standard and characterizes them into broad categories of content, services and inter-operability. At the end, a comparative analysis of the international standards efforts has helped identify the key trends of what each nation is doing, the differences between the efforts and focus, the commonalities and also bring out key learnings from National GIS point of view.

Chapter – 3 covers the Indian GIS Standards efforts. Tracing the evolution of GIS Standards efforts in India from 1980 onwards, we have looked at NNRMS Standards of 2005, the NUIS Standards of 2006, the NSDI Standards of Metadata of 2003 and the recent Karnataka-GIS Standards efforts. It was easily possible for us to see the major differences in the Indian efforts vis-à-vis the international efforts – especially the issue of ready GIS data availability impacting the focus of efforts between them. A comparative analysis of the Indian standards has been able to bring out the variations amongst the standards and identify the key gaps that need to be bridged in the context of National GIS.

Chapter – 4 addresses an analysis and assessment of GIS Portals – especially to understand and record the capabilities in the context of National GIS Portal Standards. Our research team has looked at 2 international GIS/Image Portals – US National Map of the United States Geological Survey (USGS), Google Earth of Google Inc,. We have also looked at 6 Indian GIS Portals – Bhuvan of National Remote Sensing Centre (NRSC), NICMAPS of National Informatics Centre (NIC), MapmyIndia by MapmyIndia Pvt Ltd, India-NSDI Portal of National Spatial Data Infrastructure (NSDI), Surveykshan Portal of Survey of India and Karnataka State's G2G GIS Portal. The analysis has helped us to bring out the characteristics,

functionalities and capabilities of each of these Portals and the key-learnings have helped to define frameworks for National GIS Portals.

In Chapter- 5, we have detailed an exhaustive set of standard parameters and their values – detailing content, database, quality, portal, metadata, catalog, map services, tiling services, portal encoding, exchange and inter-operability etc. In defining these, we have taken the key learnings from the earlier chapter – thereby ensuring that National GIS Standards proposed make up for the gaps.

In Chapter – 6 we define the most crucial element for National GIS standards – need for a National Spatial Framework – the accurate and authoritative foundation on which National GIS must get developed. When GIS data comes from different sources and frames (administrative frame, geographic frame, pixel frame etc), the need for a common linked spatial frame across these individual frame-units is extremely important. We define how a National Spatial Framework needs to be developed and made available as a basic product of National GIS in public-domain.

In Chapter – 7, we analyse and list some of the important technologies that will be important for the nation to consider, master and develop in the context of National GIS. National GIS will require integration of many of these technologies – further it would also impact many other technologies. Thus, if India develops a National GIS, it would have to necessarily build and enhance capabilities in these key technology area.

At the end, in Chapter – 8, we give a set of recommendations and key actions for National GIS Standards.

There is also a subsidiary report from the work of the research team. The NIAS research team had conducted evaluation of eight GIS Portals – 6 of which are from Indian GIS efforts. These evaluations are quite detailed and exhaustive and cover the functional capabilities, data content and design robustness of the Portals. These detailed evaluations have been compiled inti a separate report of NIAS – R31.2015 of May, 2015. We have extracted key-learnings from these evaluations and have included them in our report – but readers can refer to the second report for further details on each Portal evaluation.

We take this opportunity to express our deepest conviction that National GIS is EVEN NOW the need of the hour for the country – even if it is a concept that fructified in 2011. The Standards that have been defined by NIAS will certainly help implementation – specifically for the integrated development of the National GIS Asset and also for operationalizing National GIS Application Decision Support. It will also help hasten the implementation – as now there will be a set of standards for Government to work upon quickly.

We hope there will be all-round national commitment for implementing NATIONAL GIS is available – ultimately, the nation will benefit immensely from National GIS. NIAS will continue its efforts in this direction …….

NIAS Team takes the opportunity to thank DST, the Expert Panel Members and all those like-minded experts/professionals from various government agencies, industries and academia WHO SHARE the same vision, and commitment towards National GIS.

Mukund Rao V S Ramamurthy Baldev Raj
May 18, 2015

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Executive Summary

Department of Science and Technology (DST) has sponsored a project to National Institute of Advanced Studies (NIAS) for a techno-consulting study to define National GIS Standards – a suite of technical standards and protocols that will help implementation of National GIS – systematic organisation/maintenance of GIS Asset based on an authoritative National Spatial Framework, efficient services of GIS Data and Applications on a standards-based GIS Portal and assessment of important GI technologies that will be useful and relevant, in the long run, for National GIS.

NIAS has undertaken an exhaustive standards analysis study – various international GIS standards efforts have been analysed; the presently available Indian GIS standards of NNRMS, NSDI and others have been studied and a comparative analysis of the standards have been undertaken. NIAS has also studied in-depth the various GIS Portals (GoogleEarth, USGS National Map, MapmyIndia, Bhuvan, NSDI-India, Surveykshan, NICMAPS, Karnataka-GIS proto-type portal etc) and has drawn important conclusions on their functionality, capability, architecture/design and use. Based on these analyses, NIAS has recommended a suite of National GIS Standards covering various aspects of GIS Content, GIS database design and GIS Applications.

1. Standards are fundamental requirement for any GIS to enable technologies – imaging, GIS, GPS and applications – thematic mapping, services and outputs etc to work together. Standards are important not only to facilitate data sharing and increase interoperability but also to bring a systematization and "automation" into the total process of mapping and GIS.

2. From a national perspective, National GIS must bring vast benefits to GOVERNANCE and also to the stakeholders (ministries/policy-makers/decision-makers/citizens) by bringing about the geographical depiction of the aspirations and needs of the people, analytics of the state of national resources and economy, disparity (gaps/needs) in current state of development and bring forth decision-options that can be the basis of a "inclusive and scientific governance" – a unique Decision Support System (DSS) powered by upto-date image and map information with geo-tagged tables and developmental data.

3. National GIS implementation will fundamentally require:

    - National GIS Standards – a suite of technical standards and protocols for National GIS that will allow easy GIS Asset organisation/maintenance, GIS services of Data and Applications on a standards-based GIS Portal
    - an authoritative National Spatial Framework (NSF) as a nation-wide, uniform GIS template.
    - capability in important GI technologies that the nation would have to develop/acquire, in the long run, for National GIS.

4. Globally, GI has emerged as a key determinant in shaping contemporary societies and supremacy of nations and has emerged as vital differentiators for DSS in diverse spheres such as governance, business endeavors and citizen centric activities. There is hardly any

nation in the world that does not rely on GI for its planning, development and defence/ security needs.

5. In today's transforming world, nations that possess an advanced and progressive system of GIS would lead and chart ways in their own national and in the international arena far ahead of those that would use more traditional forms of information management. GIS technology is gaining critical importance in the international and multilateral frameworks – like, addressing cross-cutting issues of environment, rivers/drainage systems, borders, climate change and even in homeland security cooperation and in defence (particularly as defence equipment and systems are based on geospatial technology usage).

6. A detailed view of GIS standardisation environment in the world has been studied. GIS Standardisation started in late 1980s when the earliest concept of a Spatial Data Infrastructure (SDI) was proposed in USA.

- US has undertaken tremendous leading work on GIS standardisation and we feel that US looks at standardisation from a stand-point of a nation that already had well-organized, multi-source digital map data, images and geo-tagged data available. Federal Geographic Data Committee (FGDC) is the key US interagency committee that promotes the coordinated development, use, sharing, and dissemination of geospatial data. The recent focus of FGDC has been on standardisation related to GIS applications and services - both, data and applications services and exchange of GIS data across "systems". The USGS National Map is a national service from USGS that fully adopts and conforms to FGDC standards and is a visible example of use of GIS Standards.
- Europe-INSPIRE has excellent standards that define Metadata, Data Specifications, Network services, Data and Service sharing and Coordination and measures for monitoring & reporting. INSPIRE has focus is on Content Standardisation in a considerable way. Thus, INSPIRE defines what content should be included and what schema details are essential for each data element – these are well defined in INSPIRE.
- OGC standards are immensely popular and adopted by government and industry and bring about a high-level of focus on inter-operability and open-ness – though open standards are a different regime from OGC standards. OGC standards have been defined to systematize metadata, map services and web-services and host of applications services. Driven by the advanced GI eco-system in US and the intensive involvement of private sector, OGC standards are de-facto services and applications standardisation across government and industry and has brought the focus of inter-operability across GIS environment. OGC standards have been adopted by many nations and commercial data providers as part of their Spatial Data Infrastructures, and offer an effective mechanism for sharing geospatial information
- ISO/TC 211 is a standard technical committee formed within ISO, tasked with covering the areas of digital geographic information (such as used by geographic information systems) and geomatics. The work within ISO/TC211 is done in working groups, each with a specific focus. ISO standards are more driven by government agencies and are an effort to

bring about a slow-process of standards definition for imagery, geo-spatial services, quality and information management.

- China claims that they have made efforts in GIS standardisation but we have not been able to access, in spite of repeated contacts with SBSM and NASG and other agencies, the "standards documents" to be able to make a judgment on these. However, it appears from initial web-analysis of China-NASG, that they are progressing on a definitive path towards a nation-wide GIS and map data availability and services.

7. GIS Standardisation is viewed differently in different nations. This difference is emanating because the development of maturity of a GIS in nation is different. US has a long heritage of digital map data available from 1970s (Digital USGS maps and TIGER data and Street-Address data) and thus they have evolved much earlier on nation-wide content and updation. Thus, US focus is on data exchange/access and services. Europe has varying levels of maturity on Europe-wide GI content – and thus they also address GI content definition along-with access/exchange, services.

8. The following key parameters are identified for standards development:

- Content Standards – standards that define GIS content.
- Metadata Standards – that define the details of Metadata – data about GIS content.
- Schema/Data Dictionary/Data Models – defining the data dictionary and schema for each of the Content in the GIS.
- Spatial Framework – defining the geographical-envelope of the national frame based on precise boundaries and also including the internal spatial relationships of reference points that "pin" the data to precise locations on Earth in relative to the spatial frame of the boundary.
- Quality – defining quality parameters and value-limits for GIS content.
- Image – defining what images (and their parameters) form a part of the National GIS.
- GIS Services – defining standards for GIS data and application services on web platform.
- Mobile GIS Services - defining standards for GIS data and application services on mobile platform.
- Portal Standards – defining the standards for Portals and their Security
- Interoperability – defining the standards for inter-operability related to data and services.

9. In India, GIS Standardisation efforts have been on-going from 1990s and these include:

- NNRMS, an inter-agency programme of the Department of Space (DOS), has published NNRMS Standards in 2005. NNRMS standards are quite comprehensive and cover the gamut of basic GIS elements - Image Standards, Thematic Mapping Standards, GIS Database Standards, Output Standards, Thematic Accuracy Standards. NNRMS Standards also has proposed a spatial framework.
- India's National Spatial Data Infrastructure (NSDI) was defined in 2001 and the first major effort was made in defining common conventions and standards. NSDI Standards are

limited to Metadata definition and SOI data exchange. Similarly, the NSDI Exchange Standards – which were extremely narrow-spectrum applicability for SOI DVD data have out-lived their relevance in present time-frame and we do not see any practical cases of NSDI Exchange Standard being practically applied anymore.

- Ministry of Urban Development (MUD) initiated the National Urban Information Systems programme in 2004 and in 2006 adapted, from NNRMS Standards, a set of customized NUIS Standards pertain to urban development – urban planning. The NUIS Standards have been applied for NUIS project 153 town and have some validity and robustness.
- NIC has also built upon the initial standard used for 2004 National GIS Pilot which was based on NNRMS Standard. NIC seems to have made their own variations and defined and adopted their own internal standards for their GIS Portal quite successfully. This shows that users do have customizing capabilities when they use commercial COTS GIS engines and can undertake a level of standards activity based on what the software provides.
- Karnataka state defined its Karnataka-GIS (K-GIS) vision in 2013. To demonstrate the K-GIS seamless and applications concept, Karnataka defined its own K-GIS standard as a logical extension to its own RS and GIS activity bust basing much of its definitions based on NNRMS Standards – thus its learnings also will be important when National GSI Standards is defined.

10. Indian standards definition efforts have centered more around data generation (images/maps etc) and less on data services and applications. This, is because in Indian image and GIS data availability and accessibility has major gaps and not easily available for users – thus efforts are being repeated for organizing GIS data.

11. There is no standard spatial framework on which maps/GIS is generated – data foundations are not uniform and in-compatible bringing data mis-match prominently.

12. Good definitions/description are lacking in India but they are a must for GIS Standards – as it brings extremely good and uniform understanding of the standards (we have seen that in Indian standards even a common feature “Landuse” is defined differently in different GIS and thus bring different understanding).

13. National GIS Portal is envisaged as a national gateway for accessing all GIS services – GIS data, GIS applications and GIS Metadata. It is through the National GIS Portal that users will make smarter governance decisions, develop relationships and increase citizen engagement. As a part of looking at National GIS Service Standards, various GIS portals of the world were evaluated and assessed – to determine a “bar” that needs to be set for functionality, excellence and quality for National GIS Portal. Below is a summary of the evaluations:

    - The NATIONAL MAP 2.0 Portal of United States Geological Survey (USGS) provides a “window” to US spatial data along with satellite images and has robust capabilities of GIS services – viewing and querying. USGS National Map doesn’t really offer specific GIS applications – especially as it is mainly a map viewer. The most important aspect of the USGS Portal is the rich data content for the whole of US. The Portal facilitates building queries among spatial data as well as attributes data.

- Google Earth is the most widely used image and map Portal to view earth's surface and other planet's data. Google offers 1m images all over India and even 0.30m images in certain areas. Apart from images, GoogleEarth offers basic layers of road, railines and large volume of POI data. Ease of use is the strongest point of GoogleEarth as even common citizen and government agencies depend upon Google Earth. Design is very robust and the Portal is high-performing.
- Bhuvan is a "portal" of National Remote Sensing Centre (NRSC) for displaying IRS images and thematic maps – providing a "window" into the spatial data holdings of NRSC and NNRMS projects. Bhuvan has "lots of data" – mainly coming from NNRMS project outputs from 2002 onwards – this makes it more a "GIS data-bank" or a digital map REPOSITORY of NNRMS projects. Bhuvan services are just visualization tools and Bhuvan does not have integrative/applications and decision-support capability – even basic GIS querying capability is lacking. Design of Bhuvan and its user-interface needs considerable improvements – as it is too "complex" and not uniform functionally – thus making it very difficult for users to understand and use the Portal for regular decisions. Reliability of the content and displays has major gaps – performance is quite slow and also non-uniform across modules.
- India-NSDI Portal is supposed to facilitate search on India's map/image metadata holdings – one of the earliest portals aiming to provide spatial information metadata services. A basic India administrative hierarchy is encapsulated in the Portal – but there is hardly any Metadata populated – though the schema and structure of NSDI Metadata Standards has been encapsulated. NSDI portal does not have any GIS applications and integrative capabilities. Performance is very slow and reliability of data is a major gap.
- MapmyIndia Portal is first private map Portal in India - through which it provides "visual window" of nation-wide basic map data holdings and large amount of POI data that are constantly updated. Location-based address geo-coding has been successfully provided in many cities in the Portal. The Portal offers specialised location/navigation services and also commercial services. MapmyIndia has good basic GIS data that is well-updated BUT does not offer any GIS applications/integrative capabilities.
- Prototype K-GIS Portal has been developed by Karnataka State Remote Sensing Application Centre (KSRSAC) through which it provides access to its large state-wide image/map data access with tools for "displays and basic queries". The Portal has 51+ 1:50k content AND alls of these are seamless to the state of Karnataka – BUT are of different time-lines (coming from different RS and GIS projects of KSRSAC). Prototype K-GIS Portal does not have applications/ integrative decision-support capabilities.
- Surveykshan is a Geoportal of, Survey of India which is responsible for all geodetic, geophysical and topographical surveys and maps within India. Surveykshan displays Survey of India's Digital OSM maps in WMS format, which is at present available for 22 states of India. The Portal is quite poor in performance and reliability and continuity of data – which are not GIS_Ready. GIS Applications for decision-support is not available.
- NICMAPS is a "portal" of National Information Centre (NIC) through which it provides "visual display" of GIS data from NIC and map data from Survey of India (SOI) and other agencies alongwith non-spatial data holding of NIC. NICMAPS provides a "window" to full-coverage Indian spatial data along with satellite images. NICMAPS does not support any application

on the portal but has advance services like Locators, Swipe & Spotlight, Elevation profile and so on. The portal is quite stable and data available on it is quite robust.

14. Some of the observations from analysis of the GIS Portals, in the context of National GIS, include:

- **Content** is what "makes or breaks" a GIS Portal and thus the GIS Portal must have high-quality, verified and scrutinized and upto-date GIS Content – and the mantra needs to be "keep Content that is GIS-ready, uniform, good quality, current, seamless and standardized". In the Indian context, we observe that none of the GIS Portals have content that conforms to what should be in National GIS. **In our analysis, National GIS cannot be a "collection of whatever map/image data is available" – a systematic GIS Asset needs to be designed with layer/image definitions, feature definitions, schema definitions – which are seamless across the nation uniformly, standardized as per a National GIS Standard and constantly updated as per an update cycle.**
- **Metadata** is an important element of any Portal – that helps understand the data about the data. In our analysis, Metadata is poor across all GIS Portals that we have studied and analysed except the USGS National Map Portal that contains Layer Metadata as per FGDC Standards. **In our assessment, National GIS must organise Metadata systematically – in fact, it can be the easiest to organise and systematically populate at the first step – thereby allowing users to immediately know what data is available in National GIS and allow for efficient search.**
- **Data Dictionary**: A data dictionary is a collection of descriptions of the GIS feature objects or items in a GIS data model for the benefit of users, application developers and others who need to refer to them – basically, identifying each GIS feature and its relationship to other objects. Efforts at making a good data dictionary is yet to be put and visible in the Indian Portals. **National GIS needs a well-designed Data Dictionary that will be the foundation of all data development, exchange and integrated analysis.**
- **Quality of GIS content** is extremely important for a GIS Portal to be authoritative and useful for applications. There are typically three types of consistency that is important for GIS portals - point in time consistency, ensuring that all GIS content and its data model are uniform at a specific point in time; transaction consistency, consistency of a piece of GIS content across a GIS Portal operation and application consistency, transaction consistency between various GIS Applications and processes across the Portals. The importance of ensuring data consistency is to maintain the integrity of the GIS content available on the Portal. This is lacking in most Indian GIS Portals. **Unless care is taken to define quality standards, measure quality of data and ingest only data of highest quality, National GIS will fail in its objective to be that one-source authoritative data.**
- Image inclusion is important for GIS portals – not just satellite images, aerial images or UAS images BUT any image that can be geo-tagged has to be an important element of the National GIS content. From a satellite image perspective, GoogleEarth is best as it provides highest resolution image across the country; Bhuvan has reliable IRS image inclusion BUT they are mostly of resolutions around 2.5m and coarser. In both these portals, latest images are not available and mostly ~5+ years old images are seen. Fusion of images over maps is

critical and important – only google Earth allows for this in a limited content. Bhuvan does not have this fusion capability that is extremely important for decision-making. **Images – be they from satellites/air-platforms/ground, are the fundamentals of National GIS Portal. Robust image management techniques and fusion techniques are important.**

Worldover satellite images are reaching sub-metre levels operationally and with global coverage – why is it that Indian IRS systems, even today, are still "struggling" at metre-level resolutions for operational availability? In late 1990s, India was the world's leading country with highest resolution civilian satellite of 5.8m PAN – but in 2015, India seems to have trailed behind in the world as far as state-of-art in high-resolution image operational availability is concerned.

Should governance or Decision Support in India suffer because of the non-availability of high-quality/resolution satellite images – which, today is anyway available all over the world from non-Indian commercial satellites? In fact, National GIS MUST demand for high quality and high-resolution images and drive ISRO to plan and provide best quality/resolution satellite images in an operational manner – comparable, if not superior, to what is available in the world?

- GIS Services is the heart of any GIS portal. The more services that are offered the better characterized is the GIS portal. GIS services should include GIS Data Services (that is 2-way on-line GIS data service - access to actual GIS-Ready data and ability to upload GIS-ready data to Portal) and GIS Applications Services (that is providing variety of GIS applications and modelling capability of display, query, integrative modelling, geo-correlation analysis, geo-analytics, routing applications, predictive applications, simulative applications etc; allowing variety of GIS Apps to be publishable). Just data visualization and display cannot make a good GIS Portal. In our assessment, we hardly see Decision Support capabilities of any of these Indian GIS portals. **National GIS must have well-designed and robust National GIS services – both, GIS Data Services that allow access and download of GIS-Ready data AND GIS Application services for different users (agriculture/ urban/rural/governance/citizens……) which needs to be a set of decision-tools packaged into a GIS Application Decision Support module.**
- **Mobile GIS Services** are basically the availability of mobile apps for GIS Portals by way of which GIS data and Apps can be easily accessed on mobile and hand-held devices. GoogleEarth, MapmyIndia have excellent mobile services capability – these are quite robust and widely used. Other Indian Portals "claim" mobile-services but there are basically low-performing data visualization**.**
- **Interoperability** is related to producing GIS portal results in standard compatible web browsers, GIS engines, operating systems and devices and are based on the latest web standards. In the GIS domain, OGC has defined a set of inter-operability GIS Apps standards that must forma base for all Portal interoperability. Most of the Indian Portals are poor in inter-operability and need robust standards adoption**.**

15. National GIS will require a quantum jump from the existing philosophies, approaches and design, content and technologies, development and operations that have been adopted in India – leading ahead quickly into an operational GIS Decision Support capability in next 2-3 years BUT also excelling the national capability in GIS activities for next 10-15 years, at the least. **In our view, fresh and new efforts to organize National GIS Asset/Application Services/Portal will be is best step forward.**

16. NIAS has identified the following categories of Standards for National GIS:

- National GIS Content Standard – which basically includes what content needs to be included in National GIS.
- National GIS Database Standard (including Quality) – which defines the details of GIS database related standards for the National GIS and includes data quality parameters
- National GIS Services Standard – basically outlining Data, Applications and Portal services.

17. The National GIS Content Standards needs to include ~84 features, including 43 essential and 41 additional content for National-GIS – grouped into 17 categories. It would be important to have a National GIS Content Thesaurus – that defines the class-categories and enables a common understanding and also links the categories to the purpose and use of the classification system. Naming Convention for National GIS content so that the name is easily understandable typology. Coding schemes for National GIS content must follow the source coding schemes.

18. 28 parameters of a National GIS Database Standard and their values have been identified for a systematic GIS database to be organised to power National GIS.

19. As part of the National GIS Services Standard, details of National GIS Metadata Standards, National GIS Portal standards, National GIS catalog standard, National GIS map services standard, National GIS map tiling services standard, National GIS feature services standard, National GIS portal encoding standard, National GIS exchange standard, National GIS web coverage services standard, Georss simple standard, National GIS sms ingest standard and National GIS Applications standard have been provided.

20. The National Spatial Framework (NSF) is a critical and essential element to develop an authoritative and reliable National GIS Asset. Without a NSF, in-consistency in GIS data will be very high. In our study of GIS data of different Indian Portals (as well as foreign) we have seen the in-consistency in data in large measures - for example, Bhuvan administrative boundaries DO not match with Surveykshan administrative boundaries; Bhuvan's 1:50k wasteland DO Not match with 1:10k landuse; NICGIS has its own roads that DO NOT match with Bhuvan roads; MapmyIndia points-of-interest data DO NOT match with Bhuvan points; …..and so on are many examples.

21. In National GIS, content will come from any of these 4 basic sources – each having its own referencing systems:

- Satellite image – the satellite image is on a "pixel-frame" with a Earth-reference coordinate system super-imposed.
- Topographic frame – defined by geographic frame of SOI OSM maps – thus derivative maps using the OSM frame carry-forward the geographic referencing.
- Administrative frame - villages/taluk/district/state/nation on which all administrative data and governance are associated. This does not have an inherent geographic referencing.
- Ground surveys (using instrument like GPS/TS and Smartphones etc) – by which lat-long coordinates of the instrument positioning devices (commonly using positioning satellites – GPS, Glonass or in future IRNSS) providing geo-referencing.

22. The 84 features of National GIS Content that have been identified are based on one of the above four basic frames – thus they carry the characteristic of the basic frame in the GIS. The issue is to cross-correlate and geo-reference these 4 basic frames – so that across the 84 features a common geo-referencing is achieved – allowing easy super-position/overlay and integrated analysis. This will, more importantly, also ensure ground-match of features – so that location, distances, area etc are well maintained.

23. The key is to develop a NSF where a "one-time effort" is made to standardize the reference of satellite-image based coordinates; SOI OSM based coordinates and GPS/TS based coordinates. For this one time exercise, it would be essential to use a SOI topographic map's geographic frame for precise national boundary (this is presently available on 1:50k); the best-accurate Indian administrative boundary frame (state/district/taluk boundaries – this is available in 1:50k SOI OSM maps); the best-resolution satellite-image for India (which is corrected using GCPs – would be good to use ~1m images as they are available) and "fuse-integrate" these 3 together to create the basic foundation frame – so that this foundation can easily assimilate the features coming out from satellite images or features of SOI OSMs and the administrative frame. It would be essential to use a set of Ground Control Points (precision measured coordinates in this frame) that can be super-imposed on the precision Indian boundary layer and create cross-referencing to satellite images and for local referencing – thus also ensuring in the GIS that a "tight pinning-down" of the frame to Indian land-mass. Integrating village boundaries will be easy into the taluk boundaries (of the administrative boundary frame) and thus creating a seamless village layer for the country. When any local survey is done, the GCP frame will provide a cross-referencing to the survey points to the NSF – thus the data will "sit properly".

24. NSF must become the basic geo-referencing frame for any GIS data ingest into National GIS BUT more importantly ensure that all GIS data are co-registered. NSF must be a basic freely-available product form national GIS.

25. NSF can also be the foundation of a very quickly organised National Spatial Foundation Dataset (NSFD) – a minimalistic template product from national GIS.

26. The National GIS Standards needs to be compliant with international ISO TC211 processes – especially as India is already committed to ISO standardisation efforts through the Bureau of Indian Standards (ISO is a multi-lateral body for standardisation and India is represented by BIS).

A Expert Standing Committee can be tasked to help National-GIS to review, update the National GIS Standards from time-to-time.

27. A concerted effort needs to be taken to make aware, promote, encourage and generate/organise these GIS Standards, NSF and GIS Process documents and also encourage for using these to be able to integrate into the common platform of the National GIS. All government/enterprise and other private agencies would comply with these standards and NSF so that practices within their own processes will be able to contribute to and benefit from National GIS.

28. National GIS implementation will require India to acquire technological capability in key areas of geo-spatial technology –a suite of technologies have been identified for India. National GIS must also assess futuristic applications that would be "demanded" from the nation and also develop the broader GI eco-system in India in next 10-15 years

1. Background

1. India has taken up the definition and implementation of National GIS[1] as a major initiative. It is recognized that developmental activities in India will demand a new paradigm and governance regimes will need considerable change. India will require a vastly different information regime to arm itself for meeting the future developmental challenges – powered by very efficient national information systems that will have to be the foundation for the governing and the governed – bringing the assessment of development needs, bridging disparity and gaps, bringing equity, transparency, inclusivity and citizen participation. One such area is Geographical Information Systems – a system (of hardware/Software/data/applications/policies) that deals with spatially referenced and geographically tagged/linked data.

2. Over the years, India has developed successful activities in imaging (from satellites, aerial and ground platforms and now from Unmanned Aerial Systems), mapping (topographic and thematic), positioning, surveying and GIS databases and applications. GIS technology is widely used and a large knowledge-base has been created in the country. In spite of fairly wide usage of GIS as a technology, the full potential of GIS has yet to be exploited for decision-support and planners, stake holders for governance-process, citizens and many other groups. Some of the past projects/ initiatives have certainly been successful to establish GIS application potentials in a "project mode" but GIS is yet to become part and parcel of a "service orientation" and get assimilated into the process of governance, planning and nation-building in a significant manner.

3. Realizing the importance and relevance of GIS and also to bridge the existing gaps in GIS, Government of India (GOI) is considering a NATIONAL GIS programme - a new information regime supporting GIS based Decision Support services for governance, private enterprise and citizens AND by maintaining a nation-wide, standardized, seamless and most current GIS Asset for the nation.

4. National GIS implementation will fundamentally require:

    4.1. National GIS Standards – a suite of technical standards and protocols for National GIS that will allow easy GIS Asset organisation/maintenance, GIS services of Data and Applications on a standards-based GIS Portal

    4.2. an authoritative National Spatial Framework (NSF) as a nation-wide, uniform GIS template.

    4.3. capability in important GI technologies that the nation would have to develop/acquire, in the long run, for National GIS.

5. Standards are fundamental requirement for any GIS to enable technologies – imaging, GIS, GPS and applications – thematic mapping, services and outputs etc to work together. Standards are

[1] Implementation of a National GIS under INGO – Programme document (http://www.moes.gov.in/writereaddata/files/national_gis.pdf). A National GIS Vision document prepared by Planning Commission's Interim Core Group on National GIS and published by Ministry of Earth Sciences in October, 2011.

important not only to facilitate data sharing and increase interoperability but also to bring a systematization and "automation" into the total process of mapping and GIS.

6. In addition, critical for implementation for National GIS will be a national policy - NIAS has earlier defined a National GIS policy as part of a Department of Science and Technology (DST), Government of India (GOI) sponsored policy-research study in in January, 2012. As an outcome of this study, NIAS has submitted to DST a National GI Policy document that includes a draft of a possible National GI Policy[2].

7. Now, NIAS has undertaken this techno-consulting study, sponsored by DST, to define the National GIS Standards and National GIS Spatial Framework through a process of exhaustive technical analysis and assessments of standardisation across the globe and in India, parametric analysis of GIS standards and wide range of consultation with experts and stake-holders of National GIS.

8. This report is the outcome of the NIAS techno-consulting study.

1.1. NATIONAL GIS

9. It is essential to understand the perspective of National GIS that has been outlined in the National GIS vision of 2011.

10. Over the years, India has developed successful projects in GIS – both in government and commercial domain. The use of satellite images and its down-stream GIS data concept started in early 1980s in India – and since then numerous experimental projects, pilot-projects and area-specific projects have been implemented by various agencies. As a result of these efforts, today, GIS technology is widely used and a good knowledge-base has been created in the country over the years. GIS based initiatives (or projects) of the Natural Resources Information System (NRIS) under National Natural Resources Management System (NNRMS); National Spatial Data Infrastructure (NSDI) of Department of Science and Technology (DST); establishing G2G GIS by National Informatics Centre (NIC); Delhi State Spatial Data Infrastructure (DSSDI) of Delhi State; National Urban Information System (NUIS) of Ministry of Urban Development (MUD); various City-GISs (example Mumbai, Bangalore, Kanpur, Kolkata and many others; GIS-based Power management solutions under Restructured Accelerated Power Development and Reforms Programme (R-APDRP) of Ministry of Power; recent efforts at modernization of land records under NRLMP; launch of Bhuvan Image Portal of Department of Space (DOS) and many others have been implemented. In addition, various GIS initiatives of the states - of particular mention is innovative GIS of the states of Gujarat, Karnataka, Maharashtra, AP and many others have helped bring showcase potentials of state-wide GIS. In addition to these government agencies efforts, many private sector agencies have also been successful in implementing GIS solutions and in providing GIS services.

11. As mentioned in the National GIS Vision document, in spite of fairly wide usage of GIS in many projects, the full potential of GIS as a tool for GOVERNANCE and Decision Support has not been

[2] Mukund Rao and K R Sridhara Murthi (2012). Perspectives for a National GI Policy, (Report R 11 -2012) National Institute of Advanced Studies, Bangalore, September, 2012. Report No: R11-2012. (www.nias.res.in/docs/R11-2012-GI-Policy.pdf)

exploited – mainly to the benefit and support of planners, stake holders for governance-process, decision-makers, citizens and many others. While the GIS projects till now have certainly been successful to repeatedly demonstrate and establish usefulness of GIS applications – they have just remained in a "project mode" activity. Thus, one major change that is required is to bring GIS into the process of governance and decision-making – GIS should be given a massive "service orientation" and GIS should get assimilated to into the process of governance, planning and nation-building in a significant manner.

12. We re-iterate the key questions that face the nation with regard to GIS:

12.1. how can the nation ensure that its decision making/governance process is embedded with a comprehensive, easy-to-use GIS Decision Support System that brings scientific, transparent, participatory and quality dimensions into decisions, planning and development

12.2. how can the nation ensure that GIS-Ready data is always easily available and maintained/ updated – by adding that critical capability differentiator over the images and maps that have already been invested in

12.3. how can India maintain a high-level of national capability in The GIS technology area and also leverage itself to be in the fore-front of GIS technology at the international arena

1.2. FOCUS OF NATIONAL GIS – MEETING GOVERNANCE NEEDS

13. The focus of National GIS must be to create a new paradigm for governance and development with emphasis on inclusive growth and development – especially to reduce disparity, expedite development and bring in demographic dividends that will be unique. GIS can rapidly becoming a catalyst for several transformational changes in the country - mainly in scientific management of natural resources, spatial planning, holistic decision making, participative governance and citizen engagement. National GIS must bring in the paradigm of embedding GIS into governance and in establishing G (G signifying GIS-based)-Governance (G-Gov) as the next frontier[3].

14. The vision of National GIS is aligned to enable a scientific mapping of the resources, disparities and needs, and aspirations of beneficiaries and society, especially the most disadvantaged; support sustainable and spatial planning; assist quick and reliable monitoring of plan implementation and status of development; enable transparent systems for inclusivity of society; and support real-time mapping of feedback and redressal systems.

15. Many states have implemented state-wide GIS that have been successfully put to use in governance. The state of Gujarat's GIS is one such example – it has been built/developed as a seamless state-wide GIS and is impacting governance and decision-making in MNREGA, forests right act implementation, sustainable agriculture production, disaster management, irrigation management, village-level amenities planning etc. Similarly, Karnataka state has developed a prototype of a seamless state-wide multi-layered Karnataka-GIS that is providing, for the first time, a full view of image and map information for the state departments and agencies. Maharashtra and

[3] Mukund Rao, R Sivakumar, K R Sridhara Murthi, Shailesh Nayak and T Ramasami - India's Vision for National GIS (based on space-images and positioning, survey and maps, virtual GI, geo-tagged data) (2013). Paper presented and published in Proceedings of (Ref: IAC-13,B1,4,7x16548) 64th International Astronautical Congress, Beijing in September, 2013.

AP have also implemented good governance-specific applications of GIS. These, and other state efforts, have shown how GIS usage are implemented in sectors like Rural Development, Urban Development, Infrastructure development, Facilities development and Utilities development.

16. Learning from these state examples, focus of National GIS must be TOWARDS GOVERNANCE – which means to meet the GIS applications need of government agencies and citizens and be oriented to the national and state-level programme of development and programmes.

17. From a national perspective, National GIS must bring vast benefits to GOVERNANCE and also to the stakeholders (ministries/policy-makers/decision-makers/citizens) by bringing about the geographical depiction of the aspirations and needs of the people, analytics of the state of national resources and economy, disparity (gaps/needs) in current state of development and bring forth decision-options that can be the basis of a "inclusive and scientific governance" – a unique Decision Support System (DSS) powered by upto-date image and map information with geo-tagged tables and developmental data.

18. At the same time, GIS has to an arena for India to maintain technological and developmental edge. As mentioned in the National GIS vision, in the transforming world, nations that will possess a sound and progressive system of geographical information management will lead and chart ways in their national and international arena far ahead of those that would use more traditional forms of information management.

2. International Scenario in GIS Standards

19. Globally, GI has emerged as a key technology in shaping growth of societies, supremacy of nations and has emerged as a vital differentiator for DSS in diverse spheres of human activity - governance, business and citizen centric activities. There is hardly any nation in the world that has not implemented GIS for planning, development and defence/security needs. In fact, many nations have developed heavy reliance on GI and use of advanced technologies of satellite images, surveying and mapping, GIS databases and integrated applications to the extent that there is an overall characterization of a "geospatial divide" that is emerging between those that have advanced programmes with those that have lower capability.

20. In the last 2 decades, many nations have considered a "cooperative sharing" framework for maps and images under their (national) Spatial Data Infrastructure (SDI) concept – where map/image data generating agencies agree to share their maps/images as per defined standards and protocols. India too embarked on a national SDI (NSDI) in early 2000s and undertook limited experiments in Metadata sharing. However, at the global level, the framework of SDI turned into a mere sharing-platform for map/image generating agencies (putting up whatever maps are generated) and served very limited the needs of user agencies/ministries/citizens in meeting their decision-making needs. Thus, the SDI concept has been unable to bridge and close the ever-existing gap between what map/image data is readily available with what GIS image/data the users require for decisions/governance. Many nations and corporates have realized this gap and recognize that a nation(global)-wide, seamless image/map data of what users would require and which is readily available to users is fundamental to make GIS more relevance and user-centric.

21. From a global perspective, images/maps are becoming a critical capability that provides technological edge to nations. As has been mentioned in the National GIS vision, GIS technology is gaining critical importance in the international and multi-lateral frameworks – like, addressing cross-cutting issues of environment, rivers/drainage systems, borders, climate change and even in homeland security cooperation and in defence (particularly as defence equipment and systems are based on geospatial technology usage).

22. The early efforts of NRIS in India, NSDI in the world has brought many issues of technology standardisation to the fore.

23. The wide availability of satellite data and digitalization of map information made it easily possible for generation and organisation of images/maps in digital GIS format as "layers" and amenable to "integrated analysis". This has triggered a commercialization of the GIS domain and mass markets for spatial information have become a reality – growing in recent times. There has been explosive growth of actors involved in the generation and use of spatial information, often spread in different regions and different legal jurisdictions. This on one hand we are seeing un-hindered proliferation of GIS databases and projects and on other hand we see a "chaotic" regime for image/map data exchange and sharing of GIS data and applications.

24. Availability of authoritative and national-oriented GIS data and applications services is being recognized as key in the next stage of GIS proliferation and usage – especially, in the context of being user-centric and meeting governance needs. While the last 2 decade witnessed a major trend towards "cooperative sharing GIS frameworks" – where map/image data generating agencies share their maps/images as per defined standards, it is now realized that just sharing what image/map data is readily available does not meet the requirement of decision makers at different levels.

25. India has realized this gap and identified that a "nation-wide system" to ensure ready availability of nation-wide, seamless GIS image/map data is fundamental need to trigger GIS based applications DSS for governance and nation-building - effectively supporting diverse needs of governance, business enterprises and citizens. Similarly, USA, Korea, China and European nations are already in the process of extensively working on a nation-wide GIS and also in establishing a GIS standardisation. Corporates like Google are already providing global image/data services for many years and large number of private sector efforts at GIS services have successfully emerged. In tandem with these national/corporate efforts, the efforts of multi-lateral bodies – like ISO, OGC, GSDI etc are also in areas of bringing attention, focus and solutions for inter-operability and integration of the government and private sector efforts in GIS.

26. We have studied the GIS standardisation environment in the world and in the ensuing sections we provide analysis of emerging scenarios of GIS standards and learnings from them in the context of defining India's National GI Standards.

2.1. USA – FGDC[4] and USGS

27. One of the longest and most stable efforts in GIS and digital maps have been from the United States of America (USA). As early as 1990s, US positioned the concept of National Spatial data Infrastructure and brought in concepts and issues related to GIS data sharing, access and focus on standardisation. The US Executive Order (EO) 12906 on Coordinating Geographic Data Acquisition and Access: The National Spatial Data Infrastructure of April 1994 called for establishment of National Geospatial Data Clearinghouse and data documentation using the FGDC metadata standard.

28. The Federal Geographic Data Committee (FGDC) is the key US interagency committee that promotes the coordinated development, use, sharing, and dissemination of geospatial data on a national basis based on It also said that "The FGDC shall develop standards for implementing the NSDI, in consultation and cooperation with State, local, and tribal governments, the private and academic sectors, and, to the extent feasible, the international community, consistent with OMB Circular No. A–119 ("Federal Participation in the Development and Use of Voluntary Standards"), and other applicable law and policies."

29. With respect to standards, Federal agency responsibilities under OMB Circular A-16 are to use FGDC data standards, FGDC Content Standards for Digital Geospatial Metadata, and other appropriate

[4] Julie Binder Maitra (2014). Geospatial Standardization in the U.S. and India – a communication provided to NIAS on Feb 3, 2014 for this project study.

standards, documenting spatial data with the relevant metadata, and making metadata available online through a registered NSDI-compatible Clearinghouse node.

30. The purposes of Section 216, Common Protocols for Geographic Information Systems, of the e-Government Act of 2002 (E-Government Act of 2002 (Public Law 107-347, 2002) are to reduce redundant data collection and information and promote collaboration and use of standards for government geographic information. Common protocols shall be designed to maximize the degree to which unclassified geographic information from various sources can be made electronically compatible and accessible and promote the development of interoperable geographic information systems technologies that allow widespread, low-cost use and sharing of geographic data by Federal agencies, State, local, and tribal governments, and the public and enable the enhancement of services using geographic data.

31. The FGDC Policy on Recognition of Non-Federally Authored Geographic Information Standards and Specifications (Federal Geographic Data Committee, 2005) builds on OMB Circulars A-16 and A-119. It establishes a mechanism for FGDC recognition of non-Federally authored standards or specifications that are relevant to the missions and spatial data responsibilities of Federal agencies as set forth in OMB Circular A-16. Neither Circular A-16 nor A-119 expressly defines a mechanism for the identification, selection, and coordinated implementation of non-Federally developed standards. The FGDC Policy on Recognition of Non-Federally Authored Geographic Information Standards and Specifications outlines a fast-track process for adopting standards developed by a rigorous external standards process, for example, ISO or the OGC.

32. OMB Circular A-16 Supplemental Guidance (Office of Management and Budget, 2010) and associated documents further define and clarify elements of OMB Circular A-16 to facilitate the adoption and implementation of a coordinated and effective Federal geospatial asset management capability. It will improve support of mission-critical business requirements of the Federal Government and its stakeholders. It provides the foundation for a portfolio management approach to Nationally Geospatial Data Asset Themes (NGDA Themes) and their associated National Geospatial Data Asset Datasets (NGDAs). A-16 Supplemental Guidance does not emphasize Framework data themes and instead focuses on Nationally Geospatial Data Asset Themes (NGDA Themes) and their associated National Geospatial Data Asset Datasets.

33. There are 5 stages in process of standardization that is adopted by FGDC:

    33.1. Proposal Stage: The Proposal Stage defines the needs for and benefits of a standard. At the end of the Proposal Stage the FGDC recognizes the standard as a project and adds it to the standards' register, but work or funding for the standard may not yet be identified.

    33.2. Project Stage: The Project Stage defines the funding and administration for the standard. The development methodology, work groups and members, and development schedule are documented. At the end of the Project Stage work begins on standards development.

    33.3. Draft Stage: This is the actual stage of standards development. The standard receives comments and input from as many constituent groups as possible. At the end of the Draft Stage the Standard is ready for public review.

33.4. Review Stage: The first portion of the review stage is for public comment and official public review. The latter portion of this stage is for internal FGDC format and integration review. At the end of this stage the standard is ready for FGDC approval.

33.5. Final Stage: The Final Adoption Stage is where the standard becomes an officially recognized FGDC Standard.

34. The four basic categories of standards are: Data, Processes, Organizations, and Technology. FDGC take care of making Standards for Data and Process whereas for Organization and Technology. Following are the standards endorsed by FDGC:

34.1. Content Standards (National Vegetation Classification, Wetland, Soil, Trail, Utilities etc.)

34.2. Spatial Data Transfer Standard

34.3. Geospatial Positioning Accuracy Standards

34.4. Geographic information Framework Data Standard (Cadastral, Governmental unit and other geographic area boundaries, Elevation, Hydrography, Transportation, Geodetic Control, Digital Orthoimagery)

35. FGDC External endorsed standards include standards from ANSI (American National Standards Institute), OGC (Open Geospatial Consortium) and ISO/TC211 (International Organization for Standardization Technical Committee 211). These standards play an important role in enabling interoperability.

36. The detail of FGDC Standards and an analysis made by NIAS on the same is given in **TABLE 2.1.**

37. The USGS National Map[5] is a classic example of collaborative effort among the USGS and other Federal, State, and local partners to improve and deliver geographic information for the Nation. It has many uses ranging from recreation to scientific analysis to emergency response. The National Map is easily accessible for display on the Web, as products and services, and as downloadable data.

38. The USGS National Map fully adopts and conforms to FGDC standards and is a visible example of a geo-spatial agency that has organised geo-spatial data and services using these standards in an operational manner.

39. The geographic information available from the US National Map includes Orthoimagery (aerial photographs), elevation, geographic names, Hydrography, boundaries, transportation, structures, and land cover. Other types of geographic information can be added within the viewer or brought in with The National Map data into a Geographic Information System to create specific types of maps or map views. The National Map is a significant contribution to the National Spatial Data Infrastructure (NSDI) and currently is being transformed to better serve the geospatial community by providing high quality, integrated geospatial data and improved products and services including new generation digital topographic maps.

[5] (http://nationalmap.gov)

40. A detailed analysis of what USGS National Map is given **TABLE – 2.2**.

2.2. EUROPE - INSPIRE[6]

41. Europe has a programme of INFRASTRUCTURE FOR SPATIAL INFORMATION IN THE EUROPEAN COMMUNITY (INSPIRE) through a directive that came into force on 15 May 2007 by the European Commission. INSPIRE and is implemented in various stages, with full implementation required by 2019. The INSPIRE directive aims to create a European Union (EU) spatial data infrastructure. This will enable the sharing of environmental spatial information among public sector organizations and better facilitate public access to spatial information across Europe.

42. A European Spatial Data Infrastructure will assist in policy-making across boundaries. Therefore the spatial information considered under the directive is extensive and includes a great variety of topical and technical themes.

    42.1. Data should be collected only once and kept where it can be maintained most effectively.

    42.2. It should be possible to combine seamless spatial information from different sources across Europe and share it with many users and applications.

    42.3. It should be possible for information collected at one level/scale to be shared with all levels/scales; detailed for thorough investigations, general for strategic purposes.

    42.4. Geographic information needed for good governance at all levels should be readily and transparently available.

    42.5. Easy to find what geographic information is available, how it can be used to meet a particular need, and under which conditions it can be acquired and used.

43. The INSPIRE process for GIS Standardisation includes a 3-step process:

    43.1. Preparatory phase – including a Co-decision procedure, Start of preparation of Implementing Rules

    43.2. Transposition phase – including Directive entered into force where INSPIRE Committees starts its activities and continues of preparation of Implementing Rules. Finally transposition into national legislation where the standards are adopted as Rules

    43.3. Implementation phase where Implementation and monitoring of measures and Continuation of preparation of Implementing Rules and their adoption is taken up

44. INSPIRE has excellent standards that define Metadata, Data Specifications, Network services, Data and Service sharing and Coordination and measures for monitoring & reporting

45. INSPIRE standards are detailed with an analysed by NIAS in **TABLE – 2.3**.

[6] (http://inspire.ec.europa.eu/)

2.3. OGC STANDARDS[7] [8]

46. The OGC is an international voluntary standards organization focused on defining, testing, and maintaining standards that enable geodata discovery, sharing, integration, viewing, and processing across different technologies and vendor products, the web and wireless networks. Any organization can participate in the work of the OGC. There are currently 470+ member organizations from 37 countries representing the private sector GIS companies, commercial open source organizations, government, NGOs, universities, research organizations and system integrators.

47. An OGC standard is a document processed and approved by the OGC membership. Any OGC member can participate in the development and maintenance of an OGC standard. The document submission and approval consensus process is guided by the OGC Technical Committee Policies and Procedures. Both Member and public engagement in the standards development process – including review and implementation testing – ensuring a mature and robust standard. Characteristics of an open standard are:

    47.1. Availability: Open Standards are available for all to read and implement.

    47.2. Maximize End-User Choice: Open Standards create a fair, competitive market for implementations of the standard. They do not lock the customer in to a particular vendor or group.

    47.3. No Royalty: Open Standards are free for all to implement, with no royalty or fee.

    47.4. No Discrimination: Open Standards and the organizations that administer them do not favor one implementer over another for any reason other than the technical standards compliance of a vendor's implementation.

    47.5. Open development process: The standard is adopted and is maintained by a not-for-profit organization, and its ongoing development occurs on the basis of an open decision-making procedure available to all interested parties (consensus or majority decision etc.)

    47.6. No Constraints: There are no constraints on the re-use of the standard.

    47.7. Application Independence: To ensure that access to resources is not dependent on a single application.

48. OGC clearly distinguished between open standards and open source are two different things. See the Open Source and Open Standards[9] white paper jointly published by the OGC and the Open Source Geospatial Foundation.

49. OGC employs proven policies and procedures to guide the development, testing, validation, demonstration, adoption and maintenance of geospatial standards. These standards are freely available to anyone, are maintained by OGC's international membership, and are typically

[7] Mark Reichardt (2014) – Communications received from OGC on October 8, 2014 vide email on Draft Document

[8] Mark Reichardt (2014) – Open standards and the NGIS. A note communicated from OGC to NIAS in January, 2014

[9] Open Source and Open Standards http://wiki.osgeo.org/wiki/Open_Source_and_Open_Standards

submitted to organizations such as ISO and the International Telecommunications Union (ITU) for Adoption as dejure international standards.

50. OGC suggests that given NGIS's role as a mechanism to improve government-wide decision making through improved place-based decision support tools, to modernize government geodata maintenance, and to enable citizen-centric benefits, open standards are key to:

50.1. Enable interoperability between existing data providing organizations and users across the web or mobile networks.

50.2. Assure rapid mobilization of new data sources, application tools and services into existing systems and enterprises – regardless of the supplying vendor or provider.

50.3. Reduce system lifecycle effort and costs

50.4. Future proof NGIS to accept new technologies and data sources as needed

51. Applicable geospatial standards for inclusion in NGIS include those of ISO and OGC, with supplementary IT open standards and specifications from groups such as W3C, ISO, IITF and OASIS providing a broader framework of interoperability related to critical functions such as security. OGC also suggests that standards enable interoperability for the entire core NGIS functional requirements -- publishing, discovery, maintenance, processing and broad access to geospatial holdings maintained by Indian government agencies, and should be an underpinning of the NGIC Portal environment as well as NGIS Application Products and Services.

52. In the OGC, content models refer to community agreements on the elements, relationships between elements, semantics and so forth for a specific data set in a given domain. Further, content models are implementation independent and vendor neutral. In order to automate and make the exchange of domain specific geospatial data seamless, consensus needs to be built among the community participants on:

52.1. A shared data model for data exchange, in terms of a lingua-franca for different systems to understand each other;

52.2. Common definitions of the different data entities and their properties; and

52.3. Common controlled vocabularies and taxonomies.

52.4. Consensus building is not a trivial task. Communities have deep knowledge and expertise for their domains. These communities work together to come to agreements and consensus on the domain content models

53. OGC visualises that as GIS matures, there will no doubt be the desire to integrate sensor feeds with other geospatial data sources – for greater situational awareness and decision making. The OGC Sensor Web Enablement (SWE) standards will enable GIS to publish and discover sensors, access sensor observations, and fuse these observations in a location and time context.

54. Increasingly, mobile devices are a becoming a key source for geospatial data capture, maintenance and application. While OGC web services standards noted above work in the mobile internet

environment, OGC notes that there are other adopted and in-work standards that may be of relevance to the GIS - Open GeoSMS is a recently adopted OGC standard that defines a standard approach to encoding a geo-tag for an SMS message. Open GeoSMS enables mobile users to transparently send location information in the header of their mobile text messages.

55. There are several OGC standards activities that will be important for Phase II and beyond in GIS deployment. These include:

55.1. GeoPackage: Soon to be approved, the GeoPackage (GPKG) standard is an open, app-independent, platform-independent, portable, interoperable, self-describing data container and API. Designed for the mobile world, this standard is intended to support multiple mapping and geospatial applications such as fixed product distribution, local data collection, and geospatially enabled analytics.

55.2. Version 3.0 of Catalogue Services – Web with the OpenSearch Geo and Temporal extension. This OGC candidate standard specifies a set of geospatial and temporal extensions to the OpenSearch query protocol. Open Search is a collection of simple formats for the sharing of search results.

55.3. Points of Interest: Encoding standard of points of interest data that includes an abstract data model and JSON and XML Schema implementations of that data model.

56. The India SDI community should carefully consider the characteristics of successful national SDI implementations. Interestingly, the characteristics of a successful SDI are the same as for a successful standards development organization such as the OGC. Standards alone are helpful, but focus on other factors such as clear policy and service level agreements for instance are important. As India moves to implement the NGIS, careful consideration should be given to:

56.1. Service level agreements between contributing agencies and providers to assure system / data availability, agreed upon open standards, adherence to copyright and intellectual property rights.

56.2. Acquisition / procurement language that encourages the use of a consistent baseline of open standards for all NGIS components.

57. A clear policy position on the acceptance / use of international and commercial geospatial sources in times of crisis/emergency. OGC standards have been adopted by many nations and commercial data providers as part of their Spatial Data Infrastructures, and offer an effective mechanism for sharing geospatial information during time of crisis/emergencies. Often the major challenge during a crisis is a lack of policy and procedures on how to use externally contributed geo-information provided by the international and commercial community.

58. OGC has a Class A Liaison with ISO TC/211. Through this liaison, OGC routinely submits standards for processing and approval as ISO Standards – thus, OGC has high-level technical liaison with ISO.

59. OGC through its transparent Standards and Interoperability programs, offers a structured path for development, testing, validation and demonstration of its open standards.: OGC also convenes a variety of Domain Working Groups (DWGs) , which enable stakeholders involved in a program or community of interest to interact and evolve workflows /recommendations for standards where required, for meeting any specific requirements.

60. A summary of OGC Standards and an analysis of the same done by NIAS is given in **TABLE – 2.4**.

2.4. CHINA

61. The National Administration of Surveying, Mapping and Geo-information (NASG)[10] of China is responsible for all mapping and geospatial activities. While, China begun to formulate its surveying & mapping geographic information standards since 1950s, starting with the 2 technical regulations of "Geodetic Surveying Rules of the People's Republic of China" and "Basic Regulations on Surveying and Mapping", it is under NASG that China has preliminarily created a systematic and feasible surveying & mapping geographic information standard system featuring distinct hierarchy, scientific classification and excellent coordination. It released and implemented "National Geographic Information Standard System" and "Surveying & Mapping Standard System" in 2009. As of the end of 2012, China had formulated approximately 230 surveying & mapping geographic information standards, including 110 national standards and about 120 industrial standards.

62. To promote technical progress, improve the level of standardization and make itself geared to international standards, China, as a P member country of ISO/TC 211, actively advocates and uses international standards and makes adoption of standard a regular task. Amongst the 58 international standards, technical specifications or technical reports that have been released by ISO/TC 211, 30 have been converted or being converted by into the Chinese national standards, thereby gradually establishing a synergetic mechanism for both domestic and international standardization.

63. China has a structure consisting of National Technical Standardization Committee of Geographic Information and NASG Surveying & Mapping Standardization Work Committee, which are complementary to each other. In order to ensure scientific, institutional and normalized surveying & mapping standardization, China has published a series of management methods and plans including

63.1. Management Method for Surveying & Mapping Standardization

63.2. Management Method for Geographic Information Standardization

63.3. Management Procedure for Standard Formulation and Revision in Surveying & Mapping Projects

63.4. Notice on Strengthening Standardization Management of Fundamental Surveying & Mapping and Major Surveying & Mapping Projects

[10] National Administration of Surveying, Mapping and Geo-information (NASG) website - http://en.nasg.gov.cn/

63.5. 11th Five-year Planning' for Surveying & Mapping Standardization

63.6. 12th Five-year Planning' for Surveying & Mapping Geographic Information Standardization", thereby strengthening the standardization management.

64. As a technical organization of China engaging in standardization in the field of geographic information, National Technical Standardization Committee of Geographic Information is mainly responsible for planning, coordination and centralized management of national standards of geographic information. It aims to speed up geographic information standardization in China, promote construction and application of geographic information resources and propel geographic information sharing. Entrusted by the Standardization Administration of the People's Republic of China, NASG is responsible for leading and managing the committee for standardization of geographic information.

2.5. ISO-TC 211[11]

65. ISO/TC 211 is a standard technical committee formed within ISO, tasked with covering the areas of digital geographic information (such as used by geographic information systems) and geomatics. It is responsible for preparation of a series of International Standards and Technical Specifications numbered in the range starting at 19101. ISO/TC 211 is concerned with the standardization in the field of digital geographic information. This work aims to establish a structured set of standards for information concerning objects or phenomena that are directly or indirectly associated with a location relative to the Earth.

66. The goal of ISO/ TC 211 is to develop a family of international standards that will support the understanding and usage of geographic information. To increase the availability, access, integration, and sharing of geographic information, enables inter-operability of geospatially enabled computer systems. Contribute to a unified approach to addressing global ecological and humanitarian problems. To ease the establishment of geospatial infrastructures on local, regional and global level and contribute to sustainable development.

67. There are 6 stages in process of standardization that ISO adopts:

67.1. Proposal Stage: New Work Item Proposal

67.2. Preparatory stage: Working Draft

67.3. Committee stage: Committee Draft

67.4. Enquiry stage: Draft International Standard

67.5. Approval stage: Final Draft International Standard

67.6. Publication stage: International Standard

68. The work within ISO/TC211 is done in working groups, each with a specific focus. The currently active working groups are:

[11] Adapted by NIAS team from (http://www.isotc211.org/)

68.1. Working Group 1: Framework and reference Model

68.1.1. ISO 19101:2002 Geographic information - Reference model - Under revision

68.1.2. ISO/TS 19103:2005 Geographic information - Conceptual schema language - Under revision in WG 4

68.1.3. ISO/TS 19104:2008 Geographic information - Terminology - Under revision

68.1.4. ISO 19105:2000 Geographic information - Conformance and testing

68.1.5. ISO/TR 19121:2000 Geographic information - Imagery and gridded data

68.1.6. WI 19124 Geographic information - Imagery and gridded data components - Completed with review summary, N 1017

68.1.7. ISO/TS 19129:2009 Geographic information - Imagery, gridded and coverage data framework - Moved to new WG 6

68.1.8. WI 19130 Geographic information - Sensor and data models for imagery and gridded data - Moved to new WG 6

68.1.9. WI 19104 Geographic information - Terminology (Revision of ISO/TS 19104:2008)

68.2. Working Group 4 - Geospatial services

68.2.1. ISO 19116:2004 Geographic information - Positioning services

68.2.2. ISO 19117:2012 Geographic information - Portrayal

68.2.3. ISO 19118:2011 Geographic information - Encoding

68.2.4. ISO 19119:2005 Geographic information - Services (under revision)

68.2.5. ISO 19119:2005 Amd 1:2008 Geographic information - Services - Amendment 1

68.2.6. ISO 19125-1:2004 Geographic information - Simple feature access - Part 1: Common architecture (under revision)

68.2.7. ISO 19125-2:2004 Geographic information - Simple feature access - Part 2: SQL options (under revision)

68.2.8. ISO 19128:2005 Geographic information - Web Map server interface

68.2.9. ISO 19136:2007 Geographic information - Geography Markup Language (GML)

68.2.10. ISO 19142:2010 Geographic information - Web Feature Service

68.2.11. ISO 19143:2010 Geographic information - Filter encoding

68.2.12. ISO 19149:2010 Geographic information - Rights expression language for geographic information - GeoREL

68.2.13. WI 19103 Geographic information - Conceptual Schema Language (Revision of ISO/TS 19103:2005)

68.2.14. WI 19119 Geographic information - Services (Revision of ISO/TS 19119:2005)

68.2.15. WI 19136-2 Geographic information - Geography Markup Language - Part 2: Extended schemas and encoding rules

68.2.16. WI 19161 Geodetic References

68.2.17. WI 19164 Registry service

68.3. Working Group 6 – Imagery

68.3.1. ISO/TR 19120:2001 Geographic information - Functional standards

68.3.2. ISO 19101-2:2008 Geographic information - Preference model - Part 2: Imagery

68.3.3. ISO 19115-2:2009 Geographic information - Metadata - Part 2: Extensions for imagery and gridded data

68.3.4. ISO/TS 19129:2009 Geographic information - Imagery, gridded and coverage data framework

68.3.5. ISO/TS 19130:2010 Geographic information - Imagery sensor models for geopositioning

68.3.6. ISO/TS 19130-2 Geographic information - Imagery sensor models for geopositioning - Part 2: SAR, InSAR, lidar and sonar

68.3.7. ISO/TS 19139-2:2012 Geographic information - Metadata - XML Schema Implementation - Part 2 : Extensions for imagery and gridded data

68.3.8. ISO/TS 19159-1 Geographic information - Calibration and validation of remote sensing imagery sensors - Part 1: Optical sensor

68.3.9. WI 19159-2 Geographic information - Calibration and validation of remote sensing imagery sensors - Part 1: Lidar

68.3.10. WI 19130-1 Geographic information - Imagery sensor models for geopositioning (Revision of ISO/TS 19130:2010)

68.3.11. WI 19163 Geographic information - Content components and encoding rules for imagery and gridded data

68.4. Working Group 7 - Information communities

68.4.1. ISO 19110:2005 Amd. 1:2011

68.4.2. ISO 19115-1:2014 Geographic information - Metadata – Part 1: Fundamentals

68.4.3. ISO/TR 19122:2004 Geographic information/Geomatics - Qualification and certification of personnel

68.4.4. ISO 19126:2009 Geographic information - Feature concept dictionaries and registers

68.4.5. ISO 19137:2007 Geographic information - Core profile of the spatial schema

68.4.6. ISO/TS 19139:2007 Geographic information - Metadata - Implementation specifications (revision initiated)

68.4.7. ISO 19144-1:2009 Geographic information - Classification Systems – Part 1: Classification system structure

68.4.8. ISO 19144-1:2009 Corrigendum 1:2012

68.4.9. ISO 19144-2:2012 Geographic information - Classification systems - Part 2: Land Cover Meta Language (LCML)

68.4.10. ISO 19150 Geographic information - Ontology - Review summary N 2705

68.4.11. ISO/TS 19150-1 Geographic information - Ontology - Part 1: Framework

68.4.12. ISO 19152:2012 Geographic information - Land Administration Domain Model (LADM)

68.4.13. WI 19110 Geographic information - Methodology for feature cataloguing (Revision of ISO 19110:2005)

68.4.14. WI 19115-3 Geographic information - Metadata - Part 3: XML schema of metadata fundamentals

68.4.15. WI 19150-2 Geographic information - Ontology - Part 2: Rules for developing ontologies in the Web Ontology Language (OWL)

68.4.16. WI 19160 Addressing (stage 0)

68.4.17. WI 19160-1 Addressing - Part 1: Conceptual model

68.4.18. WI 19160-4 Addressing - Part 4: International postal address components and template languages

68.5. Working Group 9 - Information management

68.5.1. ISO 6709:2008 Standard representation of geographic point location by coordinates

68.5.2. ISO 19111-2:2009 Geographic information - Spatial referencing by coordinates - Part 2: Extension for parametric values

68.5.3. ISO/TS 19127:2005 Geographic information -- Geodetic codes and parameters (revision initiated)

68.5.4. ISO 19131:2007 Geographic information - Data product specifications

68.5.5. ISO 19131:2007/Amd 1:2011

68.5.6. ISO 19135:2005 Geographic information - Procedures for item registration

68.5.7. ISO 19135-2 Geographic information - Procedures for item registration - Part 2: XML Schema Implementation

68.5.8. ISO 19138:2006 Geographic information - Data quality measures (Withdrawn, replaced by ISO 19157:2013)

68.5.9. ISO 19145:2013 Geographic information - Registry of representations of geographic point location

68.5.10. ISO 19146:2010 Geographic information - Cross-domain vocabularies

68.5.11. ISO 19153:2014 Geospatial Digital Rights Management Reference Model (GeoDRM RM)

68.5.12. ISO 19156:2011 Geographic information - Observations and measurements

68.5.13. ISO 19157:2013 Geographic information - Data quality

68.5.14. ISO/TS 19158:2012 Geographic information - Quality assurance of data supply

68.5.15. Review summary: Geographic information - Amendment to ISO 19113:2002 Geographic information - Quality principles and ISO 19115:2003 Geographic information - Metadata

68.5.16. WI 19107 Geographic information - Spatial schema (Revision of ISO 19107:2003)

68.5.17. WI 19109 Geographic information - Rules for application schema (Revision of ISO 19109:2005)

68.5.18. WI 19135-1 Geographic information - Procedures for item registration - Part 1: Fundamentals (Revision of ISO 19135:2005)

68.5.19. WI 19157-2 Geographic information - Data Quality - Part 2: XML Schema Implementation of ISO 19157

68.5.20. WI 19162 Geographic information - Well known text representation of coordinate reference systems

68.6. Working Group 10 - Ubiquitous public access

68.6.1. ISO 19148:2012 - Geographic information - Linear referencing

68.6.2. ISO 19155:2012 Geographic information - Place Identifier (PI) Architecture

68.6.3. WI 19147 Geographic information - Transfer Nodes

68.6.4. WI 19154 Geographic information - Ubiquitous public access - Reference model

68.6.5. WI 19155-2 Geographic information - Place Identifier (PI) architecture - Part 2: Place Identifier (PI) linking

69. Some of the GI standards that ISO has developed are listed in **TABLE – 2.5.** India also participates and conforms to ISO standards process – for which the Bureau of Indian Standards (BIS) is the key nodal agency. For GIS, there is a separate BIS Committee on GIS Standardisation.

2.6. COMPARATIVE ANALYSIS OF INTERNATIONAL GIS STANDARDS

70. Based on the understanding of various standardisation efforts described in previous sections, some of the important observations that are made are as follows:

70.1. GIS Standardisation is viewed differently in different nations – mainly due to maturity of a GIS in nation being varied. US has a long heritage of digital map data available from 1970s (Digital USGS maps and TIGER data and Street-Address data) and thus they have evolved considerably in making available on nation-wide image/map content. Thus, US standardisation focus is more on GIS services and digital sharing of image/map data. On the other hand, Europe has varying levels of image/map data availability in its member states – thus, Europe-wide GI content is still being developed. INSPIRE is therefore addressing standards for GIS content but also is quickly adapting GIS services to serve image/map data and applications. Thus, INSPIRE defines what content should be included and what schema details are essential for each data element – these are well defined in INSPIRE.

70.2. US has undertaken tremendous work on standardisation and we feel that the foundational work on GIS standards that have emanated from US efforts are inspiring many other nations – which is turning out to be quite beneficial from standardisation point of view. US has also a tremendous standardisation on a nation-wide spatial framework and geodetic network – that defines a very robust and reliable spatial foundation dataset across the US continent.

70.3. OGC standards are immensely popular with high-stress on inter-operability across systems and software. OGC also stresses open-ness of standards – though open standards are a different regime from OGC standards. Driven by the systematicity of the GI eco-system in US and the intensive involvement of private sector, OGC standards have emerged as de-facto services and applications standardisation across industry. OGC standards have been well adopted to systematize metadata, map services and web-services and host of applications sector. GIS portal Standards are well-defined by OGC and are adopted by different entities – thus, we now see many GIS Portals in operation on the web.

70.4. ISO standards are driven by government agencies and are an effort to bring about a standards definition for imagery, geo-spatial services, quality and information management. Endorsement of governments for standards is a time-consuming process – but the advantage has been that ISO has become the forum for government agencies driven standardisation efforts.

70.5. There is quite a harmony of standards in different for a – for example, what OGC defines as Standards are also discussed and adopted under ISO forum; ISO Standards are then

adopted at national levels and so on. Thus, this cross-fertilisation of standards is helping the efforts of standardisation across the world.

70.6. China claims that they have made efforts in GIS standardisation but one has to access the documents to be able to make a judgment on these. However, it appears from initial web-analysis of China-NASG, that they are progressing on a definitive path towards a nation-wide GIS and map data availability and services.

71. From our study and understanding of GIS Standardisation across the globe, we identify the following key parameters for comparison:

71.1. **Content Standards** – standards that define GIS content. The focus of content can start from generation process, schema and database generation. We feel that content standards are extremely important in – to address the high-variability in images/maps that are available from different agencies and from content inter-operability point of view. Content Standards need to define what image/map data are included in GIS - their definitions and descriptions for a uniform-understanding protocol.

71.2. **Metadata Standards** – that define the details of Metadata – data about GIS content. Details of what elements of Metadata are required and their definitions and schema are essential definition.

71.3. **Content Schema/Data Dictionary/Data Models** – defining the data dictionary and schema for each of the Content feature in the GIS.

71.4. **Spatial Framework** – defining the geographical-envelope or the spatial frame that "pins" the GIS feature as precisely as possible to the ground feature and allows cross-referencing of GIS Content features authoritatively and accurately.

71.5. **Quality** – defining quality parameters and value-limits for GIS content. Parameters could be on thematic-basis or spatial basis or a combination of both.

71.6. **Image** – defining what images (and their parameters) form a part of the GIS content. Images standardisation can be based on spatial resolution, temporal updates, sources etc

71.7. **GIS Services** – defining standards for GIS data and application services on web platform.

71.8. **Mobile GIS Services** - defining standards for GIS data and application services on mobile platform.

71.9. **Portal Standards** – defining the standards for Portals and their Security

71.10. **Interoperability** – defining inter-operability related to data and services across systems and software.

72. The comparative analysis of the above parameters for the key standards that we have studied is summarized in **TABLE – 2.6**.

TABLE – 2.1: DETAILS OF FGDC STANDARDS

Standard Parameters	Standard Document and Web Link	Definition
Content Standards	**Cadastral** *http://www.fgdc.gov/standards/projects/FGDC-standards-projects/framework-data-standard/GI_FrameworkDataStandard_Part1_Cadastral.pdf*	Cadastral data describe the geographic extent of past, current, and future right, title, and interest in real property, including above, surface, and below ground and water, and the conceptual structure to support the description of that geographic extent
	Governmental unit and other geographic area boundaries *http://www.fgdc.gov/standards/projects/FGDC-standards-projects/framework-data-standard/GI_FrameworkDataStandard_Part5_GovernmentalUnitBoundaries.pdf*	Governmental Unit and Other Geographic Area Boundaries is to establish the content requirements for the collection and interchange of data to facilitate the maintenance and use of that information. This part applies to the following geographic area like Governmental units, Administrative units, Statistical units and Other units.
	Elevation *http://www.fgdc.gov/standards/projects/FGDC-standards-projects/framework-data-standard/GI_FrameworkDataStandard_Part3_Elevation.pdf*	Elevation refers to a vertical position above or below a reference surface. The document deals with modeling of Elevation data in different forms, Terrestrial elevation data and Bathymetric data.
	Hydrography *http://www.fgdc.gov/standards/projects/FGDC-standards-projects/framework-data-standard/GI_FrameworkDataStandard_Part6_Hydrography.pdf*	Hydrography includes surface water features such as lakes, ponds, streams or rivers, canals, oceans, and shorelines. Each hydrographic feature is assigned a permanent feature identification code and may also be identified by a feature name. Network connectivity, direction of flow, and a linear reference system are also described.
	Transportation-Rail *http://www.fgdc.gov/standards/projects/FGDC-standards-projects/framework-data-standard/GI_FrameworkDataStandard_Part7b_Transportation_Rail.pdf*	The rail transportation system includes physical and non-physical components representing the rail mode of travel that allow the movement of goods non-physical components representing the rail mode of travel that allow the movement of goods and people between locations. It also includes the supporting infrastructure necessary for rail operations and maintenance
	Transportation-Road *http://www.fgdc.gov/standards/projects/FGDC-standards-projects/framework-data-standard/GI_FrameworkDataStandard_Part7c_Transportation_Road.pdf*	The Road transportation system includes physical segments of the road network, their connectivity and their usage.

Standard Parameters	Standard Document and Web Link	Definition
	Transportation-Transit *http://www.fgdc.gov/standards/projects/FGDC-standards-projects/framework-data-standard/GI_FrameworkDataStandard_Part7d_Transportation_Transit.pdf*	Transit systems include physical infrastructure components such as public transportation stops and facilities, as well as non-physical features such as routes and patterns that are used to define the movement of public transportation vehicles.
	Transportation-Inland Waterways *http://www.fgdc.gov/standards/projects/FGDC-standards-projects/framework-data-standard/GI_FrameworkDataStandard_Part7e_Transportation_Waterways.pdf*	This document gives information of TranFeature, ProjectDepthArea, MileMarker, TranPoint, TranSeg, SailingLine.
	National Vegetation Classification *http://www.fgdc.gov/standards/projects/FGDC-standards-projects/vegetation/NVCS_V2_FINAL_2008-02.pdf/at_download/file*	The National Vegetation Classification Standard (NVCS) provides a standard framework and classification approach for natural, semi-natural, planted and cultivated vegetation types. All areas having equal to or more than 1% of the surface area with live vegetation cover are classified within the NVCS.
	Wetland Classification *http://www.fgdc.gov/standards/projects/FGDC-standards-projects/wetlands-mapping/2009-08%20FGDC%20Wetlands%20Mapping%20Standard_final.pdf*	Wetlands are lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water. For purposes of this classification wetlands must have one or more of the following three attributes: (1) at least periodically, the land supports predominantly hydrophytes (2) the substrate is predominantly undrained hydric soil and (3) the substrate is nonsoil and is saturated with water or covered by shallow water at some time during the growing season of each year.
	Coastal and Marine Ecology Classification *http://www.csc.noaa.gov/digitalcoast/_/pdf/CMECS_Version%20_4_Final_for_FGDC.pdf*	Coastal and Marine Ecology Classification Standard (CMECS) offers a simple standard framework and common terminology for describing natural and human influenced ecosystems, from the upper tidal reaches of estuaries to the deepest portions of the ocean. The framework is organized into two settings, biogeographic and aquatic, and four components, water column, geoform, substrate, and biotic.
	National Shoreline *http://www.fgdc.gov/standards/projects/FGDC-standards-projects/shoreline-data-content/201005_ShorelineDataContentStandard.doc*	National Shoreline data Standard compromises shorelines within navigable coastal and inland waterways for the United States, its Commonwealths, and Territories. The functional scope of the standard includes definition of data models, schemas, entities, relationships, definitions, and cross walks to related standards.
	United States Thoroughfare, Landmark, and Postal Address Data Standard *http://www.fgdc.gov/standards/projects/FGDC-standards-projects/street-address/FGDC_endorsedAddressStandard.zip*	Address standards cover thoroughfare, landmark, and postal addresses within the United States, including its outlying territories and possessions. It provides, in four separate parts, a data content, classification, quality, and exchange standard for thoroughfare, landmark, and postal addresses.

Standard Parameters	Standard Document and Web Link	Definition
	Soil *http://www.fgdc.gov/standards/projects/FGDC-standards-projects/soils/soil997.PDF*	Soil Geographic Data Standard includes set of data standards for the inventory, mapping, and reporting on the soil resources of the United States. The soil attribute data associated with soil maps include the physical and chemical properties of the various soils being described, interpretative information, the arrangement of these soils into the soil map units identified on the soil maps, and information about the soil map units themselves.
	Utilities Data *http://www.fgdc.gov/standards/projects/FGDC-standards-projects/utilities/utilities.pdf*	Utilities Data Content Standard describes eleven feature classes like compressed air, electrical distribution, electrical monitoring/control, fuel distribution, heating/cooling systems, industrial waste, natural gas distribution, saltwater, storm drainage collection, wastewater collection, and water distribution.
	Remote Sensing Data *http://www.fgdc.gov/standards/projects/FGDC-standards-projects/swath_data/FGDC-STD-009-1999.doc*	Content Standard for Remote Sensing Swath Data defines a concept called a swath that provides a means for associating certain kinds of remote sensing data with their geolocation.
	Trail *http://www.fgdc.gov/standards/projects/FGDC-standards-projects/trail-data-standard/Federal_Trail_Data_Standards_FGDC-STD-017-2011.pdf*	Trails provide public access to opportunities for outdoor recreation as well as access to many significant prehistoric and historic sites. Trails of all kinds, including Congressionally and secretarially-designated trails, are strongly recognized by the public and governmental agencies as important recreational and cultural resource corridors. The Federal Trail Fundamentals include four concepts that are the cornerstones of effective trail planning and management Trail Type, Trail Class, Managed Use, Designed Use.

Standard Parameters	Standard Document and Web Link	Definition
	Buildings and Facilities Data *http://www.fgdc.gov/standards/projects/FGDC-standards-projects/FederalBldgsFacilities/GSA-Draft-Standards-Proposal-for-Buildings-and.doc*	**This is a Proposal Document.** This standard is based on the location of buildings and facilities as represented by point feature geometry and the identification of the feature classes, minimum attributes, and associated valid attribute values needed to identify the building or facility. Potential attributes include real property unique identifier, name, address, coordinates, etc.
	Cultural Resource *http://www.fgdc.gov/standards/projects/FGDC-standards-projects/cultural-resources/CRSTD_Proposal_02-14-08.doc*	**This is a Proposal Document**. The standard will be used to create, maintain, and distribute cultural resource spatial data.
	Earth Cover Classification Standard *http://www.fgdc.gov/standards/projects/FGDC-standards-projects/earth-cover/standards/projects/FGDC-standards-projects/earth-cover/eccs_proposal.pdf*	**This is a Proposal Document.** The purpose of the Earth Cover Classification Standard (ECCS) is to facilitate the production and exchange of earth cover digital data.
Spatial Framework Definition	**Geodetic control** *http://www.fgdc.gov/standards/projects/FGDC-standards-projects/framework-data-standard/GI_FrameworkDataStandard_Part4_GeodeticControl.pdf/*	Geodetic control standard provides a common, consistent, and accurate reference system for establishing coordinates for all geographic data. Federal Data Content Standard, each geodetic control point have 4 basic elements like Designations (Unique identifier, Descriptive identifier, URI), Coordinates (Horizontal, Vertical, Orthometric height, Ellipsoid height), Accuracy and Geodetic datum (Datum tag, Epoch date)
	Grids *http://www.fgdc.gov/standards/projects/FGDC-standards-projects/usng/fgdc_std_011_2001_usng.pdf*	Grid standard defines a preferred U.S. National Grid (USNG) for mapping applications at scales of approximately 1:1,000,000 and larger. It defines how to present Universal Transverse Mercator (UTM) coordinates at various levels of precision. It specifies the use of those coordinates with the grid system defined
	Geospatial Positioning Accuracy Standards- Reporting Methodology *http://www.fgdc.gov/standards/projects/FGDC-standards-projects/accuracy/part1/chapter1*	Reporting Methodology provides a common methodology for reporting the accuracy of horizontal coordinate values and vertical coordinate values for clearly defined features where the location is represented by a single point coordinate
	Geospatial Positioning Accuracy Standards- National Standard for Spatial Data Accuracy *http://www.fgdc.gov/standards/projects/FGDC-standards-projects/accuracy/part3/chapter3*	National Standard for Spatial Data Accuracy (NSSDA) implements a statistical and testing methodology for estimating the positional accuracy of points on maps and in digital geospatial data, with respect to georeferenced ground positions of higher accuracy.

Standard Parameters	Standard Document and Web Link	Definition
	Geospatial Positioning Accuracy Standards - Geodetic Networks *http://www.fgdc.gov/standards/projects/FGDC-standards-projects/accuracy/part2/chapter2*	This document provides a common methodology for determining and reporting the accuracy of horizontal coordinate values and vertical coordinate values for geodetic control points represented by survey monuments. It provides a means to directly compare the accuracy of coordinate values obtained by one method with the accuracy of coordinate values obtained by another method for the same point.
	Geospatial Positioning Accuracy Standards - Architecture, Engineering, Construction (A/E/C) and Facility Management *http://www.fgdc.gov/standards/projects/FGDC-standards-projects/accuracy/part4/FGDC-endorsed-standard*	Architecture, Engineering, Construction (A/E/C) and Facility Management provides accuracy standards for engineering drawings, maps, and surveys used to support planning, design, construction, operation, maintenance, and management of facilities, installations, structures, transportation systems, and related projects.
	Geospatial Positioning Accuracy Standards - Nautical Charting Hydrographic Surveys *http://www.fgdc.gov/standards/projects/FGDC-standards-projects/accuracy/part5/FGDC-STD-007.5-2005.pdf*	Nautical Charting Hydrographic Surveys standard provides minimum standards for the horizontal and vertical accuracy of features associated with hydrographic surveys that support nautical charting. Such features include, but are not limited to, water depths, objects on the seafloor, navigational aids, and shoreline.
Image Standards	**Digital Orthoimagery** (*http://www.fgdc.gov/standards/projects/FGDC-standards-projects/framework-data-standard/GI_FrameworkDataStandard_Part2_DigitalOrthoimagery.pdf/*	Digital orthoimages are georeferenced images of the Earth's surface for which image object displacement caused by sensor orientation, sensor distortions, and terrain relief has been removed. Digital orthoimages have the geometric characteristics of a map and image qualities of a photograph.
Database Schema	Details of data schema is included in Content Standards document	
Quality Standards.	Details of data schema is included in Content Standards document	
Metadata Standard	**Content Standard for Digital Geospatial Metadata** *http://www.fgdc.gov/standards/projects/FGDC-standards-projects/metadata/base-metadata/v2_0698.pdf*	Metadata Content Standard provides a hierarchy of data elements and compound elements that define the information content for metadata to document a set of digital geospatial data. A Feature may contain Metadata, Identification Information, Data Quality Information, Spatial Data Organization Information, Spatial Reference Information, Entity and Attribute Information, Platform and Mission Information, Instrument Information and Location Information.
GIS Web Portal Standards	US adopts OGC Web Services Standards	

Standard Parameters	Standard Document and Web Link	Definition
Data Exchange (Encoding) Standards	**Encoding Standard for Metadata** *http://www.fgdc.gov/standards/projects/FGDC-standards-projects/encoding-metadata/standards/projects/FGDC-standards-projects/encoding-metadata/proposal*	**This is a Proposal Document.** This standard defines methods for the encoding of FGDC metadata element structure and content for the purposes of search and retrieval and metadata exchange by declaring an unambiguous computer-readable and parseable format for use within the geospatial data community.
	Spatial Data Transfer Standard (SDTS) - Logical Specifications *http://thor-f5.er.usgs.gov/sdts/standard/latest_draft/pdf/part1.pdf*	This part addresses the logical specifications in terms of conformance requirements, a conceptual model, quality specifications, the data structure model, and the transfer format.
	Spatial Data Transfer Standard (SDTS) - Spatial Features *http://thor-f5.er.usgs.gov/sdts/standard/latest_draft/pdf/part2.pdf*	This part addresses data content by providing a standard list and definitions of spatial features and their attributes.
	Spatial Data Transfer Standard (SDTS) - ISO 8211 Encoding *http://thor-f5.er.usgs.gov/sdts/standard/latest_draft/pdf/part3.pdf*	This part specifies the implementation of SDTS in terms of the International Organization for Standardization (ISO 8211) for a Data Descriptive File for Information Interchange.
	Spatial Data Transfer Standard (SDTS) - Topological Vector Profile *http://thor-f5.er.usgs.gov/sdts/standard/latest_draft/pdf/part4.pdf*	Topological Vector Profile (TVP) contains specifications for an SDTS profile for use with geographic vector data with planar graph topology.
	Spatial Data Transfer Standard (SDTS) - Raster Profile and Extensions *http://thor-f5.er.usgs.gov/sdts/standard/approved/fgdc/srpe0299.pdf*	The Raster Profile is for 2-dimensional image and gridded raster data. It permits alternate image file formats using the ISO Basic Image Interchange Format (BIIF) or Georeferenced Tagged information File Format (GeoTIFF).
	Spatial Data Transfer Standard (SDTS) - Point Profile *http://www.fgdc.gov/standards/projects/FGDC-standards-projects/SDTS/sdts_point/sdts_pt6.pdf*	The Point Profile contains specifications for use with geographic point data only, with the option to carry high precision coordinates such as those required for geodetic network control points.
	Spatial Data Transfer Standard (SDTS) - CADD Profile *http://www.fgdc.gov/standards/projects/FGDC-standards-projects/SDTS/sdts_cadd/standards/projects/SDTS/sdts_cadd/caddprof.pdf*	The Computer Aided Design and Drafting Profile (CADD) contains specifications for an SDTS profile for use with vector-based geographic data as represented in CADD software. The purpose of this profile is to facilitate the translation of this data between CADD packages without loss of data, and support the translation of this data betw een CADD and mainstream GIS packages.

Standard Parameters	Standard Document and Web Link	Definition
Application Services Standard for Mobile	Applications are user-specific but most users adopt local or OGC standards	
Others	**Geologic Data Model** *http://www.fgdc.gov/standards/projects/FGDC-standards-projects/geologic-data-model/standards/projects/FGDC-standards-projects/geologic-data-model/proposal.pdf*	**This is a Proposal Document.** The objective of this standard is to create a logical data model that will describe the various critical entities of a geologic map and the relations among them. This standard will describe how geologic map information will be configured in digital format, but will not proscribe methods by which geologic maps will be made.

TABLE – 2.2: DETAILS OF USGS NATIONAL MAP STANDARDS

Standard Parameters	Standard Document and Web Link	Definition
Content Standard	**Digital Elevation Models- General** *http://nationalmap.gov/standards/pdf/1DEM0897.PDF*	Identifies and provides a general overview of the characteristics of the five different Digital Elevation Model (DEM) product types. This part describes horizontal coordinate systems, units of coverage, elevation units, profile spacing (horizontal grid spacing), and data order of DEM data.
	Standards for Digital Elevation Models – Specifications *http://nationalmap.gov/standards/pdf/2DEM0198.PDF*	Defines specifications for data accuracy, classification levels, format, geometry, areas of constant elevation, data records, horizontal and vertical datums, and geographic reference systems for DEM products.
	Hydrography *http://nationalmap.gov/standards/pdf/2dqm0401.pdf*	This category of data consists of all flowing water, standing water, and wetlands.
	Transportation *http://nationalmap.gov/standards/pdf/3dqm0401.pdf*	This category of data includes major transportation systems collected in three separate overlays labelled: (1) Roads and Trails, (2) Railroads, and (3) Pipelines, Transmission Lines, and Miscellaneous Transportation Features.
	Boundaries *http://nationalmap.gov/standards/pdf/4dqm0401.pdf*	This category of data consists of (1) political boundaries that identify States, counties, cities, and other municipalities, and (2) administrative boundaries that identify areas such as national and State forests. Political and administrative boundaries are always collected as a single data set.
	Public Land Survey System *http://nationalmap.gov/standards/pdf/5dqm0496.pdf*	Land Survey System includes categories like Land Grant, Point Monument, Principal Meridian, Public Land Survey System Area, Special Survey Area, Survey Corner, and Survey Line.
	Built-up *http://nationalmap.gov/standards/pdf/6dqm0401.pdf*	This part of the standard provides a description of the Built-up features shown on USGS and USDA Forest Service single edition quadrangle maps.
	Hypsography *http://nationalmap.gov/standards/pdf/7dqm0401.pdf*	This category of data consists of information on topographic relief (primarily contour data) and supplementary spot elevations.
	Nonvegetative Surface Cover *http://nationalmap.gov/standards/pdf/8dqm0496.pdf*	This category of data consists of information about the natural surface of the Earth as symbolized on the map such as lava, sand, and gravel features. This category is not all-inclusive, as other non-vegetative surface features, such as glaciers, are found in the category of Hydrography.

Standard Parameters	Standard Document and Web Link	Definition
	Vegetative Surface Cover *http://nationalmap.gov/standards/pdf/9dqm0401.pdf*	This category of data consists of information about vegetative surface cover such as woods, scrub, orchards, and vineyards. Vegetative features associated with wetlands, such as marshes and swamps, are collected under Hydrography.
	Named Landforms *http://nationalmap.gov/standards/pdf/10dqm0401.pdf*	This part of the standard provides a description of the Named Landforms features shown on USGS
Spatial Framework Definition	Based on FGDC Standard	
Image Standards	**Digital Orthophotos – General** *http://nationalmap.gov/standards/pdf/1DOQ1296.PDF*	Provides general information on definitions, objectives, product description, sources, file structure, and format for digital orthophotos.
	Digital Orthophotos -Specifications *http://nationalmap.gov/standards/pdf/2DOQ1296.PDF*	Defines the specifications for geographic extent, collection, processing, datums and coordinates, accuracy, ground sample distance, image radiometry, image mosaicking, data quality, header data, archiving, and distribution formats for digital orthophotos.
	Standards for Digital Raster Graphics – General *http://nationalmap.gov/standards/pdf/1drg0401.pdf*	Defines the Digital Raster Graphic (DRG) series, objectives, data sources and definitions of terms used in standard.
	Standards for Digital Raster Graphics - Specifications *http://nationalmap.gov/standards/pdf/2drg0401.pdf*	Includes image format, sources, coverage, resolution, projections and georeferencing, accuracy, colors, descreening, noise filtering, data quality, and metadata for DRG data.
	Lidar Base Specification *http://pubs.usgs.gov/tm/11b4/TM11-B4.pdf*	Specifications that define the minimum parameters for acquiring and procuring light detection and ranging (Lidar) data, including: specifications for raw point cloud (las format) data stored in swaths, classified point cloud (las format) data stored in tiles, gridded DEM derivative products stored in tiles, and break line information stored as PolyLines or PolyAreas.
Database Schema		
Quality Standards.	**Standards for Digital Elevation Models - Quality Control** *http://nationalmap.gov/standards/pdf/3DEM0897.PDF*	Identifies several procedures for accuracy verification and editing that are mandatory during a quality control check of DEM data.

Standard Parameters	Standard Document and Web Link	Definition
Metadata Standard	**Digital Geospatial Metadata - 1:24,000-Scale Digital Line Graphs** *http://nationalmap.gov/standards/pdf/2META997.PDF*	Standards that define content for digital geospatial metadata for USGS NGP digital products.
	Digital Geospatial Metadata - 1:100,000-Scale Digital Line Graphs *http://nationalmap.gov/standards/pdf/3META997.PDF*	
	Digital Geospatial Metadata - 1:2,000,000-Scale Digital Line Graphs *http://nationalmap.gov/standards/pdf/4META997.PDF*	
	Digital Geospatial Metadata - Digital Raster Graphics *http://nationalmap.gov/standards/pdf/5META997.PDF*	
	Digital Geospatial Metadata - Digital Orthophoto Quadrangles *http://nationalmap.gov/standards/pdf/6META997.PDF*	
	Digital Geospatial Metadata - 7.5-Minute Digital Elevation Models *http://nationalmap.gov/standards/pdf/7META997.PDF*	
	Digital Geospatial Metadata - 30-Minute Digital Elevation Models *http://nationalmap.gov/standards/pdf/8META997.PDF*	
	Digital Geospatial Metadata - 1-Degree Digital Elevation Models *http://nationalmap.gov/standards/pdf/9META997.PDF*	
GIS Web Display Services		

Standard Parameters	Standard Document and Web Link	Definition
GIS Web Data Accessing and Processing Services		
GIS Web Applications Mapping Services		
Data Exchange (Encoding) Standards		
Portal Security Standard.		
Application Services Standard for Mobile		

TABLE – 2.3: DETAILS OF INSPIRE STANDARDS

Standard Parameters	Standard Document and Web Link	Definition
Content Standard	**Administrative units** *http://inspire.ec.europa.eu/documents/Data_Specifications/INSPIRE_DataSpecification_AU_v3.1.pdf*	The theme 'Administrative units' refers to the division of areas where Member States have and/or exercise jurisdictional rights, for local, regional and national governance.
	Cadastral Parcels *http://inspire.ec.europa.eu/documents/Data_Specifications/INSPIRE_DataSpecification_CP_v3.1.pdf*	Cadastral parcel should be considered as a single area of Earth surface (land and/or water), under homogeneous real property rights and unique ownership, real property rights and ownership being defined by national law.
	Geographical Names *http://inspire.ec.europa.eu/documents/Data_Specifications/INSPIRE_DataSpecification_GN_v3.1.pdf*	This specification describes how to model geographical names, i.e. proper nouns applied to a natural, man-made or cultural feature on Earth. Names of areas, regions, localities, cities, suburbs, towns or settlements, or any geographical or topographical feature of public or historical interest.
	Hydrography *http://inspire.ec.europa.eu/documents/Data_Specifications/INSPIRE_DataSpecification_HY_v3.1.pdf*	Hydrography in the context of this data specification is involved with the description of the Hydrographic elements, including marine areas and all other water bodies and items related to them, including river basins and sub-basins.
	Protected Sites *http://inspire.ec.europa.eu/documents/Data_Specifications/INSPIRE_DataSpecification_PS_v3.2.pdf*	Protected sites may be located in terrestrial, aquatic and/or marine environments, and may be under either public or private ownership. They may include localities with protection targets defined by different sectors and based on different objectives, especially dedicated to the conservation of nature, the protection and maintenance of biological diversity and of natural and where appropriate associated cultural resources.
	Transport Networks *http://inspire.ec.europa.eu/documents/Data_Specifications/INSPIRE_DataSpecification_TN_v3.2.pdf*	The transport component should comprise an integrated transport network, and related features, that are seamless within each national border. Road, rail, air and water transport networks and related infrastructure. Includes links between different networks. Also includes the trans-European transport network
	Agricultural and Aquaculture Facilities *http://inspire.ec.europa.eu/documents/Data_Specifications/INSPIRE_DataSpecification_AF_v3.0.pdf*	Agriculture Facilities refers to set of process and activities consisting in cultivating soils, producing crops and rearing animals; it includes harvesting, milking, breeding animals and keeping animals for farming purposes. Aquaculture Facilities refers set of activities and techniques related to the production, breeding and treatment of fish, molluscs.

Standard Parameters	Standard Document and Web Link	Definition
	Area Management /Restriction/ Regulation Zones and Reporting Units *http://inspire.ec.europa.eu/documents/Data_Specifications/INSPIRE_DataSpecification_AM_v3.0.pdf*	Areas managed, regulated or used for reporting at international, European, national, regional and local levels. Includes dumping sites, restricted areas around drinking water sources, nitrate-vulnerable zones and regulated fairways at sea or large inland waters, areas for the dumping of waste, noise restriction zones, prospecting and mining permit areas, river basin districts, relevant reporting units and coastal zone management areas.
	Atmospheric Conditions and Meteorological Geographical Features *http://inspire.jrc.ec.europa.eu/documents/Data_Specifications/INSPIRE_DataSpecification_AC-MF_v3.0.pdf*	Atmospheric conditions include physical conditions in the atmosphere. Includes spatial data based on measurements, on models or on a combination thereof and includes measurements locations. Meteorological geographical features include weather conditions and their measurements precipitation, temperature, evapotranspiration, wind speed and direction.
	Bio-geographical Regions *http://inspire.jrc.ec.europa.eu/documents/Data_Specifications/INSPIRE_DataSpecification_BR_v3.0.pdf*)	The theme Bio-geographical Regions describes areas of relatively homogeneous ecological conditions with common characteristics like Bio-geographical regions, Habitat and Biotopes, and Species Distribution.
	Buildings *http://inspire.jrc.ec.europa.eu/documents/Data_Specifications/INSPIRE_DataSpecification_BU_v3.0.pdf*	A building refers to any structure permanently constructed or erected on its site. Information on location of buildings may be supplied as points or with the actual basic form of the building. Usually buildings are part of cadastre.
	Elevation *http://inspire.ec.europa.eu/documents/Data_Specifications/INSPIRE_DataSpecification_EL_v3.0.pdf*	Digital elevation models for land, ice and ocean surface. Includes terrestrial elevation, bathymetry and shoreline. The main purpose of a Digital Elevation Model is to provide an elevation property with reference to a specified origin (vertical reference or datum). This property may be height (when the value is measured opposite to the gravity field of the Earth) or depth (when the value is measured in the direction of the gravity field). In line with existing technologies three spatial representation methods have been provided: grid, vector and triangulated irregular network (TIN).
	Energy Resources *http://inspire.jrc.ec.europa.eu/documents/Data_Specifications/INSPIRE_DataSpecification_ER_v3.0.pdf*	This theme covers historic, current and future energy resources including hydrocarbons, hydropower, bio-energy, solar, wind, etc., where relevant including depth/height information on the extent of the resource and the entire lifecycle of energy resources, irrespective of its viability in terms of economic, social and technological aspects.
	Environmental Monitoring Facilities *http://inspire.jrc.ec.europa.eu/documents/Data_Specifications/INSPIRE_DataSpecification_EF_v3.0.pdf*	The theme scope includes two main aspects. The first is the environmental monitoring facility as a spatial object, the second is the data obtained through observations and measurements taken at this facility, encoded using the ISO 19156 standard.

Standard Parameters	Standard Document and Web Link	Definition
	Geology *http://inspire.jrc.ec.europa.eu/documents/Data_Specifications/INSPIRE_DataSpecification_GE_v3.0.pdf*	The theme covers Geology characterised according to composition and structure. Includes bedrock, aquifers and geomorphology that describes the Earth's present-day surface, and the location of the geophysical campaigns and measurements that provide valuable information on the physical properties of rocks (like density, porosity, magnetic susceptibility, etc.) regardless of their organization as geologic units. The INSPIRE Geology Theme is split into the following sub-themes: Geology, Hydrogeology, Geophysics
	Habitats and Biotopes *http://inspire.jrc.ec.europa.eu/documents/Data_Specifications/INSPIRE_DataSpecification_HB_v3.0.pdf*	Habitats and Biotopes is a biodiversity theme that deals with habitats and biotopes as areas and their distinct boundaries.
	Human Health and Safety *http://inspire.jrc.ec.europa.eu/documents/Data_Specifications/INSPIRE_DataSpecification_HH_v3.0.pdf*	The INSPIRE Human Health and Safety (HH) theme describes the geographical distribution of dominance of pathologies, the effect on health or well-being of humans linked to the quality of the environment. Thematic components are human health data, biomarkers, health care/health services data, health determinant measurement data and events related to safety.
	Land Cover *http://inspire.jrc.ec.europa.eu/documents/Data_Specifications/INSPIRE_DataSpecification_LC_v3.0.pdf*	Land cover theme includes Physical and biological cover of the earth's surface including artificial surfaces, agricultural areas, forests, (semi) natural areas, wetlands, water bodies.
	Land Use *http://inspire.jrc.ec.europa.eu/documents/Data_Specifications/INSPIRE_DataSpecification_LU_v3.0.pdf*	Land Use theme is defined as the use and functions of a territory and it is description of land in terms of its socio-economic and ecological purpose. Land use theme is itself split in two different types. The Existing Land Use which objectively depicts the use and functions of a territory as it has been and effectively still is in real life. The Planned Land Use which corresponds to spatial plans, defined by spatial planning authorities, depicting the possible utilization of the land in the future.
	Mineral Resources *http://inspire.jrc.ec.europa.eu/documents/Data_Specifications/INSPIRE_DataSpecification_MR_v3.0.pdf*	The Mineral resources data theme refers to the description of natural concentrations of very diverse mineral resources of potential or proven economic interest. The important attributes such as the nature, genesis, location, extent, mining and distribution of resources reflect the two main identified categories of potential use. Management of resources and their exploitation and exploration activities and Environmental impact assessments.
	Natural Risk Zones *http://inspire.jrc.ec.europa.eu/documents/Data_Specifications/INSPIRE_DataSpecification_NZ_v3.0.pdf*	This theme defines Vulnerable areas characterised according to natural hazards (all atmospheric, hydrologic, seismic, volcanic and wildfire phenomena that, because of their location, severity, and frequency, have the potential to seriously affect society)

Standard Parameters	Standard Document and Web Link	Definition
	Oceanographic geographical features *http://inspire.jrc.ec.europa.eu/documents/Data_Specifications/INSPIRE_DataSpecification_OF_v3.0.pdf*	An Ocean Geographical Feature (OF) represents the (physical or chemical) properties of a Sea Region. This type of information is essentially a coverage describing the ocean and could be presented as a set of point data, gridded data, but also as vertical profiles through ocean depths and trajectories along the ocean surface.
	Production and Industrial Facilities *http://inspire.jrc.ec.europa.eu/documents/Data_Specifications/INSPIRE_DataSpecification_PF_v3.0.pdf*	The theme "Production and Industrial Facilities" comprises information about industrial facilities and activities of production (focusing on extraction, transformation or storage of resources, including energy production) and the main related environmental issues.
	Sea Regions *http://inspire.jrc.ec.europa.eu/documents/Data_Specifications/INSPIRE_DataSpecification_SR_v3.0.pdf*	This theme describes a Sea Region (SR) is a 2D geometry of an area or line with common (physical or chemical) characteristics that is covered by an ocean, sea or similar salt water body. The model allows the concept of named seas, as well subdivisions and aggregation of seas according to physical or chemical properties.
	Soil *http://inspire.jrc.ec.europa.eu/documents/Data_Specifications/INSPIRE_DataSpecification_SO_v3.0.pdf*	This theme describes Soils and subsoil characterised according to depth, texture, structure and content of particles and organic material, stoniness, erosion, where appropriate mean slope and anticipated water storage capacity.
	Species Distribution *http://inspire.jrc.ec.europa.eu/documents/Data_Specifications/INSPIRE_DataSpecification_SD_v3.0.pdf*	Species Distribution is a biodiversity theme focused on geographical distribution of occurrence of biological organisms aggregated by grid, region, or any administrative or analytical unit. Distributions may be represented in a wide range of formats, such as points, grid cells at different scales or polygons of specifically defined areas.
	Statistical Units *http://inspire.jrc.ec.europa.eu/documents/Data_Specifications/INSPIRE_DataSpecification_SU_v3.0.pdf*	Statistical unit informs on the location of statistical data and information. The principle of this theme is to provide stable and identified representations of the statistical units – and statistical data refers to these objects through their identifier.
	Utility and Government Services *http://inspire.jrc.ec.europa.eu/documents/Data_Specifications/INSPIRE_DataSpecification_US_v3.0.pdf*	The theme "Utility and Government Services" provides basic information (e.g. the location, basic technical characteristics or involved parties) on a wide range of administrative and social services of public interest. The theme is split in the following subthemes: Utility Networks, Administrative and social governmental services, Environmental management facilities

Standard Parameters	Standard Document and Web Link	Definition
	Addresses *http://inspire.jrc.ec.europa.eu/documents/Data_Specifications/INSPIRE_DataSpecification_AD_v3.0.1.pdf*	Location of properties based on address identifiers, usually by road name, house number, postal code.
Spatial Framework definition	**Coordinate Reference Systems** *http://inspire.ec.europa.eu/documents/Data_Specifications/INSPIRE_DataSpecification_RS_v3.2.pdf*	Systems for uniquely referencing spatial information in space as a set of coordinates (x, y, z) and/or latitude and longitude and height, based on a geodetic horizontal and vertical datum. The theme establishes a structure for spatial referencing of features by coordinates.
	Geographical Grid Systems *http://inspire.ec.europa.eu/documents/Data_Specifications/INSPIRE_DataSpecification_GG_v3.1.pdf*	Harmonised multi-resolution grid with a common point of origin and standardised location and size of grid cells. Geographical grids are an agreed, defined and harmonised grid net for Pan-Europe with standardised location and size of grid cells.
Image Standards	**Orthoimagery** *http://inspire.ec.europa.eu/documents/Data_Specifications/INSPIRE_DataSpecification_OI_v3.0.pdf*	The Orthoimagery data theme includes orthorectified image data of the earth's surface, from either satellite or airborne sensors. An orthoimage is a raster image that has been geometrically corrected ("orthorectified") to remove distortion caused by differences in elevation, sensor tilt and, optionally, by sensor optics.
Database Schema	For each content, data schema is well defined in content standard document	
Quality Standards	For each content, data-limits and broad quality is well defined in content standard document	
Metadata Standard	**Implementing Rules for Metadata** *http://inspire.jrc.ec.europa.eu/documents/Metadata/MD_IR_and_ISO_20131029.pdf*	Metadata includes information like Identification, Classification of spatial data and services, Geographic location, Temporal reference.
GIS Web Display Services	**Download Services** *http://inspire.jrc.ec.europa.eu/documents/Network_Services/Technical_Guidance_Download_Services_v3.1.pdf*	This document provides Technical Guidance for the implementation of technical service interfaces for INSPIRE Download Services.
	Discovery Services *http://inspire.jrc.ec.europa.eu/documents/Network_Services/TechnicalGuidance_DiscoveryServices_v3.1.pdf*	INSPIRE Discovery Services allow users and computer programs to search for spatial datasets and services based on their metadata records. This document specifies Technical Guidance for Member States to implement INSPIRE Discovery Services as mandated by the Regulation on INSPIRE Network Services
	View Services *http://inspire.jrc.ec.europa.eu/documents/Network_Services/TechnicalGuidance_ViewServices_v3.11.pdf*	INSPIRE View Services allow users and computer programs to view spatial datasets. This document specifies Technical Guidance for Member States to implement INSPIRE View Services as mandated by the Regulation on INSPIRE Network Services

Standard Parameters	Standard Document and Web Link	Definition
GIS Web Data Accessing and Processing Services	**Coordinate Transformation Services** *http://inspire.jrc.ec.europa.eu/documents/Network_Services/INSPIRE_Draft_Technical_Guidance_Coordinate_Transformation_Services_(version_2%201).pdf*	This document defines technical guidance for INSPIRE Coordinate Transformation Services according to the Transformation Services IR
GIS Web Applications Mapping Services	Mainly adopt ISO standards or OGC Standards for GIS Applications	
Data Exchange (Encoding) Standards	**Guidelines for the encoding of spatial data** *http://inspire.jrc.ec.europa.eu/documents/Data_Specifications/D2.7_v3.3rc3.pdf*	This document specifies requirements and recommendations for the encoding of spatial data for the purpose of data interchange between systems in INSPIRE.
	Transformation Network Services *http://inspire.jrc.ec.europa.eu/documents/Network_Services/JRC_INSPIRE-TransformService_TG_v3-0.pdf*	This technical guidance document provides a concrete interface specification and supporting documentation for the Schema Transformation Network Service. This will enable interoperability by alleviating ambiguities that could arise from different interpretations of required operations and parameters.
	SOAP Framework *http://inspire.jrc.ec.europa.eu/reports/ImplementingRules/network/INSPIRE_NETWORK_SERVICES_SOAP_Framework.pdf*	The goal of this document is to provide a definition and rationale for a proposed INSPIRE SOAP framework taking into account the issues and solutions pertaining to the specific geospatial domain
Portal Security Standard.	**Guidance to the Regulation on Data and Service Sharing** *http://inspire.jrc.ec.europa.eu/documents/Data_and_Service_Sharing/DSSGuidanceDocument_v5.0.pdf*	Guidance on access to spatial data sets and services of the Member States by Community institutions and bodies under harmonised conditions.
	Good practice in data and service sharing *http://inspire.jrc.ec.europa.eu/documents/Data_and_Service_Sharing/GoodPractice_%20DataServiceSharing_v3.pdf*	Examples of good practice in data and service sharing from various countries.
Application Services Standard for Mobile	Details not found	

TABLE – 2.4: DETAILS OF OGC STANDARDS

Standard Parameters	Standard Document and Web Link	Definition
Content Standard		
Spatial Framework definition		
Image Standards		
Database Schema		
Quality Standards	OGC has a standing Data Quality Domain Working Group	
Metadata Standard	**OGC supports ISO 19115 metadata** *http://www.opengeospatial.org/standards/as* **Catalogue Service Implementation Specification** *https://portal.opengeospatial.org/files/?artifact_id=20555* **OGC I15 (ISO19115 Metadata) Extension Package of CS-W ebRIM Profile 1.0** *http://www.opengeospatial.org/standards/cat*	Catalogue services support the ability to publish and search collections of descriptive information (metadata) for data, services, and related information objects. Catalogue services are required to support the discovery and binding to registered information resources within an information community. Most widely implemented in SDIs
GIS Web Display Services		
GIS Web Data Accessing and Processing Services	**Georeferenced Table Joining Service (TJS) Implementation Standard** *http://portal.opengeospatial.org/files/?artifact_id=40095*	This standard provides a standard interface definition for and applies to the creation and use of a Table Joining Service (TJS). This OGC standard defines a simple way to describe and exchange tabular data that contains information about geographic objects.

Standard Parameters	Standard Document and Web Link	Definition
	Web Coverage Service Interface Standard -XML/SOAP Protocol Binding Extension *http://www.opengeospatial.org/standards/wcs*	Web Coverage Service provides available data together with their detailed descriptions; defines a rich syntax for requests against these data; and returns data with its original semantics (instead of pictures) which may be interpreted, extrapolated, etc., and not just portrayed. This document specifies a core set of requirements that a WCS implementation must fulfill. WCS extension standards add further functionality to this core; some of these are required in addition to the core to obtain a complete implementation. This document indicates which extensions, at a minimum, need to be considered in addition to this core to allow for a complete WCS implementation. This core does not prescribe support for any particular coverage encoding format.
	Web Feature Service Interface Standard (WFS) *http://portal.opengeospatial.org/files/?artifact_id=39967* **Web Feature Service Implementation Specification** *http://portal.opengeospatial.org/files/?artifact_id=8339*	The Web Feature Service (WFS) represents a change in the way geographic information is created, modified and exchanged on the Internet. Web feature services allow clients to only retrieve or modify the data they are seeking, rather than retrieving a file that contains the data they are seeking and possibly much more. This document describes the OGC Web Feature Service (WFS) operations. The WFS operations support INSERT, UPDATE, DELETE, LOCK, QUERY and DISCOVERY operations on geographic features using HTTP as the distributed computing platform.
	Implementation Standard for Geographic information - Simple feature access - Part 1: Common architecture *http://portal.opengeospatial.org/files/?artifact_id=25355* **Implementation Standard for Geographic information - Simple feature access - Part 2: SQL option** *http://portal.opengeospatial.org/files/?artifact_id=25354*	This standard describes the common architecture for simple feature geometry. The simple feature geometry object model is Distributed Computing Platform neutral and uses UML notation. The base Geometry class has subclasses for Point, Curve, Surface and GeometryCollection. Each geometric object is associated with a Spatial Reference System, which describes the coordinate space in which the geometric object is defined. This define a standard Structured Query Language (SQL) schema that supports storage, retrieval, query and update of feature collections

Standard Parameters	Standard Document and Web Link	Definition
	Coordinate Transformation Services *http://portal.opengeospatial.org/files/?artifact_id=999*	Coordinate Transformation Service Standard (CT) provides a standard way for software to specify and access coordinate transformation services for use on specified spatial data. This standard addresses a key requirement for overlaying views of geodata ("maps") from diverse sources: the ability to perform coordinate transformation in such a way that all spatial data are defined relative to the same spatial reference system.
	Web Coverage Processing Service (WCPS) Language Interface Standard *http://portal.opengeospatial.org/files/?artifact_id=32319*	The OGC Web Coverage Processing Service (WCPS) defines a language for retrieval and processing of multi-dimensional geospatial coverages representing sensor, image, or statistics data. Services implementing this language provide access to original or derived sets of geospatial coverage information, in forms that are useful for client-side rendering, input into scientific models, and other client applications.
	Web Processing Service(WPS) *http://portal.opengeospatial.org/files/?artifact_id=24151*	This document specifies the interface to a Web Processing Service (WPS). WPS defines a standardized interface that facilitates the publishing of geospatial processes, and the discovery of and binding to those processes by clients. Processes include any algorithm, calculation or model that operates on spatially referenced data.
GIS Web Applications Mapping Services	**Web Map Tile Service** *http://portal.opengeospatial.org/files/?artifact_id=35326*	This Web Map Tile Service (WMTS) Implementation Standard provides a standard based solution to serve digital maps using predefined image tiles. The service advertises the tiles it has available through a standardized declaration in the Service Metadata document common to all OGC web services.
	Web Map Server Implementation Specification(WMS) *http://portal.opengeospatial.org/files/?artifact_id=14416*	Web Map Service Interface Standard (WMS) provides a simple HTTP interface for requesting geo-registered map images from one or more distributed geospatial databases. A WMS request defines the geographic layer(s) and area of interest to be processed. The response to the request is one or more geo-registered map images (returned as JPEG, PNG, etc) that can be displayed in a browser application.

Standard Parameters	Standard Document and Web Link	Definition
	Web Map Context (WMC) *http://portal.opengeospatial.org/files/?artifact_id=8618*	This specifies how individual map servers describe and provide their map content. The present Context specification states how a specific grouping of one or more maps from one or more map servers can be described in a portable, platform-independent format for storage in a repository or for transmission between clients. It includes information about the server(s) providing layer(s) in the overall map, the bounding box and map projection shared by all the maps.
	OGC OpenMI, - Open Modeling Interface (OpenMI)	To enable the runtime exchange of data between process simulation models and also between models and other modeling tools such as databases and analytical and visualization applications
Data Exchange (Encoding) Standards	**Geography Markup Language (GML) Encoding Standard** *http://portal.opengeospatial.org/files/?artifact_id=20509*	The Geography Markup Language (GML) is an XML grammar for expressing geographical features. GML serves as a modeling language for geographic systems as well as an open interchange format for geographic transactions on the Internet.
	Filter Encoding *http://portal.opengeospatial.org/files/?artifact_id=39968*	This jointly developed OGC and ISO TC/211 International Standard describes an XML and KVP (Keyword-value Pair) encoding of a system neutral syntax for expressing projections, selection and sorting clauses collectively called a query expression.
	GeoSPARQL - A Geographic Query Language for RDF(Resource Description Framework) Data *https://portal.opengeospatial.org/files/?artifact_id=47664*	This document defines a spatial extension to the SPARQL query language for geographic information. GeoSPARQL provides the following features: An RDF/OWL(Web Ontology Language) vocabulary for representing spatial information consistent with the Simple Features model. A set of SPARQL extension functions for spatial computations. A set of RIF (Rule Interchange Format) rules for query transformation.
	Styled Layer Descriptor (SLD) *http://portal.opengeospatial.org/files/?artifact_id=22364*	Styled Layer Descriptor (SLD) Profile of the OpenGIS Web Map Service (WMS) Encoding Standard defines an encoding that extends the WMS standard to allow user-defined symbolization and coloring of geographic feature and coverage data SLD addresses the need for users and software to be able to control the visual portrayal of the geospatial data. The ability to define styling rules requires a styling language that the client and server can both understand.

Standard Parameters	Standard Document and Web Link	Definition
	Keyhole Markup Language (KML) *http://portal.opengeospatial.org/files/?artifact_id=27810*	KML is an XML grammar used to encode and transport representations of geographic data for display in an earth browser, such as a 3D virtual globe, 2D web browser application, or 2D mobile application. A KML instance is processed in much the same way that HTML (and XML) documents are processed by web browsers. Like HTML, KML has a tag-based structure with names and attributes used for specific display purposes.
	Symbology Encoding Implementation Specification *http://portal.opengeospatial.org/files/?artifact_id=16700*	This Specification defines Symbology Encoding, an XML language for styling information that can be applied to digital Feature and Coverage data. This document is together with the Styled Layer Descriptor Profile for the Web Map Service Implementation Specification the direct follow-up of Styled Layer Descriptor Implementation Specification
	GML in JPEG 2000 for Geographic Imagery (GMLJP2) Encoding Specification *http://portal.opengeospatial.org/files/?artifact_id=13252* *http://docs.opengeospatial.org/is/08-085r4/08-085r4.html*	This standard applies to the encoding and decoding of JPEG 2000 images that contain GML for use with geographic imagery. This document specifies the use of the GML within the XML boxes of the JPEG 2000 data format and provides an application schema for JPEG 2000 that can be extended to include geometrical feature descriptions and annotations. The document also specifies the encoding and packaging rules for GML use in JPEG 2000
	Network Common Data Form (NetCDF) Core Encoding Standard *http://portal.opengeospatial.org/files/?artifact_id=43732*	NetCDF is a set of software libraries and self-describing, machine-independent data formats that support the creation, access, and sharing of array-oriented scientific data. The conventions for climate and forecast (CF) metadata are designed to promote the processing and sharing of netCDF files. The conventions define metadata that provide a definitive description of what the data represents, and the spatial and temporal properties of the data.
	CityGML *https://portal.opengeospatial.org/files/?artifact_id=47842*	CityGML is an open data model and XML-based format for the storage and exchange of virtual 3D city models. It is an application schema for the Geography Markup Language. The aim of the development of CityGML is to reach a common definition of the basic entities, attributes, and relations of a 3D city model.

Standard Parameters	Standard Document and Web Link	Definition
	Water Markup Language *https://portal.opengeospatial.org/files/?artifact_id=48531*	Encoding Standard for the representation of hydrological observations data with a specific focus on time series structures.
	GeoPackage Encoding Standard *https://portal.opengeospatial.org/files/?artifact_id=56357*	This Encoding Standard defines GeoPackages for exchange and GeoPackage SQLite Extensions for direct use of vector geospatial features and / or tile matrix sets of earth images and raster maps at various scales. GeoPackages are interoperable across all enterprise and personal computing environments, and are particularly useful on mobile devices like cell phones and tablets in communications environments with limited connectivity and bandwidth.
	Open Modelling Interface (MI) Standard *https://portal.opengeospatial.org/files/?artifact_id=59022*	The purpose of the Open Modelling Interface (OpenMI) is to enable the runtime exchange of data between process simulation models and also between models and other modelling tools such as databases and analytical and visualization applications. Its creation has been driven by the need to understand how processes interact and to predict the likely outcomes of those interactions under given conditions. The ultimate aim is to transform integrated modelling into an operational tool accessible to all and so open up the potential opportunities created by integrated modelling for innovation and wealth creation.
	OpenSearch Geo and Time Extensions *https://portal.opengeospatial.org/files/?artifact_id=56866*	This OGC standard specifies the Geo and Time extensions to the OpenSearch query protocol. OpenSearch is a collection of simple formats for the sharing of search results. The OpenSearch description document format can be used to describe a search engine so that it can be used by search client applications. The OpenSearch description format allows the use of extensions that allow search engines to request a specific and contextual query parameter from search clients. The OpenSearch response elements can be used to extend existing syndication formats, such as RSS and Atom, with the extra metadata needed to return search results

Standard Parameters	Standard Document and Web Link	Definition
Portal Security Standard	**Geospatial eXtensible Access Control Markup Language (GeoXACML)** *http://portal.opengeospatial.org/files/?artifact_id=42734* *http://portal.opengeospatial.org/files/?artifact_id=25219* *http://portal.opengeospatial.org/files/?artifact_id=25220*	The Geospatial eXtensible Access Control Markup Language (GeoXACML) defines an extension to the XACML Policy Language that supports the declaration and enforcement of access restrictions on geographic information. GeoDRM System would manage the access at the time (i) the user accesses the geographic information from the service and (ii) afterwards, when the geographic information is stored somewhere else.
	Geospatial Digital Rights Management Reference Model (GeoDRM RM) *http://portal.opengeospatial.org/files/?artifact_id=14085*	The GeoDRM RM defines the framework for web service mechanisms and rights languages to articulate, manage and protect the rights of all participants in the geographic information marketplace.
Application Services Standard for Mobile	**Location Services** *http://portal.opengeospatial.org/files/?artifact_id=25487*	The OpenGIS Tracking Service Interface Standard supports a very simple functionality allowing a collection of movable objects to be tracked as they move and change orientation.
	GeoSMS Standard *https://portal.opengeospatial.org/files/?artifact_id=44146*	Standard on Short Message Service (SMS) encoding and interface to facilitate communication of location content between different LBS (Location-Based Service) devices or applications. SMS is the open text communication service standard most commonly used in phone, web and mobile communication systems for the exchange of short text messages between fixed line or mobile phone devices.
	Navigation Service *http://portal.opengeospatial.org/files/?artifact_id=28493*	Open Location Services Interface Standard (OpenLS) specifies interfaces that enable companies in the Location Based Services (LBS) value chain to “hook up” and provide their pieces of applications such as emergency response for example, personal navigator, traffic information service, proximity service, location recall, mobile field service, travel directions, restaurant finder, corporate asset locator, concierge, routing, vector map portrayal and interaction, friend finder, and geography voice-graphics.

Standard Parameters	Standard Document and Web Link	Definition
Others	**Observations & Measurements (O&M)** *https://portal.opengeospatial.org/files/?artifact_id=47040* *http://portal.opengeospatial.org/files/?artifact_id=41510*	The general models and XML encodings for observations and measurements.
	Sensor Model Language (SensorML) *http://portal.opengeospatial.org/files/?artifact_id=21273* *https://portal.opengeospatial.org/files/?artifact_id=55939*	The primary focus of the Sensor Model Language (SensorML) is to provide a robust and semantically-tied means of defining processes and processing components associated with the measurement and post-measurement transformation of observations. The main objective is to enable interoperability, first at the syntactic level and later at the semantic level (by using ontologies and semantic mediation), so that sensors and processes can be better understood by machines, utilized automatically in complex workflows, and easily shared between intelligent sensor web nodes.
	PUCK Protocol Standard *https://portal.opengeospatial.org/files/?artifact_id=47604*	Defines a protocol to retrieve a SensorML description, sensor "driver" code, and other information from the device itself, thus enabling automatic sensor installation, configuration and operation.
	Sensor Observation Service (SOS) *https://portal.opengeospatial.org/files/?artifact_id=47599* *http://portal.opengeospatial.org/files/?artifact_id=26667*	The SOS standard is applicable to use cases in which sensor data needs to be managed in an interoperable way. This standard defines a Web service interface which allows querying observations, sensor metadata, as well as representations of observed features
	Sensor Planning Service (SPS) *http://portal.opengeospatial.org/files/?artifact_id=38478*	SPS is an open interface for a web service by which a client can 1) determine the feasibility of collecting data from one or more sensors or models and 2) submit collection requests.
	Ordering Services Framework for Earth Observation Products Interface Standard *https://portal.opengeospatial.org/files/?artifact_id=43928*	Ordering Services describes the interfaces, bindings and encodings required to order Earth Observation (EO)products in a heterogenous, distributed environment. The intent of this standard is to describe an interface that can be supported by many data providers (satellite operators, data distributors, etc.), most of whom have existing (and relatively complex) facilities for the management of these data.

Standard Parameters	Standard Document and Web Link	Definition
	GeoAPI 3.0 Implementation Standard *http://portal.opengeospatial.org/files/?artifact_id=39397*	The GeoAPI Implementation Standard defines, through the GeoAPI library, a Java language application programming interface (API) including a set of types and methods which can be used for the manipulation of geographic information structured following the specifications adopted by the Technical Committee 211 of the International Organization for Standardization (ISO) and by the Open Geospatial Consortium (OGC).
	Web Service Context Atom Encoding Standard *https://portal.opengeospatial.org/files/?artifact_id=55183*	This standard describes the Atom encoding of the OWC Context conceptual model. The goal of this standard is to provide a definition of how to encode a context document, which can be extended to allow a context referencing a fully configured service set to be defined and consistently interpreted by clients.
	SWE Common Data Model Encoding Standard *http://portal.opengeospatial.org/files/?artifact_id=41157*	This Defines low level data models for exchanging sensor related data between nodes of the OGC® Sensor Web Enablement (SWE) framework. These models allow applications and/or servers to structure, encode and transmit sensor datasets in a self-describing and semantically enabled way.
	Extension Package for ebRIM Application Profile: Earth Observation Products *https://portal.opengeospatial.org/files/?artifact_id=56905*	This standard is part of a suite of OGC documents that describe service interfaces and encodings for managing Earth Observation (EO) data products. The services include collection level and product level catalogues, online-ordering for existing and future products, online access, etc. The service interfaces and operations described in this standard are intended to support the identification of (EO) data products from previously identified data collections.

TABLE – 2.5: DETAILS OF ISO/ TC -211 STANDARDS

(ISO TC-211 documents are available only to Members; NIAS could not access the original ISO documents of many of the Standards – even after repeated requests to DST. Thus, for many listed ISO Standards document reference and its detailed definition is lacking)

Standard Parameters	Standard Document and Web Link	Definition
Content Standard		
Spatial Framework definition	**Geographic information - Positioning services**	
	Geodetic References	
	Registry service	
	Geographic information - Imagery sensor models for geopositioning	
	Geographic information - Spatial referencing by coordinates - Part 2: Extension for parametric values	
	Geographic information -- Geodetic codes and parameters	
	Geographic information - Registry of representations of geographic point location	
	Geographic information - Well known text representation of coordinate reference systems	
Image Standards	**Geographic information - Imagery and gridded data**	
	Geographic information - Imagery, gridded and coverage data framework	
	Geographic information - Functional standards	
	Geographic information - Preference model - Part 2: Imagery	
	Geographic information - Imagery sensor models for geopositioning - Part 2: SAR, InSAR, lidar and sonar	

Standard Parameters	Standard Document and Web Link	Definition
	Geographic information - Metadata - XML Schema Implementation - Part 2 : Extensions for imagery and gridded data	
	Geographic information - Calibration and validation of remote sensing imagery sensors - Part 1: Optical sensor	
	Geographic information - Calibration and validation of remote sensing imagery sensors - Part 1: Lidar	
Database Schema	Geographic information - Terminology	
	Geographic information - Core profile of the spatial schema	
	Geographic information - Ontology - Part 1: Framework	
	Geographic information - Land Administration Domain Model (LADM)	
	Geographic information - Methodology for feature cataloguing	
	Geographic information - Metadata - Part 3: XML schema of metadata fundamentals	
	Addressing - Part 1: Conceptual model	
	Addressing - Part 4: International postal address components and template languages	
	Geographic information - Spatial schema	
	Geographic information - Rules for application schema	

Standard Parameters	Standard Document and Web Link	Definition
Quality Standards	**Quality principles** *http://www.ird.fr/informatique-scientifique/methodo/standards/normes_iso_ogc/iso_geo/afnor/ISO_19113_DE_2002_ANGLAIS.pdf*	This International Standard establishes the principles for describing the quality of geographic data and specifies components for reporting quality information. It also provides an approach to organizing information about data quality.
	Quality evaluation procedures *http://www.ird.fr/informatique-scientifique/methodo/standards/normes_iso_ogc/iso_geo/afnor/ISO_19114_DE_2003ANGLAIS.pdf*	This International Standard provides a framework of procedures for determining and evaluating quality that is applicable to digital geographic datasets, consistent with the data quality principles defined in ISO 19113.
	Data quality measures *http://www.ird.fr/informatique-scientifique/methodo/standards/normes_iso_ogc/iso_geo/afnor/ISO_TS_19138_DE_2006-ANGLAIS.pdf*	This Technical Specification defines a set of data quality measures. These can be used when reporting data quality for the data quality sub elements identified in ISO 19113
	Geographic information - Data quality	
	Geographic information - Quality assurance of data supply	
	Geographic information - Rules for application schema	
Metadata Standard	**Metadata** *http://www.ird.fr/informatique-scientifique/methodo/standards/normes_iso_ogc/iso_geo/afnor/ISO_19115_DE_2003-ANAGLAIS.pdf* *http://www.ird.fr/informatique-scientifique/methodo/standards/normes_iso_ogc/iso_geo/afnor/ISO_19115_AC1_DE_2006-ANGLAIS.pdf*	This International Standard defines the schema required for describing geographic information and services. It provides information about the identification, the extent, the quality, the spatial and temporal schema, spatial reference, and distribution of digital geographic data.

Standard Parameters	Standard Document and Web Link	Definition
	Feature cataloguing *http://www.ird.fr/informatique-scientifique/methodo/standards/normes_iso_ogc/iso_geo/afnor/ISO_19110_DE_2005-ANGLAIS.pdf*	This International Standard specifies how the classification of feature types is organized into a feature catalogue and presented to the users of a set of geographic data.
	Geographic information - Metadata - Part 2: Extensions for imagery and gridded data	
	Geographic information / Geomatics -- Qualification and certification of personnel	
	Geographic information - Feature concept dictionaries and registers	
	Geographic information - Classification Systems – Part 1: Classification system structure	
	Geographic information - Classification systems - Part 2: Land Cover Meta Language (LCML)	
	Geographic information - Procedures for item registration	
	Procedures for item registration -Part 2: XML Schema Implementation	
	Geographic information - Cross-domain vocabularies	
GIS Web Display Services	**Geographic information - Portrayal**	

Standard Parameters	Standard Document and Web Link	Definition
GIS Web Data Accessing and Processing Services	**Simple feature access - Part: 1 Comman articitecture** *http://www.ird.fr/informatique-scientifique/methodo/standards/normes_iso_ogc/iso_geo/afnor/ISO_19125-1_DE_2004_ANGLAIS.pdf*	This describes the common architecture for simple feature geometry
	Geographic information - Simple feature access - Part 2: SQL options	
	Geographic information - Web Feature Service	
GIS Web Applications Mapping Services	**Web map server interface** *http://www.ird.fr/informatique-scientifique/methodo/standards/normes_iso_ogc/iso_geo/afnor/ISO_19128_DE_2005-ANGLAIS.pdf*	A Web Map Service (WMS) produces maps of spatially referenced data dynamically from geographic information. It specifies operations to retrieve a description of the maps offered by a server to retrieve a map, and to query a server about features displayed on a map. This International Standard is applicable to pictorial renderings of maps in a graphical format; it is not applicable to retrieval of actual feature data or coverage data values.
	Geographic information - Services	
Data Exchange (Encoding) Standards	**Standard representation of geographic point location by coordinates** *http://www.ird.fr/informatique-scientifique/methodo/standards/normes_iso_ogc/iso_geo/afnor/ISO_6709_DE_2008-ANGLAIS.pdf*	This International Standard is applicable to the interchange of coordinates describing geographic point location. It specifies the representation of coordinates, including latitude and longitude, to be used in data interchange.
	Conceptual schema language *http://www.ird.fr/informatique-scientifique/methodo/standards/normes_iso_ogc/iso_geo/afnor/ISO_TS_19103_DE_2005-ANGLAIS.pdf*	This standard is concerned with the adoption and use of a conceptual schema language (CSL) for developing computer-interpretable models, or schemas, of geographic information.
	Metadata XML schema implementation *http://www.ird.fr/informatique-scientifique/methodo/standards/normes_iso_ogc/iso_geo/afnor/ISO_TS_19139_DE_2007-ANGLAIS.pdf*	This Technical Specification defines Geographic MetaData XML (gmd) encoding, an XML schema implementation derived from ISO 19115.
	Geographic information - Encoding	

Standard Parameters	Standard Document and Web Link	Definition
	Geography Markup Language (GML)	
	Geography Markup Language - Part 2: Extended schemas and encoding rules	
	Geographic information - Filter encoding	
	Geographic information - Content components and encoding rules for imagery and gridded data	
Portal Security Standard.	Geographic information - Conformance and testing	
	Geospatial Digital Rights Management Reference Model (GeoDRM RM)	
Application Services Standard for Mobile	Geographic information - Transfer Nodes	
	Geographic information - Linear Referencing	
	Dynamic position identification schema for ubiquitous space (μ-position)	
	Geographic information - Location based services-Multimodal routing and navigation	
	Geographic information - Location based services-Tracking and Navigation	
	Geographic information - Schema for moving features	

TABLE – 2.6: COMPARATIVE ANALYSIS OF VARIOUS STANDARDS

No	Parameters	FGDC	OGC	INSPIRE	ISO/TC-211	USGS
1	Content Standards	Yes	Community Agreements	Yes	No	Yes. Adopts FGDC Standard
2	Metadata Standards	Yes	Yes	Yes	Yes	Yes. Adopts FGDC Standard
3	Schema/Data Dictionary/Data Models	Yes	Community Agreements	Yes	Yes	Yes. Adopts USGS Schema
4	Spatial Framework	Yes	No	No	Yes	Yes. Defined based on FGDC Standard
5	Quality	Yes	No (Only Data Quality Domain WG)	Yes	Yes	Yes.
6	Image	Yes	Yes	Yes	Yes	Yes.
7	GIS Services (Data and Apps)	Follows ISO & OGC Standards	Yes	Follows ISO and OGC Standards	Yes	Follows OGC Standards
8	Mobile GIS Services	-	Yes	No	Yes	-
9	Portal Standards	Follows ISO & OGC Standards	Yes	Yes	Yes	-
10	Interoperability	Yes	Yes	Yes	Yes	-

3. Current Eco-System of GI Standards in India

73. Standards for topographic mapping existed in India – but was all classified within Survey of India – with just basic "indication standards" in form of representable features on printed SOI maps defined at 12.5 m for a 1:50k scale topographic maps. The advent of IRS images brought in yet another aspects of standardisation parameter in terms of spatial resolution – which started with 72m and 36.5m resolution of the first IRS-1A.

74. With IRS images availability, RS based GIS projects for Regional planning in Bharatpur[12] and District Level Planning in Panchmahals[13] and later many other projects for Wasteland Development, Urban Development and many others were taken up – they provided practical and hands-on experience in organising then 1:50k scale GIS for demonstrative decision-support. Based on these experiences, guidelines for GIS standardisation[14] was outlines in 1995 in an ISRO document. However, it was the National (Natural) Resources Information System (NRIS) which, for first time in 2000s, recognized the value of GIS Standards and embarked upon developing a standard for the NRIS implementation as GIS standards[15.] NRIS Standards laid the foundation for many a GIS activity in the country and, in combination with SOI maps, triggered and spurred 1:50k and 1:250k GIS activities across the country.

75. In 2001, Department of Science and Technology (DST) and ISRO initiated the National Spatial Data Infrastructure initiative. Under this NSDI activity, 2 major efforts of standardisation were initiated and defined. The first pertained to exchange of SOI digital topographic data – hitherto in Digital Vector Data (DVD) format into NSDI Exchange Standard[16.] The second pertained to Metadata Standard that defined the standards of Metadata for NSDI[17].

76. The next major effort at Standards in India was in form of National Natural Resources Management System (NNRMS) Standard[18] - basically necessitated to overcome improvements over NRIS Standards required because image resolutions had reached 5.8m and 2.5m expectations and thematic mapping was possible at 1:10k scale. The NNRMS Standards outlined a comprehensive set of standards for images, thematic mapping at different scales and GIS – and going ahead with defining a spatial framework concept. The NNRMS Standard was quite comprehensive and soon most agencies in India started adopting the NNRMS Standards for all GIS activities.

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12 A GIS based information system for regional planning - a case study for Bharatpur - Project report of Space Applications Centre (SAC) and Town and country planning organisation (TCPO) in 1992.

13 District Level Planning for Panchmahals district – Project report of Space Applications Centre (SAC)

14 Guidelines for GIS standardisation (http://library.cept.ac.in/cgi-bin/koha/opac-detail.pl?biblionumber=13539) - Mukund Rao and V Jayaraman. ISRO-NNRMS TR-105 95, ISRO (NNRMS) publication

15 NRIS node design & standards. A NNRMS publication - ISRO-NNRMS-SP-72-99 of 1999 and available on http://www.nnrms.gov.in/reports/96-00.htm

16 NSDI Exchange Standards – A SOI Publication of November, 2003

17 NSDI Metadata Standard - a NNRMS publication (http://www.nnrms.gov.in/greennnrms/download/NSDIMetadataDocument.pdf) – ISRO-NNRMS-TR-104-2003 of October 2003.

18 NNRMS Standards (http://www.nnrms.gov.in/greennnrms/download/NnrmsStandardsDoc.pdf) – A report from ISRO - ISRO: NNRMS: TR: 112: 2005 of June, 2005.

77. The first "National GIS" pilot project (in 2004-2005) by ISRO/DOS and NIC for Planning Commission was based on NNRMS Standards. NIC is continuing this effort and has brought a national GIS Portal. Even initiatives of NUIS were based on NNRMS Standards and customized for urban planning – NUIS Standard[19]. NNRMS Standards have been adopted for many projects - SIS-DP of ISRO/DOS, Bhuvan of ISRO/DOS and many others.

78. The trends of GIS set initially by the NRIS through NSDI and NNRMS standards set into motion adoption of a basic level of standardisation in image, mapping and GIS activity and paved the way for many users adopting GIS activities prolifically.

79. In 2010, the Planning Commission brought in the operational concept of National GIS and provided a vision for National GIS[20]. At same time, some states – especially Gujarat, followed by Karnataka, started organising state-wide GIS that matched and aligned with National GIS concept and widely developed state-GIS applications for decision-support. Karnataka developed a K-GIS[21] Standards for it state-wide GIS Portal and adopted it operationally – becoming the few initial states to formally announce a GIS Standard.

80. Thus, as can be seen, over the past ~25 years, India has made considerable progress and developments in GIS and Standards for GIS. In the ensuing sections, we bring in the characteristics of the presently relevant GIS standards in India.

3.1. NNRMS STANDARDS, 2005

81. The NNRMS Standards[22] is an all-encompassing framework that facilitates and enables NNRMS community to build and develop systematic "repository compliant" databases and services. These Standards are "generic" in nature and designed to enable systematic generation of the NNRMS Repository flexible enough to be able to incorporate any spatial data but confirming to a basic set of parameters. Thus, the Standards are independent of specific content, source of generation of spatial data, specific software and are more generic to spatial databases. NNRMS is an inter-agency programme and content would get generated by various agencies participating in NNRMS. As far as content is concerned, both images and maps are visualized to be a part of the Repository.

82. The detailed assessment of NNRMS Content is shown in **TABLE – 3.1** (which is an indicative list but is illustrative of the type of content). The content is categorised for the various scales and includes a total of ~87 layers, as of now – out of which 16 layers conform to 1:250K standards; 53 layers conform to 1:50K standards; 14 layers conform to 1:10K standards and 4 layers conform to 1:2K standards. In the NNRMS Standards a total end-to-end process standardisation has been adopted. The NNRMS Standards comprise of about 39 parameters (including basic and quality parameters) for the different scales and values (at 3-sigma limits) identified. The NNRMS Content

[19] NUIS Design Standard. A publication of NNRMS under the NNRMS Standing Committee on Urban management of November, 2004. http://tcp.cg.gov.in/nuis/Design_Standards.pdf

[20] Ibid 1.

[21] Karnataka-GIS Vision. A KSRSAC and Karnataka Knowledge Commission document of Feb, 2013. Available at https://www.karnataka.gov.in/ksrsac/pages/home.aspx

[22] Ibid 18

of 87 layers have been standardised for naming conventions, layer type, layer-code and layer-description so that the name will include an easily understandable typology.

83. The **TABLE – 3.2** shows the NNRMS Standard parameters and their values. The parameters have been defined based on the Thematic Mapping and NRIS/GIS applications experience as well as the simulation exercises carried out to determine limits of precision required and are the most comprehensive set of parameters. The parameters and values of the NNRMS Standards are recommendatory and define the process – thus, they set tolerable limits of precision rather than a "logical" accept/reject criterion for the maps/GIS. Broadly 5 critical Standard types have been identified as given below:

83.1. Image Standards: Images, either from satellites or aerial surveys, are the primary source of input and the starting point for the NNRMS Repository. 8 basic parameters are identified for the NNRMS Image Standards.

83.2. Thematic & Cartographic Mapping Standards: Thematic Maps are a result from the interpretation and analysis of the images, either from satellites or aircrafts, and are the primary source of input for the GIS database of the NNRMS Repository. The stringency in the parameter values in the mapping is maintained to enable a good GIS establishment. 11 basic parameters are identified for the NNRMS Thematic Map Standards.

83.3. GIS Database Standard: GIS database are the core of the Repository and result from the digitalization and ingest of thematic maps, either from satellites or aircrafts, into the GIS database of the NNRMS Repository. The stringency in the parameter values in the images and mapping have considerable bearing on the precision achievable at GIS database end. Further, the accuracies of the outputs/services from the NNRMS would depend upon the GIS database Standards.13 basic parameters are identified for the NNRMS GISDB Standards.

83.4. Output Standards: The GIS database would be the core for NNRMS Outputs and Services. 7 basic parameters are identified for the NNRMS Output/Service Standards.

83.5. Quality Standards: As the NNRMS Standards have been developed as a process standard – involving various elements, the Quality Certification (QC) of the NNRMS products would be a function of the Quality Assurance (QA) at the individual process level and the final Quality Evaluation of the product that would be given to the user. The NNRMS Metadata would have all the Quality Assurance and Certification parameters – where the concept will be to integrate the individual Quality Evaluation parameters for the total process.

84. Thus, it is expected that each process of the NNRMS activity would generate a process Quality Assurance report – which would evaluate all the parameters of the Standards at that process level. Each of these process standard parameters would be evaluated and archived in the Metadata database. The evaluation would measure the level of compliance to the process standard parameter values and deviation/variation, if any.

85. A final Quality Certification before delivery of the NNRMS product would be conducted to certify the compliance of the product to the NNRMS Standards and also identify deviation/variation, if any.

3.2. NSDI STANDARDS, 2003-2009

86. Encapsulating vast amount of map information and images available in the country into a National Spatial Data Infrastructure (NSDI) provide information transparency and sharing opportunity with citizens, society, private enterprise and government as a national resource. One of the major elements of the NSDI is defining common conventions and technical agreements, standards, metadata definitions, network and access protocols – all of which will make it easily possible for the NSDI to come into existence.

87. Metadata is first element and interface of the user to any GIS – which enables a user to find, on-line, spatial data that is available. Metadata serves two major purposes – both for the spatial data generator and for the spatial data user. For the generator, the Metadata Standard provides a framework to document the spatial data and declare its content for users. For the user, the Metadata Standard serves many important purposes, including finding the spatial data of the need; browsing spatial data; deciding on whether the spatial data will meet the application need and finding how the spatial data can be accessed. Therefore, the metadata elements and schema needs to be standardized at National level. In this regard, the metadata standards developed earlier by NNRMS (ISRO)[23] was adopted by NSDI and later updated in 2009.

88. The NSDI Metadata is intended to serve Metadata for Search and Location of spatial data in NSDI – related to Identification Information – basic information about the spatial data layer; Spatial Data Organization Information – the mechanism used to represent spatial information in the data NSDI; Spatial Reference Information – description of the reference frame for, and means of encoding, coordinates in the data set. The Metadata Standards also allows investigation of spatial data of NSDI – subsequent to search and location, more detail is needed about individual spatial data sets and more comprehensive and more specific metadata - Accuracy of the spatial data – in terms of positional, thematic accuracies; Data Quality Information – an assessment of the quality of the spatial data set; Entity and Attribute Information – information about the content of the data set; Metadata for Browsing intended data; Metadata for Access of Spatial data of NSDI

89. The fundamental aspects of the NSDI Metadata was the initial concept of a GIS framework for Spatial data – map and image data from different NSDI agencies. This could be at different scales – 1:250K to 1:10K through 1:50K and 1:25K and inclusion of non-framework Spatial data which would get “fused” into a GIS framework for compatibility. The Metadata Standards was supposed to be web-enabled so that on-line access on nsdi.org is possible. This will at least open up information about spatial data availability.

90. Thus the objectives of the NSDI Metadata Standard are to provide a common set of terminology and definitions for the documentation of digital spatial data. The standard establishes the names

[23] Ibid 17

of data elements to be used for these purposes, the definitions of these and data elements, and information about the values that are to be provided for the data elements.

91. As per the Metadata Standards, NSDI would have 28 major elements - Data Identification Information, Contact Information, Coverage, Geographic location of the dataset (by four coordinates or by Description), Citation, Metadata date stamp, Type, Subject, Description, Publisher, Dataset responsible party, Distribution Format, On-line resource, Dataset topic category, Language, Abstract describing the data, Spatial representation type, Spatial resolution of the dataset, Reference system, Temporal extent information for the dataset, Vertical extent information for the dataset, Quicklook, For Image Data, Rights, Team (organisation Name), Attributes/Entity and Attribute Information, Projection Information and Data Quality.

92. NSDI Exchange Standard proposed format provides for inclusion of digital images acquired by satellites and Digital Elevation Model (DEM) and coded raster data in addition to the earlier National Standard Exchange (NSDE) format of Survey of India digital Cartographic vector data. Furthermore the NSDE format also accommodates various types of thematic data sets along with the associated attribute data in tabular form.

93. The data in NSDE Format will be supplied to users as a set of files. When supplying the data on media all the files would be copied unlabelled in the same sequence with the End-Of-File (EOF) mark after each file and one extra EOF mark at the end of all files to indicate the end. In case the dataset cannot be accommodated in one media, the files will be copied sequentially into additional media which will be serially numbered and indicated in first file.

3.3. NUIS STANDARDS[24], 2006

94. As a sequel to the proposal, to define and develop the NUIS Scheme Design and Standards, the NUIS Standards Committee (NNRMS SC-U) prepared a draft NUIS Design and Standards report in September 2005. The report essentially outlines the content at 1:10000 / 1:2000 / 1:1000 scales, Design standards framework encompassing standardization of content design, exchange and metadata, data elements (USIS, NUDB&I and NUO) to be adopted as National NUIS Standards. The standards address the different levels of planning and management and have now come out a comprehensive document for the implementation of NUIS Scheme. The major elements of the data standards are highlighted below:

95. Detailed design parameters for USIS have been evolved within NUIS framework. The spatial framework, to be adopted for the two different levels of USIS - Master Plan (1:10000) and Zonal Plan / Detailed Town Planning Schemes (1:2000) scales, is given in **Table – 3.1**,

96. The 8 major Standards elements for the NUIS are Image Standards, Thematic Mapping Standards, Spatial Framework Standards, Classification Content & Codification Standards, Geospatial Database Standards, Quality Certification Standards, Output / Deliverables Standards, Metadata Standards.

[24] National Urban Information System (NUIS) - Design and Standards - Ministry of Urban Development Document of July 2006 http://tcp.cg.gov.in/nuis/Design_Standards.pdf

97. Details of NUIS Standards content is given in **TABLE- 3.1** and the standards specifications for NUIS is given in **TABLE – 3.2**.

3.4. PROTOTYPE K-GIS STANDARDS, 2013

98. Aligned with this National GIS Vision, K-GIS envisages a complementary Karnataka-wide GIS system as an integral element to deliver state specific data assets and DSS applications that are relevant for the development of the state. Consistent with the National GIS, K-GIS also envisages K-GIS Asset, a seamless, State-wide GIS-Ready dataset which is standardized and updated and configured to meet the GIS data and application needs of government, citizens and enterprises and K-GIS DSS Applications, a suite of GIS applications for decision- and work processes of different departments; GIS applications for public services and citizens and also hosting/publishing enterprise GIS solutions. A prototype K-GIS Portal, a single gateway access to K-GIS Asset and K-GIS DSS Applications - with specialized Metadata service, GIS Applications service, data ingest service, data sharing service, publishing services etc.

99. As of now, KSRSAC has for the whole state 1:50k GIS content will be based on available 1:50k SOI map foundation. This can be a starting point But it is important to establish a Karnataka Spatial Framework compatible for 1:10k K-GIS Asset and base K-GIS assets on this framework. It is essential for these 2 frameworks to be positioned immediately. It should be ensured that a Karnataka Spatial Foundation Dataset – consisting of national/state/district/taluk boundaries linked to Census names is available as a common and foundation base data for K-GIS.

100. The prototype K-GIS Standards are founded on principles of "National GIS" which are "open standards" and be "inter-operable" across platforms and systems and be totally neutral to any technology (thus, not being tied with any particular GIS or System technology). These must also be compliant with National GIS Standards fully and also be based upon international ISO TC211 standardization efforts – especially as India is already committed to ISO/TC standardization efforts through the Bureau of Indian Standards.

101. As a state system, the possibility of an integration (if the need arises and is warranted by government) of an appropriate sub-set of the K-GIS to National GIS is critically essential. It is important to consider this in advance at design stage. Existing GIS Standards like NNRMS Standard of 2005, NSDI Metadata Standards of 2003/20011 and NSDI Exchange Standards of 2001; NUIS Standards of 2004 have been studied and can be easily updated/enhanced and integrated into prototype K-GIS Standards.

102. Thus, while a broad definition of Standards and Processes are envisioned, at the time of implementation, KSRSAC could first define following standards and processes:

    102.1. Prototype K-GIS Content Standard: This Standard would define the content standards for K-GIS Asset – identifying what feature would form part of the K-GIS and from where it would be sourced/generated.

    102.2. Karnataka State Spatial Framework (KSF), as a subset of National Spatial Foundation (NSF), definition with a core standard layer of state/international boundary (with

states, districts and other major features) as Geospatial dataset. The KSF, initially is to be defined equivalent to 1:50k SOI Open Series Maps and also later for 1:10k K-GIS Asset requirement.

103. Details of prototype K-GIS Standards content is given in **TABLE- 3.1** and the standards specifications for prototype K-GIS is given in **TABLE – 3.2**.

3.5. ANALYSIS OF EXISTING STANDARDS

104. We have analysed the above GIS Standards and present below some important observations/ conclusions:

104.1. Standardisation in Indian context is considerably different. In Indian efforts, the standardisation has centered more around data generation (images/maps etc) and less on GIS services and applications (though in recent years, Indian efforts of private and public agencies have seen adoption of OGC services standards to an increasing extent). This, according to us, has a reason and that pertains to the fact that in Indian data availability and accessibility has major limitations and gaps – image/map data is not readily available in GIS-Ready format. As a result, efforts are being repeated for generating image/map data (if we see examples of NRIS, NUIS, SIS-DP etc this is clearly apparent). As against this, in other parts of world like US, Europe etc, basic data availability and accessibility is not a major issue and thus standardisation efforts centre more around GIS services and applications (we can clearly see this in efforts of FGDC, OGC, INSPIRE etc). In our view, the present Indian characteristic of GIS Standards (centered around generating data) will continue as long as we do not also reach that stage where image/map data availability/accessibility is no more an issue – hopefully, National GIS should rhelp each that stage.

104.2. Yet another major element for GIS Standards in India is there is no common spatial framework on which images/maps/GIS is generated – every user seems to re-create "convenient versions" of the spatial framework that he needs for the GIS. However, single-source from SOI 1:50k national OSM maps is utilized by every user. The user-versioning of this frame-of-India in GIS is so varied that the uniformity and conformity in GIS image/maps to national scene is lost and the various GIS are highly in-compatible.

104.3. NNRMS standards are relatively more comprehensive and cover the gamut of basic categories of GIS elements - Image Standards, Thematic Mapping Standards, GIS Database Standards, Output Standards, Thematic Accuracy Standards. NNRMS Standards also has proposed a spatial framework. Further, NNRMS Standards also have powered some unique variations in NUIS Standard, prototype K-GIS Standard and also being used for SIS-DP project and Bhuvan portal. However, it needs to be noted that the NNRMS Standards have a 2005 vintage.

104.4. NSDI Standards are limited to Metadata definition and SOI data exchange. However, we see a serious issue here – no data is populated in the NSDI Portal based on this Standard – in fact, all NSDI Metadata returns blanks in the Portal. Thus, one gets a feeling that on paper the NSDI Metadata Standards are well-designed but their practical applicability

has yet to be established with operational metadata of different agencies and different areas serviced through the Portal.

104.5. Similarly, the NSDI Exchange Standards – which were extremely narrow-spectrum applicability for SOI DVD data have out-lived their relevance in present time-frame and we do not see any practical cases of NSDI Exchange Standard being practically applied anymore.

104.6. NUIS Standards pertain to a specific theme – urban planning and is based on NNRMS Standard. The NUIS Standards have been applied for NUIS project 153 town and have some validity and robustness.

104.7. NIC has also built upon the initial standard used for 2004 National GIS Pilot which was based on NNRMS Standard. NIC seems to have made their own variations to NNRMS Standard and adopted them for their GIS Portal quite successfully. This shows that users do have customizing needs and they do it as and when required.

104.8. Prototype K-GIS Standard is mainly a logical extension to national GIS activity and adapts ahead from NNRMS Standards – thus its learnings also will be important when National GSI Standards is defined.

105. Some other important observations that we make are:

105.1. GIS Standards must not be static and must evolve and update very frequently – like NRIS was defined in 1999 and NNRMS Standards defined in 2005 - subsequently with all technological changes there has been no effort till 2015 for renewing GIS Standards. As a result, many users we interacted with feel that even the 2005 NNRMS Standards needs changes – not just of period-updates but also in concept of starting to build robustnesss to Content Standards and also need to define GIS Services Standards. National GIS must include both robust content and services standards.

105.2. A Spatial framework is most critical for National GIS – we have seen in many cases that we evaluated the very shape and profile of India is different in most GIS projects and thus features do have spatial in-compatibility issues. This sort of spatial in-compatibility is amazing in 2015 National GIS time-frame and must be eliminated. This would be only possible when all Indian users access/use ONE SINGLE SPATIAL FRAME for India (it may be noted that even in US, Europe and China – now they are facing issues of spatial in-compatibility in past GIS works and are rectifying the same with technological inputs). National GIS Standards must address this important requirement.

105.3. Good data definitions and data dictionary are a must for GIS Standards – they not only make GIS content easily understood but also power good Metadata services. The definition of every term and every GIS parameter is important so that everybody has the same understanding and meaning for the GIS Standards (we have seen that even Landuse is defined differently in different GIS but are cross-analysed even though the landuse category terms are different). We must learn from what OGC and ISO have done – with their excellently defined data dictionary models. It is essential to have a DEFINITIONS section for the Standards and a thesaurus for each content feature in National GIS.

3.6. TOWARDS NATIONAL GIS STANDARDS – KEY DRIVERS

106. Standardisation and Process definition would be key for the success of National GIS. The National GIS needs, in fact, have a suite of national Standards – broadly two categories of Standards, namely:

106.1. Basic GIS Standards for National GIS Asset and its activities - defining the content and its characteristics of National GIS Asset; GIS database standards for the National GIS database, GIS Quality Standards etc

106.2. Service Standards: The success of National GIS is also dependent on the data and DSS GIS services and linkages to other national services, database and applications (like E-Governance; ERP, CRM etc)

107. The National GIS Standards needs be founded on principles of "open standards" and be "inter-operable" across platforms and systems and be neutral to any technology (thus, not being tied with any particular GIS or System technology). The National GIS Standards must be consistent) with international ISO TC211 standardisation efforts – especially as India is already committed to ISO/TC standardisation efforts through the Bureau of Indian Standards (ISO is a multi-lateral body for standardisation and India is represented by BIS).

108. Robust characteristics of existing GIS Standards like NNRMS Standard of 2005, NSDI Metadata Standards of 2001/2009 and NSDI Exchange Standards of 2001; NUIS Standards of 2004 could be adapted/enhanced and integrated into National GIS Standards Standards.

109. Towards National GIS, the National Spatial Framework (NSF) is critical and essential element to develop an authoritative and responsible National GIS Asset. The NSF needs to be well-planned, designed and developed with utmost professional and determined finesse. Just like when one constructs a building, the foundation is crux and critical – if one gets the foundation in error then the building does not have longevity and intended use. In the National GIS system, unlike when one develops a project GIS, India (as a nation) has to be correctly and as-accurately represented so that every inch of India is reflected correctly – in terms of its coordinates, distances, area etc. This needs to be done by geographic referencing all information (like in an Atlas the coordinate grid does). While this looks easily doable – the complexity comes in when different "primary source" data are put together. In India, all information (maps or tabular) are referenced on 4 basic platforms – either on a satellite/aerial image (which is processed and supplied by NRSC); or, on a SOI OSM reference (which is supplied by SOI); or, from a survey instrument like GPS/TS etc; or, on an administrative frame of villages/taluk/district/state (which generally is from Census or states). Thus, the features/layers are all BASED on one of these 4 referential primary source. Now, if one does not have the spatial geometry across these 4 sources standardized/referenced then the GIS Asset can have across-errors that would compound to differences in coordinates for the same feature referenced – thus, locations of features, distances and area measurements would come out differently – LEADING TO USER CONFUSION. NIAS believes that NSF is critical for National GIS.

TABLE – 3.1: CONTENT DETAILS OF NNRMS, NUIS, NIC AND PROTOTYPE K-GIS STANDARDS

No	CATEGORIES	NNRMS STANDARD			NUIS			NIC	Prototype K-GIS
		http://www.nnrms.gov.in/greennnrms/download/NnrmsStandardsDoc.pdf			http://tcp.cg.gov.in/nuis/Design_Standards.pdf			https://gisserver1.nic.in/india/login.aspx	http://www.karun-adu.gov.in/ksac/documents/KGIS-STAKEHOLDER-BOOK.pdf
	(As Per National GIS Proposal)	Used for BHUVAN , SIS-DP, NRIS, NRDB			Used for 137 Cities of India under NUIS			Used for Nationwide GIS Portal	Used for Karnataka G2G Portal
		1:50000 (53 LAYERS)	1:10000 (14 LAYERS)	1:2000 (4 LAYERS)	1:10000 (16 LAYERS)	1:2000 (4 LAYERS)	1:1000(7) LAYERS)	23 layers	1:50,000 (90 Layers)
1	BOUNDARY CONTENT	Admin Boundaries - National, State, District, Taluk Village Village Boundaries (CRD) Village Boundaries (DMSP) Cadastral Information (CRD) Habitation (DMSP) Command Area Boundaries Watershed Boundaries Forest Boundaries Special Forest Boundaries	Forest Boundaries	Forest Boundaries	Admin Boundaries - Metro Region, DP Areas, (Municipal/ Corporation/ Cantt/Planning Zones) etc.	City Planning Zone, Municipal, Ward, Local Boundary		state_hq2011 (Point) District_hq2011 (Point) subdt_hq2011 (Point) state2011 (Polygon) district2011 (Polygon) Villages (Polygon) Census Villages (Point) Habitations (Point) National Capital (Point) State Capitals (Point) District Hqrs (Point) Sub District Hqrs (Point) Census Towns (Point) Panchayat Hqrs (Point)	Administrative Boundaries- State, District, Taluk, GP, Village Seamless Cadastre with Survey No. Habitation Hobble Boundary Parliament Boundary Assembly Boundary Wards Metro/City Region ULB - Corporation/ Municipal Command Areas boundary Forest Circle Forest Division Forest Range Watershed

No	CATEGORIES	NNRMS STANDARD			NUIS			NIC	Prototype K-GIS
		http://www.nnrms.gov.in/greennnrms/download/NnrmsStandardsDoc.pdf			http://tcp.cg.gov.in/nuis/Design_Standards.pdf			https://gisserver1.nic.in/india/login.aspx	http://www.karunadu.gov.in/ksac/documents/KGIS-STAKEHOLDER-BOOK.pdf
	(As Per National GIS Proposal)	Used for BHUVAN , SIS-DP, NRIS, NRDB			Used for 137 Cities of India under NUIS			Used for Nationwide GIS Portal	Used for Karnataka G2G Portal
		1:50000 (53 LAYERS)	1:10000 (14 LAYERS)	1:2000 (4 LAYERS)	1:10000 (16 LAYERS)	1:2000 (4 LAYERS)	1:1000(7) LAYERS)	23 layers	1:50,000 (90 Layers)
								Census Villages (Point) Habitations (Point) State Boundaries (Polygon) District Boundaries (Polygon) Sub-District Boundaries (Polygon) Block Boundaries (Polygon)	Boundary Watershed - Region Watershed - Basin Watershed - Catchment Watershed - Sub Catchment Watershed - Watershed - SubWaterShed Watershed - MiniWaterShed Watershed - Micro Watershed
2	CULTURAL FEATURES	Rail Network Roads Road Network (DMSP) Rail Network (DMSP)	Rail (NUIS) Road (NUIS) Transport Node (NUIS)	Urban Networks	Rail Road Transportation Nodes	Urban Network (Line Network)	Urban Network (Line Network)		Rail Network Road Network

No	CATEGORIES	NNRMS STANDARD			NUIS			NIC	Prototype K-GIS
		http://www.nnrms.gov.in/greennnrms/download/NnrmsStandardsDoc.pdf			http://tcp.cg.gov.in/nuis/Design_Standards.pdf			https://gisserver1.nic.in/india/login.aspx	http://www.karunadu.gov.in/ksac/documents/KGIS-STAKEHOLDER-BOOK.pdf
	(As Per National GIS Proposal)	Used for BHUVAN , SIS-DP, NRIS, NRDB			Used for 137 Cities of India under NUIS			Used for Nationwide GIS Portal	Used for Karnataka G2G Portal
		1:50000 (53 LAYERS)	1:10000 (14 LAYERS)	1:2000 (4 LAYERS)	1:10000 (16 LAYERS)	1:2000 (4 LAYERS)	1:1000(7) LAYERS)	23 layers	1:50,000 (90 Layers)
3	HYDROLOGY CONTENT	Drainage (DMSP) Canals	Drainage (NUIS) Canal (NUIS)		Drainage Canal				Drainage Network Surface Water Bodies Canal Network Water Bodies (Reservoir, River, Tank) Wells (Observation Wells)
4	URBAN AND SETTLEMENT CONTENT	Settlement		Urban Features	Details of MP / DP proposal maps etc. Vocational details of Slums, Heritage Buildings / Sites, Industries, Infrastructure maps etc. Details on new layouts/ plotted areas and land use regulation and controls etc.				Settlement points Slums Heritage Locations

No	CATEGORIES	NNRMS STANDARD			NUIS			NIC	Prototype K-GIS
		http://www.nnrms.gov.in/greennnrms/download/NnrmsStandardsDoc.pdf			http://tcp.cg.gov.in/nuis/Design_Standards.pdf			https://gisserver1.nic.in/india/login.aspx	http://www.karunadu.gov.in/ksac/documents/KGIS-STAKEHOLDER-BOOK.pdf
	(As Per National GIS Proposal)	Used for BHUVAN , SIS-DP, NRIS, NRDB			Used for 137 Cities of India under NUIS			Used for Nationwide GIS Portal	Used for Karnataka G2G Portal
		1:50000 (53 LAYERS)	1:10000 (14 LAYERS)	1:2000 (4 LAYERS)	1:10000 (16 LAYERS)	1:2000 (4 LAYERS)	1:1000(7) LAYERS)	23 layers	1:50,000 (90 Layers)
5	ENVIRONMENTAL CONTENT	Wetlands (NRC) Wetland-2000 (Wasteland Mapping Project) Vegetation (NRC) Coastal Wetland (Coastal Zone Mgmt. Project) Glacier (NRC/ Glacier Studies) Snow (NRC/ Glacier studies)							Wetlands Mining Leases Wetlands and Tanks Plantations Sites Forest Types Forest Status Forest Density Corridor Mapping Coastal Zone Management maps Environmental Hot-Spots Industries Map Industry Board Layout/Assets Biodiversity Maps – Richness, Characterization maps National Park/ Sanctuary Boundaries Wildlife habitat areas

No	CATEGORIES	NNRMS STANDARD			NUIS			NIC	Prototype K-GIS
		http://www.nnrms.gov.in/greennnrms/download/NnrmsStandardsDoc.pdf			http://tcp.cg.gov.in/nuis/Design_Standards.pdf			https://gisserver1.nic.in/india/login.aspx	http://www.karunadu.gov.in/ksac/documents/KGIS-STAKEHOLDER-BOOK.pdf
	(As Per National GIS Proposal)	Used for BHUVAN , SIS-DP, NRIS, NRDB			Used for 137 Cities of India under NUIS			Used for Nationwide GIS Portal	Used for Karnataka G2G Portal
		1:50000 (53 LAYERS)	1:10000 (14 LAYERS)	1:2000 (4 LAYERS)	1:10000 (16 LAYERS)	1:2000 (4 LAYERS)	1:1000(7) LAYERS)	23 layers	1:50,000 (90 Layers)
									Wildlife tagging monitoring Fire Line HL Boundary Water Quality measurement points Air Pollution Monitoring Points
6	GEOLOGICAL CONTENT	Geomorphology (NRC) Geomorphology (NRIS) Geomorphic units /landforms (RGNDWM) Lithology (NRIS) Lithologic units/ Rock types (RGNDWM) Structures (NRIS) Structures (RGNDWM) Minerals (NRIS)	Geomorphology (NUIS) Physiography (NUIS) Lithology (NUIS)		Geomorphology (outside city area) Physiography Lithology (outside city area) Geological structures (outside city area)				Mineral Locations Structure

No	CATEGORIES	NNRMS STANDARD			NUIS			NIC	Prototype K-GIS
		http://www.nnrms.gov.in/greennnrms/download/NnrmsStandardsDoc.pdf			http://tcp.cg.gov.in/nuis/Design_Standards.pdf			https://gisserver1.nic.in/india/login.aspx	http://www.karunadu.gov.in/ksac/documents/KGIS-STAKEHOLDER-BOOK.pdf
	(As Per National GIS Proposal)	Used for BHUVAN , SIS-DP, NRIS, NRDB			Used for 137 Cities of India under NUIS			Used for Nationwide GIS Portal	Used for Karnataka G2G Portal
		1:50000 (53 LAYERS)	1:10000 (14 LAYERS)	1:2000 (4 LAYERS)	1:10000 (16 LAYERS)	1:2000 (4 LAYERS)	1:1000(7) LAYERS)	23 layers	1:50,000 (90 Layers)
7	LANDCOVER/ LANDUSE CONTENT	Wasteland-2003 (Wasteland Mapping Project) Land use/ Landcover (NRC) Land use/ Landcover (NRIS) Land use/ Landcover (DMSP) Coastal Land use (Coastal Project) Coastal Wetland (CRZ Project) Surface Water Bodies (NRIS)	Urban Land Use / Land Cover (NUIS)	Urban Land Cover	Urban Land Use / Land Cover Surface Water Bodies	Urban Land Cover (Polygon) Urban Land Use (Point)	Urban Land Cover (Polygon) Urban Land Use (Point)		Wastelands Land use / Land Cover Urban Land Use
8	LAND OWNERSHIP INFORMATION								Urban Property Maps Land Ownership Categories Re-surveyed Cadastral boundaries Property Boundaries/Points KFDC Leased Lands

No	CATEGORIES	NNRMS STANDARD			NUIS			NIC	Prototype K-GIS
		http://www.nnrms.gov.in/greennnrms/download/NnrmsStandardsDoc.pdf			http://tcp.cg.gov.in/nuis/Design_Standards.pdf			https://gisserver1.nic.in/india/login.aspx	http://www.karunadu.gov.in/ksac/documents/KGIS-STAKEHOLDER-BOOK.pdf
	(As Per National GIS Proposal)	Used for BHUVAN , SIS-DP, NRIS, NRDB			Used for 137 Cities of India under NUIS			Used for Nationwide GIS Portal	Used for Karnataka G2G Portal
		1:50000 (53 LAYERS)	1:10000 (14 LAYERS)	1:2000 (4 LAYERS)	1:10000 (16 LAYERS)	1:2000 (4 LAYERS)	1:1000(7) LAYERS)	23 layers	1:50,000 (90 Layers)
9	TERRAIN INFORMATION	Slope (Derived from NRIS) DEM National	DEM Local					Terrain	Slope Contours
10	SOILS INFROMATION	Soils (NRC) Soils (NRIS) Land Degradation (NRC)			Soil (Outside City Area)				Soil Land Degradation
11	SATELLITE IMAGES	LISS-III (Old dates coverage) Images of Country						Satellite Imagery [AWiFS (56M) LISS (23.5), PAN (5.8M)]	Cartosat -1 Liss-4 or XS at <5m QuickBird/ Alternative High Resolution High Resolution Image (Back drop)

No	CATEGORIES	NNRMS STANDARD			NUIS			NIC	Prototype K-GIS
		http://www.nnrms.gov.in/greennnrms/download/NnrmsStandardsDoc.pdf			http://tcp.cg.gov.in/nuis/Design_Standards.pdf			https://gisserver1.nic.in/india/login.aspx	http://www.karunadu.gov.in/ksac/documents/KGIS-STAKEHOLDER-BOOK.pdf
	(As Per National GIS Proposal)	Used for BHUVAN , SIS-DP, NRIS, NRDB			Used for 137 Cities of India under NUIS			Used for Nationwide GIS Portal	Used for Karnataka G2G Portal
		1:50000 (53 LAYERS)	1:10000 (14 LAYERS)	1:2000 (4 LAYERS)	1:10000 (16 LAYERS)	1:2000 (4 LAYERS)	1:1000(7) LAYERS)	23 layers	1:50,000 (90 Layers)
12	AMENITIES						Water supply Networks Sewerage Networks Power Networks Tele communication Network		Industrial Amenities Urban amenities as Points of interest Health Assets Point locations Power distribution Solid waste disposal sites and potential sites Public Assets POI PWD Asset points Water supply Network data UGD maps
									Electrical utility data Markup Landmark
13	MET AND CLIMATE DATA	Meteorological Data (NRIS)							
14	OCEAN STATE DATA								Ocean/Sea/Bay

No	CATEGORIES	NNRMS STANDARD			NUIS			NIC	Prototype K-GIS
		http://www.nnrms.gov.in/greennnrms/download/NnrmsStandardsDoc.pdf			http://tcp.cg.gov.in/nuis/Design_Standards.pdf			https://gisserver1.nic.in/india/login.aspx	http://www.karunadu.gov.in/ksac/documents/KGIS-STAKEHOLDER-BOOK.pdf
	(As Per National GIS Proposal)	Used for BHUVAN , SIS-DP, NRIS, NRDB			Used for 137 Cities of India under NUIS			Used for Nationwide GIS Portal	Used for Karnataka G2G Portal
		1:50000 (53 LAYERS)	1:10000 (14 LAYERS)	1:2000 (4 LAYERS)	1:10000 (16 LAYERS)	1:2000 (4 LAYERS)	1:1000(7) LAYERS)	23 layers	1:50,000 (90 Layers)
15	PUBLIC-INTERFACE DATA								
16	DERIVED MAPS (NNRMS)	Post Flood (DMSP) Pre Flood (DMSP) Ground Water Prospects (Derived from NRIS) Land Capability (Derived from NRIS) Land Resource Development Plan (Derived from NRIS)							Flood/Drought/ Emergency locations Ground water prospects Land capability Soil Irrigability Oil Palm Suitability Hydro-Soil(Run-off potential)
		Water Resource Development Plan - area (Derived from NRIS) Water Resource Development Plan - location (Derived from NRIS)							
17	Large Scale Base Map	Large Scale Base Map – Polygon, Line & Point (LSM) Features of Land							

No	CATEGORIES	NNRMS STANDARD			NUIS			NIC	Prototype K-GIS
		http://www.nnrms.gov.in/greennnrms/download/NnrmsStandardsDoc.pdf			http://tcp.cg.gov.in/nuis/Design_Standards.pdf			https://gisserver1.nic.in/india/login.aspx	http://www.karunadu.gov.in/ksac/documents/KGIS-STAKEHOLDER-BOOK.pdf
	(As Per National GIS Proposal)	Used for BHUVAN , SIS-DP, NRIS, NRDB			Used for 137 Cities of India under NUIS			Used for Nationwide GIS Portal	Used for Karnataka G2G Portal
		1:50000 (53 LAYERS)	1:10000 (14 LAYERS)	1:2000 (4 LAYERS)	1:10000 (16 LAYERS)	1:2000 (4 LAYERS)	1:1000(7) LAYERS)	23 layers	1:50,000 (90 Layers)
	Total No. of Layers	53	14	4	16	4	7	23	90
	Standards Coverage Planned	NATIONAL	NATIONAL	Settlements	URBAN SETTLEMENTS			NATIONAL	STATE
	Currency	2005	2005	2005	2006			2011	2013

TABLE – 3.2: STANDARDS DETAILS OF NNRMS, NUIS AND PROTOTYPE K-GIS

No	PARAMETER	NNRMS			NUIS	Prototype K-GIS
	CATEGORIES	http://www.nnrms.gov.in/greennnrms/download/NnrmsStandardsDoc.pdf			http://tcp.cg.gov.in/nuis/Design_Standards.pdf	http://www.karunadu.gov.in/ksac/documents/KGIS-STAKEHOLDER-BOOK.pdf
		1:50000	1:10000	1:2000 (Aerial Data)	1:10000	1:10000
A]	**IMAGE STANDARDS**					
1	Generic/Standard Resolution	ƒ 25m XS or better	ƒ 5m XS or better	.02m	5m XS or better	2.5 M (pan) + 5.8m XS (fused)
2	IRS Image Resolutions recommended	23.5 m XS supported by 5.8 m Pan / XS	5.8 multi Spectral 2.5 m (P+Mx)	-	5.8 multi Spectral 2.5 m (P+Mx)	2.5 and 5.8 mts
3	NSF	State	State	State	State	State (as subset of NSF)
4	Projection for image outputs	LCC/TM	LCC/TM	LCC/TM	UTM	UTM
5	Datum for image products	WGS 84	WGS 84	WGS 85	WGS 84	WGS 84
6	Image Frames (geometrically corrected; important for seamlessness)	15’ X 15’	3’ 45” X 3’ 45”	45” X 45”	3’ X 3’	3’ X 3’
7	Image Position (Planimetric) Accuracy (0.5 mm of scale) in m	25	5	0.5(0.25mm of Scale)	5	5
8	Band-to-Band Registration for XS data (0.25 pixel) in m	~6	~1.5	~0.1	~1.5	~1.5
B]	**THEMATIC MAPPING STANDARDS**					
1	NSF	State	State	State	State	State
2	Minimum Map Frame size for incorporation to NRR	15’ X 15’	3’ 45” X 3’ 45”	1’x1’	3’ X 3’	3’ X 3’
3	Image Registration accuracy @ 0.5 pixel (RMS)	12m	1.25m	.02m (@ 0.25 pixel RMS)	1.25m	1.25m
4	Map Projection	LCC/TM	LCC/TM	LCC/TM	UTM	UTM
5	Datum	WGS 84	WGS 84	WGS 84	WGS 84	WGS 84
6	Position (Planimetric) Accuracy (1mm of scale) in m	50	10	0.50m (@ 0.25mm of Scale)	10	10

No	PARAMETER	NNRMS			NUIS	Prototype K-GIS
	CATEGORIES	http://www.nnrms.gov.in/greennnrms/download/NnrmsStandardsDoc.pdf			http://tcp.cg.gov.in/nuis/Design_Standards.pdf	http://www.karunadu.gov.in/ksac/documents/KGIS-STAKEHOLDER-BOOK.pdf
		1:50000	1:10000	1:2000 (Aerial Data)	1:10000	1:10000
7	Minimum Mappable Unit (MMU) (3 x 3 mm of scale) in sq mts	22500	900	4 (1mm X 1mm)	900	900
8	DEM Z-Spacing as 1mm of scale in m	50	10	2	10	10
9	DEM Z-Accuracy in m	10	5	1	5	10
10	Thematic Accuracy of Classification/Mapping	90/90	90/90	90/90	90/90	90/90
11	Map Formats	• Digital GIS Compliant • Paper	• Digital GIS Compliant • Paper	• Digital GIS Compliant • Paper	• Digital GIS Compliant • Paper	• Digital GIS Compliant • Paper
C]	**GIS DATABASE STANDARDS**					
1	Spatial framework	Seamless – National	Seamless – National	Seamless – National	Seamless – National	Seamless - Karnataka State
2	Tie-Point Intervals for Spatial Framework	5’ X 5’ & 3’ 45” X 3’ 45”	45” X 45”	15”x15”	36” X 36”	36” X 36”
3	Coordinate units for Precision	Decimal-Seconds	Decimal-Seconds	Decimal-Seconds	Decimal-Seconds	(In UTM it should be in Mts)
4	Projection	Geographic	Geographic	Geographic	Geographic	UTM
5	Datum	WGS 84	WGS 84	WGS 85	WGS 84	WGS 84
6	Precision	Single	Single	Double	Single	Single
7	Minimum Frame size for NRR	15’ X 15’	3’ 45” X 3’ 45”	45”x45”	3’ X 3’	3’ X 3’
8	GIS DB Tic Registration Accuracy (0.25mm of scale) (RMS) in m	12.5	2.5	0.5	2.5	2.5 m
9	Position (Planimetric) Accuracy (1mm of scale) in m	50	10	0.50m (@ 0.25mm of Scale)	10	10 m

No	PARAMETER	NNRMS			NUIS	Prototype K-GIS
	CATEGORIES	http://www.nnrms.gov.in/greennnrms/download/NnrmsStandardsDoc.pdf			http://tcp.cg.gov.in/nuis/Design_Standards.pdf	http://www.karunadu.gov.in/ksac/documents/KGIS-STAKEHOLDER-BOOK.pdf
		1:50000	1:10000	1:2000 (Aerial Data)	1:10000	1:10000
10	Coordinate Movement Tolerance (CMT) (0.125mm of scale) in m	6.25	1.25	0.25	1.25	1.25
11	Weed Tolerance (WT) (0.125mm of scale) in m	6.25	1.25	0.25	1.25	1.25
12	Sliver Polygon Tolerance (SPT) (LESS-THAN MMU) in m	<22500	<900	<4	<900	<900
13	Grid Size (for Image/Raster Layers) (0.5mm of scale) in meters	25	5	1	5	5
D]	**OUTPUT STANDARDS**					
1	Output Formats (Filter as defined by National map Policy)	• Digital GIS compliant • Digital web-compliant • Paper	• Digital GIS compliant • Digital web-compliant • Paper	• Digital GIS compliant • Digital web-compliant • Paper	• Digital GIS compliant • Digital web-compliant • Paper	• Digital GIS compliant • Digital web-compliant • Paper
2	Output Framework	• Admin Units – State, District, Taluk, Villages • Cadastre Reference • Natural Regions • User defined region polygon • Spatial Framework grids	• Admin Units – District, Taluk, Villages • Cadastre Reference • Natural Regions • User defined region polygon • Spatial Framework grids	• Admin Units – * Villages, wards, • Cadastre Reference • Natural Regions • User defined region polygon • Spatial Framework grids	• Admin Units –State, District, Taluk, Villages, Urban Local • Body Boundaries Cantonment • Local Planning Area, Master Plan • Boundaries Cadastre Reference • Forest Boundary • Natural Regions • User defined region • polygon Spatial Framework	• Admin Units –State, District, Taluk, Villages, Urban Local Body Boundaries, Cadastre Boundaries • Natural Regions • User defined region polygon Spatial Framework Grids

No	PARAMETER	NNRMS			NUIS	Prototype K-GIS
	CATEGORIES	http://www.nnrms.gov.in/greennnrms/download/NnrmsStandardsDoc.pdf			http://tcp.cg.gov.in/nuis/Design_Standards.pdf	http://www.karunadu.gov.in/ksac/documents/KGIS-STAKEHOLDER-BOOK.pdf
		1:50000	1:10000	1:2000 (Aerial Data)	1:10000	1:10000
3	Output Media	• On-line download • Off-line Download • CD-ROM/DVD	• On-line download • Off-line Download • CD-ROM/DVD	• On-line download • Off-line Download • CD-ROM/DVD	• On-line download • Off-line Download • CD-ROM/DVD	• On-line download
4	Output Projection	LCC / UTM / Polyconic / User defined	UTM/ Polyconic/ user defined	UTM/ Relative/ User Defined	UTM/ Polyconic/ user defined	UTM
5	Output Datum	WGS 84	WGS 84	WGS 85	WGS 84	WGS 84
6	Output Formats	GIS format, GeoTIF, Shape file, Jpeg, NSDE and others	GIS format, GeoTIF, Shape file, Jpeg, NSDE and others	GIS format, GeoTIF, Shape file, Jpeg, NSDE and others	GIS format, GeoTIF, Shape file, Jpeg, NSDE and others	Shapefile, Jpeg, PNG
7	Output Symbology	As per Layer Legend	As per Layer Legend	As per Layer Legend	As per Layer Legend	As per layer legend
E]	**THEMATIC ACCURACY STANDARDS**					
1	National Framework Quality/Accuracy – Tolerable limits for area of standard admin units	<0.1% of state or district or taluk or tile areas	<0.1% of taluk or tile areas	-	<0.1% of taluk or village or tile areas	<0.1% of taluk / village / tile areas
2	Framework Verification • CMT and Weed Tolerance Bound Box	• <6.25 • As per1:50 NSF	• <1.25 • As per 1:50 NSF	<0.25	• < 1.25 • As per 1:50 NSF	< 1.25 As per 1:10 K NSF
3	Planimetric (Position) Accuracy Better than (or equal to) 1.5 mm of scale in m	75 Output to be sampled and certified for position accuracy quality	15 Output to be sampled and certified for position accuracy quality	3 Output to be sampled and certified for position accuracy quality	15 m Output to be sampled and certified for position accuracy quality	15 m Output to be sampled and certified for position accuracy quality
4	Thematic Accuracy of classification / Mapping (To be reported from Metadata)	90/90 To be reported from Metadata	90/90 To be reported from Metadata	90/90 To be reported from Metadata	90/90	90/90

No	PARAMETER	NNRMS			NUIS	Prototype K-GIS
	CATEGORIES	http://www.nnrms.gov.in/greennnrms/download/NnrmsStandardsDoc.pdf			http://tcp.cg.gov.in/nuis/Design_Standards.pdf	http://www.karunadu.gov.in/ksac/documents/KGIS-STAKEHOLDER-BOOK.pdf
		1:50000	1:10000	1:2000 (Aerial Data)	1:10000	1:10000
5	Minimum Map Unit (MMU)-Not less than or equal to (3 x 3 mm of scale) in sq meters.	22500	900	4 (1mm X 1mm)	900	900
6	Scale Distortion Factor for Analog Outputs only-Not more than (or equal to)	3%	3%	3%	3%	3%

4. Assessment of GIS Portals

110. As per the National GIS vision document, National GIS Portal is envisaged as a national gateway for accessing all GIS services – GIS data, GIS applications and GIS Metadata. The National GIS Portal will give users access to the wealth of GIS image/map data assets and GIS Applications.

111. A GIS Portal allows sharing of GIS-ready maps, perform and share applications, access GIS data etc – all of this on a website without use of any addition resources. A GIS Portal brings together all the GIS data on a web or mobile platform and allows operations to:

111.1. Create, save, and share GIS-Ready maps

111.2. Create and host GIS Apps

111.3. Search for GIS content

111.4. Create groups for sharing GIS information and Share links to GIS applications

111.5. Share map and layer packages for use

112. A GIS Portal must bring to the hands of GIS experts and users (who might not otherwise have any experience with GIS). For example, A GIS Portal includes simple viewers and query tools designed for those who are just beginning with GIS. Experienced GIS users can access models and integrated analysis tools and GIS applications.

113. Towards defining National GIS Portal characteristics, NIAS team analysed and studied various GIS portals so as to determine the "specifications bar" that needs to be defined for National GIS Portal. In our view, National GIS Portal must be of high quality, efficiency and reliability for users – showcasing best national efforts and surpass any of the best efforts in GIS Portals. Our assessment of GIS Portals should help in the design and development of National GIS Portal.

114. NIAS team has studied the following GIS Portals[25]:

114.1. USGS National Map Portal (http://viewer.nationalmap.gov/viewer/) as of July, 2014 and again in April, 2015.

114.2. Google Earth Portal (https://www.google.com/earth/download/ge/) as of July, 2014 and again in April, 2015.

114.3. Bhuvan Portal (http://bhuvan.nrsc.gov.in/bhuvan_links.php) as of July, 2014 and again in April, 2015.

114.4. NSDI Portal (http://www.nsdiindia.gov.in/nsdi/nsdiportal/index.jsp) as of July, 2014 and again in April, 2015.

114.5. MapmyIndia Portal (http://maps.MapmyIndia.com/) as of July, 2014 and again in April, 2015.

[25] R Shilpa, Vilas Chavan, Diksha Bandil-Report on Design and Functional Evaluation of GIS Portals (USGS-National Map, Google Earth, Bhuvan, (India) NSDI, MapmyIndia, Prototype K-Gis, Surveykshan and NICMAPS)-NIAS Report R 31-2015 of May, 2015

114.6. Karnataka G2G Portal – limited time access on (http://164.100.133.66/g2g/#/Views/LoginPage.xaml) as of July, 2014 and again in April, 2015.

114.7. Surveykshan Portal of Survey of India – (http://www.surveykshan.gov.in/) as of November, 2014 and again in April, 2015.

114.8. NICMAPS Portal of NIC (http://nicpmaps.rsgis.nic.in) as of November, 2014 (in April, 2015, NICMAPS was not available as it showed "under maintenance").

115. The portal evaluation was undertaken in period – July 2014 to April 2015 – thus, the evaluation has a time-stamp. It is recognised that changes in the portal could have occurred subsequently. This evaluation are technical analysis from the research team – thus, there could be variation in interpretation and judgment.

116. In the ensuing sections, we provide an assessment of this evaluation.

4.1. USGS National Map[26]

117. The NATIONAL MAP 2.0 Portal of United States Geological Survey (USGS) provides a "window" to US spatial data along with satellite images and has robust capabilities of GIS services – viewing and querying.

118. USGS has well-organised seamless data for the whole US – wide variety of standardized GIS content complying to FGDC Standards. The following content is available in USGS National Map Portal:

118.1. **Base Data Layers** - US Topography (3 layers), Geographic Names (10 Layers), Structures (10 Layers), Transportation (14 Layers), Government Unit Boundaries (18 layers), Map Indices (10 Layers), Hydrography (NHD) (13 Layers), National Land Cover Database (NLCD) (27 Layers), Elevation Availability (4 Layers), Elevation Contours – Small Scale (1 Layer), Imagery – 1 meter (1 Image layer), Imagery – 1foot (1 Image layer), Reference Polygon (Layers 12)

118.2. **Natural Hazard** - USGS US Hazard (15 Layers), USGS Stream Flow & Weather Station (5 Layers), FEMA National Flood Hazards (32 Layers), NEXRAD Weather (1 Layer), NGA US National Grid (102 Layers)

118.3. **Other Feature Data**- Scanned Topo Maps from USA Topo (1 Image), USGS Ecosystem (5 Layers), USGS Protected Area Owner (PADUS) (1 Layer), USGS Protected Area Conservation Status (PADUS) (1 Layer), USGS GAP Land Cover (3 Layers), FWS Wetlands, BLM Public Land Survey System (PLSS) (14 Layers), National Park Services (NPS) Boundaries (4 Layers)

119. USGS National Map doesn't offer GIS applications services – especially as it is more a map viewer. However, the Map Viewer is very robust and has extremely reliable and good functionalities:

[26] Ibid 25

119.1. The most important aspect of the Portal is the rich data content for the whole of US – that too at sufficient detail and information granularity. Satellite images and map layers are included in the Portal – which appear to be regularly updated.

119.2. The USGS Portal offers authoritative GIS data – as it is standardized and generated in a systematic manner for the Portal. The USGS spatial framework has been the foundation for the Portal data.

119.3. USGS Portal allows users to add their data directly on the Portal or through links from other GIS Services or Google Maps. However, we note that users cannot save their data on the Portal or share with other user - user added data lasts till current session. This is a shortfall in the capability as even user-storage is not possible.

119.4. USGS Portal has highly functional and efficient viewer capabilities that enables variety of viewing functionality.

119.5. Portal facilitates building queries – both, spatial as well as attribute queries are possible. The querying capability adds lot of value to user needs as on-line functional and simple queries can easily be addressed.

119.6. USGS Portal allows user to download actual GIS-Ready data - this is one of the notable features. Downloading GIS data is very easy and user friendly process.

119.7. Portal allows composing good quality outputs and print utilities of GIS maps.

119.8. As the Portal does not offer any integrative GIS Applications – the decision support capability of the Portal is limited.

120. USGS has put tremendous efforts on designing and architecturing the Portal and this is clearly seen in the high-level performance of the portal. Some key design issues are:

120.1. USGS National Map does not have user log in - it is open portal to everyone.

120.2. Consistent data dictionary and Metadata is available – which makes searching and understanding the data very easy.

120.3. Portal is very well designed in order to access GIS data of USA – well enmeshed with images and maps and GIS Query operation. The Portal is robust and does not crash.

120.4. The content categorisation is well organised for easy-access mode. The access design is very consistence - even fast panning doesn't affect portal visualization.

120.5. Help menu is very comprehensive. Help menu explains everything available on the portal and also other relevant information.

121. **In our assessment, the major plus points of USGS National Map Portal are in its seamless, standardized GIS Content, robust map viewer and simplicity of querying operations – all of which make the Portal very efficient, performing and easy in operation.**

4.2. GOOGLE EARTH[27]

122. Google Earth is the most widely used image Portal to view earth's surface (and also other planet's data). Maps in Google Earth are created by superimposition of images obtained from satellite imagery and aerial photography. User can explore layers created by other Google Earth users or create their own layers to display data and other information.

123. Google Earth has following data for India:

123.1. 30m/10m multispectral Landsat/CNES which is pan sharpened with 15m panchromatic Landsat imagery data as a base image of latest 2015.

123.2. 2015 high resolution (0.6m) data for major cities of India. Satellite imagery for Indian area are from Digital Globe and Spot Images

123.3. Administrative boundaries are limited upto State boundaries only.

123.4. Road Layers include NH, SH, Country roads and Streets. Names of highways, streets appear along with the roads.

123.5. Places of Interest layer are about 40-50 different categories.

123.6. 3D building sketches are available for some geographic areas, which gives user photorealistic feel of the building.

123.7. Geo-Tagged data from different websites related to ocean, Weather, Environmental study, others can be linked.

123.8. Other planet data services make Google Earth more unique in its kind.

124. Google Earth does not offer integrative GIS Applications services – thus its ability for decision-support is limited – though, world-over, users have developed their own customized applications based on data from Google Earth. However, its reliable and robust Image/Map data services across India (and globe) make it the most widely used for variety of users – in government, industries, academia and even citizens.

125. Below are some important observations from Google Earth:

125.1. High-performance Map/Image viewer services like search, measure, overlay, save and navigation tools for visualization purpose.

125.2. User friendly services like get directions - for driving, transit, walking; Add place marks are popular tools. User can also personalize the view by setting home location.

125.3. Collaboration/Embedding services are provided through Email and Google Earth API.

125.4. Image services provided in Google Earth pro version serves as a base for GIS data creation – thus, many customers use Google Earth for content generation.

125.5. Number of feed-services can be overlaid/displayed on Google Earth - Weather Services

[27] Ibid 25

from weather.com, cloud pattern display services from geostationary Earth- orbiting and low Earth-orbiting satellites or radar images – though these are not available for India.

125.6. User-Ingest in Google Earth is through tools to add point, poly, line and also overlay images. KML & KMZ files can also be added. In Pro version importing option for importing address, imagery, vector data, generic text files, geographic coordinates in various available formats is possible.

125.7. Save, Print and Measurement tools are available and very efficient.

126. Performance wise Google Earth is unbeatable. Caching with geo-clustering concept makes data fetch very fast and layer rendering is quite fast. There is an option for the user to change the RAM and hard disk cache storing capacity which can better influence on performance. Robustness is of extremely high level – there are hardly any software errors or any malfunctioning of the tools. The data on Google Earth is well seamed and referenced to a uniform framework – further the image is of very high resolution across the world. Google Earth is also available as free mobile application in IOs and Android. Google earth is built on C++ software. Google Earth provides Plug-in and JavaScript API which let user to embed Google Earth into web pages very easily.

127. **In our assessment, the major plus points of Google Earth is its seamless, well-referenced high resolution images with basic GIS layers linked to the images. The Portal is extremely efficient and high-performing – with robust and reliable viewing services. The design and development templates are of high quality with good testing and roll-out processes. The portal development processes and practices of Google earth are worth emulating for any high-quality GIS portal.**

4.3. BHUVAN PORTAL[28]

128. Bhuvan is the "portal" of National Remote Sensing Centre (NRSC) and the first successful initiative for displaying IRS images and thematic maps – providing a "window" into the spatial data holdings of NRSC and NNRMS projects.

129. The map and image data in Bhuvan is a "collection of available project-specific image/map data" (the data are all from different NNRMS projects of different time-periods). The image/map data are not updated – thus making serious use of the image/data very limited. Further, the data has been generated at different time-periods and with different standards – thus compliance to a uniform national standard is lacking – making the super-position and integrated analysis in Bhuvan difficult. Image data is Bhuvan is limited to mainly 2.5m BW and coarser resolution of 23m and 55m images – these images are not upto date (presently Bhuvan has 2012 and earlier vintage images).

130. In our analysis, we have found that Bhuvan has the following datasets:

130.1. Cartosat-1 2.5m images of 2010-2011 for most states

[28] Ibid 25

130.2. Cartosat-1 DEM for whole country of 2006-2014 time-frame (DEM are of ~10-30m elevation accuracy)

130.3. Resourcesat-1 23 and 55m m images for whole country of latest 2011

130.4. Oceansat images of 360m resolution of 2013

130.5. Broad and average cyclone, wind, NDVI etc data

130.6. Landuse on 1:250k and 1:50k scale of 2011-12

130.7. Wasteland maps on 1:50k of 2006 time-frame

130.8. Geomorphology, Lineament, Flood hazard, salt affected land, water-bodies etc on 1:50 k scale of 2006 time-frame and for whole country

130.9. City-GIS on 1:10k for 153 cities

130.10. Cartosat-2 1m images for 225 cities

130.11. 1:10k landuse and base maps of 2010 vintage for about 50-60% of the country

130.12. Points of Interest data (very sparse and disparate and un-systematic)

131. The following are specific characters of Bhuvan data that we observe:

131.1. Bhuvan data are all outputs of different user-funded RS projects that pertain to specific project goals and do not conform to a nation-wide seamless data content. As the data is from various RS projects using varied resolutions of images (from 23m to 2.5m) and of different dates (from 2002 to 2011), the Bhuvan dataset is more like a "data-bank" or a REPOSITORY of NNRMS projects. Because map data have been collated from different time-period and different image resolutions, there are clear in-consistency and data-match problems for integrated analysis.

131.2. Almost 60-70% of Bhuvan data is at coarse-level (1:250000 or 1:50000 maps) and just about 10-20% data is on larger scales (of 1:10k and better).

131.3. The collection of "data bank" does not use modern data dictionary or TOC rules – thus they appear as just varied data which are un-grouped and un-categorised.

131.4. Many of the geographical coverage of Bhuvan data is not for whole country – and they cover few districts or few states. Very few GIS data (administrative boundaries, images and landuse, wasteland etc) is available for whole country.

131.5. 6 layers of 1:10000 maps are available for 15-18 states in a limited manner and these are 2010 vintage.

131.6. City (NUIS) data is of 2010-2012 vintage on 1:10000 scale is seen and available only for about 150 limited cities.

131.7. There are no ministry/department/user tabular data (say, MNREGA data; JNNURM data; Tourism statistics; National Statistics etc) geo-tagged and thus developmental data is not available – thus, ministry decision support is hardly possible to serve specific application needs.

131.8. Limited Census data (only demographic and work-force) for 2001 and 2011 is linked to

villages layer only for 28 states – but uniform query on Census parameters and across census tables is not available.

131.9. Real-time crowd-sourcing data is "appears" possible BUT there is very very limited crowd-sourced data available and most of its is not verified – thus, reliability of crowd-sourced data is low and cannot be used for citizen services.

131.10. While many and many data-schemas have been "created" the data content is blank and absent – thus, there is no use of many of the "layers" that are claimed to be present as there is no actual data in these.

131.11. Most data that are seen on the Portal are not accessible/downloadable in GIS-Ready format – access is only in "snapshot format" (mainly tiff format; though we feel that GIS-Ready data of these holdings must be available back-office).

132. Bhuvan Portal claims many "services" and "applications" – but in our view, these modules are mere visualization tools and do not have any integrative/applications capability and do not support decision-making. Even querying capability – which are fundamental to any GIS Portals, are limited in Bhuvan and spatial/attribute based querying is hardly present as a functionality in Bhuvan modules (as they are just visualization-n-displays).

133. We have evaluated the Bhuvan modules and note that they have following use-characteristics:

133.1. GIS Applications Capability is very limited. Most of the Applications listed only have common capability of data display and visualisation. Querying – simple (spatial or attribute) or complex (combinative parameter query) is not possible – thus users cannot query across datasets using criterion and get their decision-support information from Bhuvan. Because data is varied and un-standardised (say, Roads from landuse do not match with roads on images or roads on wasteland OR similarly, with water bodies, cities etc in different project-layers), there are clearly visible registration and match problems – posing difficulties for GIS analysis if used as-is.

133.2. Portal has good and basic tools for visualisation – display maps, distance query, measure, overlay data, WMS etc

133.3. Bhuvan shows locations of "some" Automatic Weather Stations with sketchy weather-data tags; PFZ data are 2014 vintage; flood data of upto 2010 and some displays of forest fires and drought.

133.4. Agriculture – displays newspaper reports of pests in village-basis for few states and displays specific plantation areas

133.5. E-Governance – though de-centralised planning is "claimed" but there is no E-Governance decision-support possible that can be accessed for local governance or citizens OR panchayat level decision information. For example, new panchayat asset location analysis cannot be done OR financial investments in a panchayat cannot be obtained.

133.6. Events – mentions and displays just images/maps of 2013 Kumbh Mela and some sporadic sports event – like Champions League 2011 etc

133.7. Forestry – displays 2012 and old forest data from reports and images for just 2 states

133.8. Irrigation – displays irrigation projects status for specific irrigation project

133.9. Tourism – displays basic images and some 2010 tourism data for 5 cities

133.10. Urban – displays image and Urban Growth displays for 22 cities. It is not clear if GIS applications like master plan integrator OR Plan deviation analysis etc is possible for urban areas.

133.11. Disaster – just displays specific images or patchy-maps (For ex J&K Floods of April, 2015). However, real-time data in GIS-ready usage for Decision Support is very limited.

133.12. Rural- Maps of ground water prospects for 22 states are displayed JUST AS rocktypes, landforms and structures without any co-relation or legend for prospects of ground water. Thus, the module hardly serves any decision support for ground water at local area or even at district/state.

133.13. School - Contains very small scale "atlas-like" aggregated un-queryable maps of weather, rainfall, population density etc. which cannot serve any geography or scientific knowledge for students at any level.

134. Performance of Bhuvan is very in-consistent across various screens – what happens in one function is different in another function; Bhuvan is also considerably slow and performance needs to be substantially improved. We also feel that a systematic design over-haul of Bhuvan will help – especially in terms of good configuration design (input-output control, functionality control, loop-in, click minimization), configuration and optimization techniques that can be adopted.

135. Exhaustive testing needs to be done totally exhaustively and robustness has to improve considerably – there are repeated breaks, disruptions, no data, bugs, functional disparities, erroneous results etc. Help is also poor - professional Help tools can be used.

136. **In our assessment, the positive of Bhuvan is that it provides a "one-period" seamless visualization of IRS images for India. From a GIS point of view, Bhuvan is merely a "data bank" or REPOSITORY of NNRMS projects datasets that have been generated at different times, using different RS images and based on different map/GIS standards. Bhuvan services are just a visualization and display tool for the IRS images and data-bank/repository data and does not offer integrative/ analytical GIS Applications as Decision Support for users – governance, academia, industries or citizens. Bhuvan design needs to considerably improve and reliability/robustness has to enhance with good testing and use of standards.**

4.4. INDIA NSDI PORTAL[29]

137. NSDI Portal is India's only geoportal supposed to facilitate search on Metadata of various agencies. It is supposed to be a single window display of several organizations' metadata along with few GIS layers. It is one of the earliest portals developed which displays spatial information for citizens through maps in India.

[29] Ibid 25

138. NSDI Metadata is mentioned to be available with the collaborations and partnership with SOI, DST, GSI, FSI, NBSSSLUP, MoD, MHA, MoES, Census of India etc. However, most of these agencies have not populated their full Metadata – thus Meatadat holdings are extremely limited.

139. NSDI Geoportal has following dataset.

139.1. Administrative Boundaries upto taluk level on 1:250000 scale.

139.2. Hydrology features

139.3. Transport layer - Road and Rail.

139.4. Thematic layer like Landuse data

139.5. Metadata from different agencies are available. They are supposed to be as per NSDI Metadata Standard.

139.5.1. However, most Metadata fields are blank and return null data. It appears that Metadata is not populated.

139.6. IRS images from Bhuvan Portal can be linked.

139.7. Most of the listed layers are available few areas - seamless data for whole nation is not available. Data are of around 15-20 years vintage.

139.8. Maps which are available are in non queryable format; as a result one cannot query any layers.

140. There is no GIS APPLICATIONS and decision support capability in NSDI Geoportal.

141. Below are some important observations of NSDI Geoportal:

141.1. Basic visualization tools like pan, zoom, Lat long display, scale display are available

141.2. Save (gml) and upload content operations can be done on OGC complaint files. But this does not work and could not be tested.

141.3. Map query can be performed only on MapIndex (Grids) – but other spatial layers don't have this facility.

141.4. Metadata services are available through spatial query and non-spatial query. User can only view these results but there is no facility to save the data.

141.5. NSDI provides WMS services from Bhuvan.

141.6. There is no Print capability available – so one cannot take outputs of Metadata.

142. Performance-wise NSDI Portal is very slow and robustness is poor – hangs repeatedly, Many functions do not work properly. Layer rendering is extremely slow – improved caching and tiling techniques with fast servers will improve performance.

143. **In our assessment, the major plus points of NSDI Portal is its conformity to NSDI Metadata. However, the major gap is that there is no Metadata populated – thus, intent is seen but there is no real data. It is not meant for any GIS Application**

Decision Support. Performance, maintenance, updation and testing needs to substantially improve,

4.5. MAPMYINDIA PORTAL[30]

144. MapmyIndia Portal is a Indian private map Portal - through which "visual window" of nation-wide map data holdings and specialised services are provided. Portal mainly concentrates on providing map information for whole country.

145. MaymyIndia has nation-wide good-quality content – first time from a private agency in India. The Portal has following dataset – which seem to be composed into a single map-view (Note: looks they are not individually queryable):

145.1. Comprehensive Boundary data – national boundary; State Boundary; District Boundaries are available (640 in number Reported by portal); Sub-district Boundaries are available (5924 in number Reported by portal); Town Boundaries defining municipal limits (7933 is available Reported by portal); Ward Boundary for towns; Villages boundaries and village points are available.

145.2. House numbers for over 50 large cities are available

145.3. Road network data covering (reportedly over 2 million road kilometers) connecting every village and town

145.4. Railway network (reportedly ~70,000 kms) is available

145.5. Real-time Traffic layer only for Bangalore, Delhi, Pune, Hyderabad, Chennai and Mumbai is available.

145.6. Comprehensive POI data - Restaurants, Hotels, Recreation Places, Travel & tourism, Commercial and Shopping places, Community Services, Religious places, Medical Facilities, Transportation services, Residential Apartments etc. point of interest is available.

146. MapmyIndia does not have specific GIS Applications BUT offers reliable location based and navigation services. It is meant to provide specific services segment and caters to that segment efficiently.

147. Summary of observations of the data and services capability of MapmyIndia portal are given below:

147.1. Very good display capability. Maps pans fast and smooth.

147.2. Feature-wise "Search" option is good – but search by co-ordinates is not possible. Multiple features or nested search is limited.

147.3. Direction routing is very well organised, 5 destination points can be added at a time.

147.4. Portal has capability to "Add Address/Location", this service allows user to add their

[30] Ibid 25

location on portal. Portal assigns a unique code to the location and that location can be searched by other users with same location name. It is not sure whether portal verifies user added location.

147.5. Portal provides geographical location widget service which can convert into code and can be used and embedded in user applications.

147.6. Portal provides print menu with limited capability - description, no scale bar, map scale and so on.

4.6. PROTOTYPE K-GIS PORTAL[31]

148. GIS Portal of Karnataka has been developed by Karnataka State Remote Sensing Application Centre (KSRSAC) as a proto-type of Karnataka-GIS through which it provides "displays and basic queries" on KSRSACs GIS data holdings.

149. Prototype K-GIS Portal has Karnataka State-wide GIS-Ready data on 1:50,000 scale – about 51 content layers. The data content is as follows:

149.1. Administrative content - State, District, Taluk, Grampanchayat, Village, Assembly, Parliament, Cadastral, City and Ward boundaries; Microwatershed, MiniWatershed, SubWatershed, Watershed, Subcatchment, Catchement, Basin, Region, Forest Status, Forest Range, Forest Division, Forest Circle

149.2. Natural Resources Layer - Landuse 2006, Soil, Waterbodies, Ground Water Prospectus, Land Degradation, Wasteland 2009, Slope, Soil Irrigability, Runoff Potential, Land Capability, Lithology, Geomorphology, ForestDensity, ForestType, Tanks, Settlements Area, Structures, Canal Network, Drainage, Water Quality

149.3. Cultural content – Road, Raillines, Settlment Location

149.4. Utility data - Power Stations, Power Networks, Wells, Mineral locations, Mines

149.5. Satellite Images – 2.5m Cartosat base (2010) and 0.6 meter DigitalGlobe for 11 districts (2008-2013) and 5.8m XS to 23.5 m images (2009).

149.6. 2011 Demographic & occupation data has been integrated with village layer using standard Census coding scheme.

149.7. Users can add their data on the portal (with efficient drawing tools) and these are saved in Portal for future use and can also be seen by other users.

150. In our assessment, prototype K-GIS Portal data is also a collection of image/map data from different projects of KSRSAC BUT the data has all been seamed in on a standard schema and a state spatial reference. Thus, the seamless nature of data and standards compliant for the whole state make it easily usable by different users.

151. Prototype K-GIS portal does not contain any specific GIS Applications online.

[31] Ibid 25

152. The Portal is mainly visualization and query. Query functionalities are quite robust – allowing vertically-seamless spatial queries and multiple attribute queries. This querying capability makes the prototype K-GIS Portal meet basic governance needs of being able to search/select and seek customized data for sectoral departments. The user-interface is fairly simple and WYSIWYG – thus users can easily navigate different screens.

153. Below are important observation of prototype K-GIS GIS Portal capabilities:

153.1. Good tools that can help to display and query – display maps, distance query, measure query overlay data etc.

153.2. GIS Query can be Spatial or Attribute basis on seamless GIS data

153.3. Spatial analysis tools - buffer tool, clip and extract tool etc are available.

153.4. Tool for users to add points data is available – this can be saved and displayed by other users.

153.5. As data is from different projects there are still in-consistency in content coming from different time-period projects.

154. Prototype K-GIS Portal has fair-level performance and is well tested. Response time is fairly slow but breakages, crash do happen. The performance of portal is average level. At times certain query takes long time to perform. Portal has good dashboard design and functional consistency.

155. **In our assessment, the major plus points of prototype K-GIS Portal is that the data is seamless for state and standardized; it has good visualization and querying capabilities; user-interface is quite easy and navigable and performance is quite good. However, prototype K-GIS portal does not have integrative/analytical GIS Applications Decision Support capabilities – thus, departments usage is limited to good level of visualization and spatial/attribute queries; further, the G2G datasets need to be updated.**

4.7. SURVEYKSHAN PORTAL OF SOI[32]

156. Surveykshan is a geoportal of Survey of India (SOI) which displays SOIs Open Sereies Maps (OSM) maps in WMS format – this is presently available for 22 states of India.

157. Some of the major observations on SOI Portal are as follows:

157.1. Administrative Boundaries - India boundary, State boundary, District & Taluk are unique in SOI Portal – making it more authoritative for these features. Similarly, other topographic features like Contours, Road, Rail, Habitation, Utilities, and Hydrography are present in WMS format. Grid data, India UTM Grid with Grid number of 50k are also available.

157.2. Most of the content is a rendering of SOI topographic maps. There is no non-spatial data available in this portal.

[32] Ibid 25

157.3. Image services are also not available.

157.4. All content is in non-queryable/image format - so GIS-query on any of the layers is not possible.

157.5. Basic visualization tools like pan zoom in, zoom out, previous extent, next extent, fit to extent window are present.

157.6. There is NO GIS APPLICATIONS capability in Surveykshan Geoportal. Thus, decision-making apps are not available.

157.7. Layer rendering is slow - caching and tiling techniques can be used to improve the performance; performance improvements are intently possible.

158. **In our assessment, the major plus points of Surveykshan is that the administrative frame of India is authoritative. However, WMS datasets makes the use of this data very limited. It is a very elementary level Portal for an organisation like SOI.**

4.8. NICMAPS PORTAL OF NIC[33]

159. NICMAPS (http://nicpmaps.rsgis.nic.in) is a "portal" of National Information Centre (NIC) through which it provides "visual display" of GIS data of NIC – which is based on spatial data from Survey of India (SOI) and other agencies and non-spatial data holdings of NIC. NICMAPS provides a "window" to full-coverage Indian spatial data along with satellite images.

160. NICMAPS has not been available in April, 2015 (under maintenance) and thus this evaluation is as of November, 2014 when NIAS team did the first evaluation of NICMAPS.

161. NICMAPS assessment and observations are as follows:

161.1. Content of NICMAPS is mainly sourced from SOI maps – including, Administrative Maps (State, District, Taluk, Villages); habitation points; Base Maps (Scale Range 1:10000).

161.2. IRS satellite imagery of AWiFS (56M), LISS (23.5), PAN (5.8M)] are included.

161.3. NICMAPS has linked host of tabular data – census data and many other NIC data on project basis. Thus maps of many of these non-spatial features can be created.

161.4. NICMAPS links up through map services of ESRI, Bhuvan and Bingmaps etc

161.5. The Portal conforms to OGC standards.

161.6. NICMAPS does not provide any live updates, warnings & crowd sourcing information available on the portal.

161.7. Downloading data is not possible - the spatial layers cannot be downloaded but the attribute (tabular format) data can be downloaded.

161.8. NICMAPS does not offer any GIS Application Decision Support on the portal but has unique data services like Locators, Swipe & Spotlight, Elevation profile and so on.

[33] Ibid 25

Locator is certainly one of innovative service NICMAPS has introduced which works as a GIS search engine and can find location not only by names but also by pin-code of location. It has also integrated ESRI's locator search which helps to find out single line address. Swipe & Spotlight is another good service portal has included which separates spatial layers from basemap temporarily with user area of interest. Elevation profile gives elevation information about desired location. It's a quick tool which is very user friendly and gives results of Height/Depth (Meter) Vs Distance (Kilometre).

161.9. NICMAPS does not allow making bookmarks but it does have ready to use bookmarks which can directly zooms to location when it's been clicked.

161.10. NICMAPS is poor in legending – which doesn't appear with layers in TOC but portal still offers separate list of layers with relevant legends.

161.11. Simple map composing and printing utility is available in NICMAPS.

161.12. User needs to create an account to access NICMAPS Portal. The look of portal is good and easy to understand for user.

161.13. The portal is quite stable and data available on it is quite robust. The panning of map is very smooth - does not jerk hard. The colour used for designing is eye pleasing. Basemap can be changed easily.

161.14. The text available on portal is very simple but still quite differentiable with respect to admin hierarchy. The labels aren't part of layers, they are maintain separately as point data or at time appears as annotations.

162. The performance of NICMAPS is definitely appreciable - the design, data, services, architecture of portal are quite stable.

163. **In our assessment, the major plus points of NICMAPS is the portal design and robustness – making it quite different from other portals that we have evaluated. Data content is limited but a good spatial reference frame seems to have been generated by seaming the SOI OSM maps (this is a duplication of what Surveykshan has also done). The querying capability is good in NIC MAPS. It seems to show more professionalism from an IT-perspective.**

4.9. LEARNINGS FROM ANALYSIS OF GIS PORTALS

164. A comparative assessment of the different GIS Portals are given in **TABLE – 4.1A** – for USGS National Map and Google Earth AND in **TABLE – 4.1B** – for Indian Portals of Bhuvan, NSDI, Surveykshan, NICMAPS, MapmyIndia, G2G Portals (we could not accommodate all Portals comparision in one landscape orientation).

165. From the assessment of GIS Portals, the following learnings are documented:

165.1. **Content** is what "makes or breaks" a GIS Portal and thus National GIS Portal must have high-quality, verified and scrutinized and upto-date GIS Content. Declaring what content will be a part of the Portal is extremely important – and the mantra must

be to be "keep Content that is GIS-ready, uniform, good quality, current, seamless and standardized". The USGS National Map Portal has extremely good and uniform GIS-Ready content that is standardized and available for across the whole of US. MapmyIndia has limited number of layers that are uniform and uptodate and available for whole of India (by and large). GoogleEarth, of course, has limited layers, constantly updated but is not really GIS-Ready and is seamlessly available for whole of India. Bhuvan has a large "collection" of map and image content but is "patchy" and not seamless, is not standardised, is not current and gives a sense of a "data-bank" – a collection of whatever data that is available. K-GIS has state-wide GIS-Ready content that is standardized but is not current and updated. NSDI Portal is limited to Metadata content – even though it specifies Metadata much of the Metadata content itself is un-populated. NICMAPS has fairly good content and is seamless with a good spatial frame base don SOI OSM. Surveykshan Portal has limited content that is more authoritative and not in GIS-Ready format.

In our assesment, National GIS cannot be a "collection of whatever map/ image data is available" – a systematic GIS Asset needs to be designed with layer/image definitions, feature definitions, schema definitions AND created for the specific purpose of the National GIS – which are seamless across the nation uniformly, standardized as per a National GIS Standard and constantly updated as per an update cycle.

165.2. **Metadata** is an important element of any Portal – that helps understand and search data. Metadata Standards are available and if they are used to populate the various data content then they can help users much more ease of use of the GIS Portal. In our analysis, Metadata is poor across all GIS Portals that we have studied and analysed except the USGS National Map Portal that contains Layer Metadata as per FGDC Standards. NSDI Portal has extremely good Metadata Standards identified but lacks metadata records. Bhuvan has hardly any standardized Metadata. However, GoogleEarth, K-GIS and MapmyIndia, NICMAPS & Surveykshan do not really have any serious user-oriented Metadata.

In our assessment, National GIS must organise Metadata systematically – in fact, it can be the easiest to organise and systematically populate – thereby allowing users to immediately know what data is available in National GIS and allow for efficient search.

165.3. **Data Dictionary**: A data dictionary is a collection of descriptions of the GIS feature objects or items in a GIS data model for the benefit of users, application developers and others who need to refer to them – basically, identifying each GIS feature and its relationship to other objects. A good GIS Portal must have a robust data Dictionary that is publicly accessible and allows data modeling and results in a picture of object relationships – detailing descriptive names, its relationship (or it becomes part of some structure that implicitly describes relationship), the type of data (such as text or binary value) is described, possible predefined values are listed, and a brief textual description is provided. In GIS parlance, the Data Dictionary helps one understand standardized place-names, legend-names and other relationships (say, village-taluka; Landuse Level 4 to landuse Level 3 and so on) and helps all users to develop a common toponymy for the GIS Portal. The Data Dictionary signifies the robustness and foundational strength

of the GIS database that power the Portal. In our assessment, none of the GIS Portals declared any Data Dictionary models that could be accessible to users THOUGH we are clear that some level of data dictionary definition must have been available for developing the Portal. In our sense, we get that data dictionary definition seems to be at the foundation of GoogleEarth, MapmyIndia K-GIS, NICMAPS and USGS National Map Portal. We note that in Bhuvan data-schema and data dictionary is hardly accessible and the schemas are very cluttered and not professionally designed – making it difficult for users to understand the displayed data and its relevance.

National GIS needs a well-designed Data Dictionary and considerable effort is required to develop this – but once developed for all National GIS content features, the dictionary will be the foundation of all data development, exchange and integrated analysis.

165.4. **Spatial Framework** is an important element of a GIS portal – especially in the Indian context the framework needs to define an accurate geo-referencing of an authoritative India Frame (including international boundary, state boundary, district boundary and taluk boundary of India) so that Earth coordinates of India are referenced as precisely to the administrative India Frame. We find that all the Portals (of India) use different Spatial Frame – thus boundaries of India seem different, coordinates of locations are different, distance and area measurements are different and it is difficult to cross-analyse the layers in these portals. As Surveykshan is a website of Survey of India, we presume that it must have most accurate and authoritative boundaries – but there is no measure of the accuracy or authoritativeness. NICMAPS has integrated administrative boundaries from Survey of India (SOI) maps with satellite images – again, there is no measure of this geo-referencing. Bhuvan Portal seems to have a robust spatial framework for India as it has geo-referenced satellite images, India administrative boundaries – but the visual match of earth features on the images and the derived NNRMS maps have discrepancies and mis-match. Bhuvan too does not declare any measure of accuracy of geo-referencing. K-GIS seems to have adopted a similar concept of spatial framework for Karnataka state – KSRSAC has geo-referenced into a "nominal India frame" the state frame and co-registered the state frame with satellite images of 2.5m resolution (Note: this does not match with Bhuvan Spatial frame or Surveykshan frame or NICMAPS frame) – again, here too the accuracy is un-declared. The NSDI Portal does have a spatial frame just of administrative boundaries (Note: this NSDI frame does not match Surveykshan frame) – and there is no co-registration with satellite images. MapmyIndia uses its own relative spatial frame – and it seems satellite images, boundaries have been geo-referenced. GoogleEarth uses a larger global spatial frame in which India is fit and co-registered – with basic GoogleEarth features directly derived from GoogleEarth satellite images (thereby good referencing is achieved); USGS National Map uses a robust geographic spatial frame for US that seems to have co-registered satellite images, US administrative boundaries, real-time Positioning points – thus, is a robust and well-designed framework (Note: incidentally for US regions, the GoogleEarth frame and USGS National Map frame do not really correspond well and there are mis-matches).

In our analysis, the most important aspect for National GIS is to have one, single, accurate and authoritative National Spatial Frame (NSF) for India (which has been well highlighted in the National GIS vision document

and also detailed in this report elsewhere). This frame must be a one-time geo-referencing of high-resolution satellite images, authoritative administrative frame from SOI and a national Positioning network. This NSF must be available a s a freely accessible product to any user in India.

165.5. **Quality of GIS content** is extremely important for a GIS Portal to be authoritative and useful for applications. The quality tag is a derivative of the consistency checks and quality analysis of GIS content on the Portal and signifies how well the data has been prepared for the GIS Portal – thereby, giving confidence to users for usage. There are typically three types of consistency that is important for GIS portals - point in time consistency - ensuring that all GIS content and its data models are uniform to a specific time-period; transaction consistency - consistency of GIS content all across the geographic coverage (say, whole of India) which ensures that data and its attributes are uniform across the country and applications consistency - transaction consistency of various GIS Applications and processes across the Portal modules. The importance of ensuring data and applications consistency is to ensure the reliability and integrity of the GIS content available on the Portal and the Portal operations/outputs. If the 3 types of consistency are poor, it becomes difficult to rely on the Portal Data as one is not sure whether the data/attributes is uniform across the country and whether the Portal operations across any state/district yields the same results.

We have seen in-consistency within a Portal (say, Bhuvan in-consistency is quite notable as functions result differently in different modules OR data/attributes vary across layers) and also amongst Portals (example, boundaries in Bhuvan or NICMAPS do not match with boundaries in Surveykshan; landuse feature in NICMAPS do not match in content/attributes to what Bhuvan has) – in fact, even data quality tags for features are absent in almost all Portals that we have seen. We also note that "a screen-view" quality assessment will always look impressive and can be completely misleading when granularity of visualization depth increases – it is then that data consistency issues appear. Much of these in-consistencies that we have noted arise because of the basic fact that good standards have not been used for the Portal data and functions – in fact, standards across Portals are really poor.

A measurable quality-tag for data/attributes/functions need to be developed based on scientific basis – indicating time-period, data/survey details, mapping accuracy measures, location accuracy measures and an overall integrated index of quality.

In our view, National GIS cannot have in-consistent GIS data/attributes and functionalities – after, it has to be authoritative and precise – once again we stress that good National GIS Standards definition and usage are the only way that the present in-consistency and quality issues must be avoided.

In our professional experience, we have seen that bane of many GIS project is due to the poor quality of data/attributes/functions developed – unless and until care is taken to define good quality standards – with measureable quality tags, quality assurance is evaluated at data ingest level to ensure only data of high quality, National GIS could easily fail in its objective to be that one-source authoritative GIS data and applications Portal for India.

165.6. Image inclusion is important for GIS portals – not just satellite images, aerial images or UAS images BUT any image that can be geo-tagged has to be an important element of the National GIS content. Satellite images are primary for a GIS Portal – they provide the rapid continuum and update for content and also form the base for map updation process. From a satellite image perspective, GoogleEarth is best as it provides highest resolution (upto 0.3m resolution) image across the country; Bhuvan has reliable image inclusions but the resolution of Indian IRS satellite (that powers Bhuvan) are mostly of resolutions around 2.5m and larger. It is to be noted that even though the orbiting satellite provide many cross-over images in a year, in both these Portals, images are of 2-5+ years vintage.

In any Portal, fusion of any images over the map/data content is most critical and important – this, according to us, is a direct function of the authoritative spatial frame that is utilized. We have seen that most of the Portals, including Bhuvan have poor image-map correlation and this cannot be acceptable for National GIS. It is only Google Earth that has good image-map match because they derive maps from the satellite images. Bhuvan does have serious mis-match of images-maps and the fusion capability is poor. USGS National Map has failry food image-map fusion – in our view, that is because their under-lying spatial framework is quite good. K-GIS and NICMAPS also include good satellite image inclusions but do suffer from similar image-map mis-match.

Aerial images are totally absent in Indian Portals (though India does have a large archive collection of aerial images) – mainly dies to the Aerial Photo Policy restrictions in India. Aerial images are also not seen in USGS National Map or in Google Earth.

Ground photos geo-tagging content and 3D-images are totally lacking in any of the Indian Portals – though Bhuvan and K-GIS claims of having grund photo uploads on their Portals (they do have some random ground photos uploaded but these are mere test-uploads by enthusiasts and cannot qualify for serious content of ground photos). On the other hand, it is GoogleEarth that containg the best and largest collection of ground photos and 3D content-views (Bhuvan also claims of 3D content but, according to us, it is just a poor-quality 3D rendering of satellite images over a DEM frame).

Images – be they from satellites/air-platforms/ground, must be fundamental content of a National GIS Portal – satellite images must be best resolution images, latest updated images and geo-referenced to NSF; ground images must be a part and parcel of National GIS portal and efforts would be required (like Google or MapmyIndia) for a systematic ground images management in the Portal. National GIS must prepare for ingest of UAS images/data – this will be a reality in near-future. Robust image management techniques and fusion techniques are important for National GIS.

We also raise a question here for National GIS? Worldover satellite images are reaching sub-metre levels operationally and with global coverage – why is it that Indian IRS systems, even today, are still "struggling" at metre-level resolutions for operational availability? In late 1990s, India

was the world's leading country with best resolution civilian satellite of 5.8m PAN – but in 2015, India seems to have trailed behind in the world as far as state-of-art in high-resolution image operational availability is concerned.

Should Indian governance or Decision Support be denied (or suffer) from the usage of best available satellite images – which, today is available all over the world from non-Indian commercial satellite (and not from Indian satellites)? National GIS demand for best quality and resolution images should drive India to plan and provide best quality/resolution satellite images in an operational manner – comparable, if not superior, to what is available in the world?

165.7. **GIS Applications Services** is the heart of any GIS Portal. The more applications services that are offered the better characterized is the GIS Portal for a user. National GIS Applications would have to include – both, GIS Data Services (that is 2-way on-line GIS data service - access to actual GIS-Ready data and ability to upload GIS-ready data to Portal) and GIS Applications Services (providing variety of GIS Application modules with modelling/predictive capability for Decision Support; GIS Applications Services need to include functions for display, query, integrative modelling, geo-correlation analysis, geo-analytics, predictive analysis, routing and navigation, location-based services, simulative applications etc; allowing variety of GIS Apps to be publishable from different users).

In our assessment, all the Portals that we studied have very limited GIS Applications Services – most of them limit services to basic display and basic query. MapmyIndia and GoogleEarth do have applications for navigation, routing and Location-Based Analytics that is offered on its Portal. Bhuvan "claims" and lists many sectoral GIS Services BUT, according to us, all of these are just data display functionalities and do not have any integrative analytics and fusion capability or even good querying capability. In fact, Bhuvan just "packages" different data visualization – state-cutouts, panchayat cutouts, images only, newsfeed etc as Bhuvan "services" – we could not establish any bearing of these to any useful query operation OR decision-support capability.

None of these portals, including Bhuvan, provide GIS-Ready download services – thus users cannot obtain GIS-Ready data of their interest which is a critical need of users of National GIS (we have not even seen any plans in these Portals for such download in future).

National GIS must have well-designed and robust National GIS services – both, GIS Data Services that allow access and download of GIS-Ready data AND GIS Application services for different users (agriculture/urban/rural/governance/citizens……) which needs to be a set of decision-tools configures into a GIS Application Decision Support module. Thus, National GIS must have large number of such GIS Application Services that cater to different segments and allow users access to these applications. National GIS must encourage users to develop/host GIS

Applications on the National GIS Portal – thus, GIS Applications services must be democratized in its development, usage and operations.

165.8. **Mobile GIS Services** is basically the availability of mobile apps for GIS Portals by way of which GIS data and Apps can be easily accessed on mobile and hand-held devices. National GIS will require a robust mobile app – mainly to cater to citizen modules/ services and also to enable field-level governance actions.

GoogleEarth, MapmyIndia have excellent mobile services capability – these are quite robust and widely used. Bhuvan also has released PocketBhuvan module but there are serious issues of its usage and robustness and link to main server. K-GIS also claims of a Mobile service but one is unable to test it. In other GIS portals – NICMAPS/USGS National MAP/Surveykshan that we studied we did not see any mobile device interface.

Mobile GIS apps are extremely important for National GIS – these have to be well integrated into the National GIS framework for mobile platform modules – especially so IF governance applications and citizen applications are to be catered to. Well-designed separate suite of Mobile GIS applications must be developed for National GIS – a platform on which any registered user can access National GIS anywhere in India.

165.9. **GIS Portal Standards** are the Portal standards that are used to maintain performance and enhance user experience in using GIS Portals. National GIS Portal must deliver integrated GIS content and GIS applications and be a "virtual collaborative workplace" of variety of enterprise-class users. It must also provide a good and open GIS Aps development platform for new applications and also enable integration of any existing GIS applications and processes. Object-oriented design patterns are essential for GIS portals allowing creational patterns that can create GIS App objects; design structural patterns that help group GIS App objects into larger GIS Menus/Models and design behavioral patterns that define the communication between GIS Apps to portray the complex vicissitudes of a GIS Portal. National GIS Portal will be a large suite of "GIS Applications" or Portlets that perform each of the specific GIS data and applications operations – say, display, zoom, legending, buffering, search, predictions, change analysis and so on. Applications must rely on the Web and Mobile infrastructure to access user profile information, access remote content, look up credentials, and store persistent data.

At same time, the national GIS Portal architecture has to be robust to manage large volumes of image/map data and instant queries of users – requiring a robust server infrastructure of a clustered environment or based on virtualisation-technology to obtain and maximize improved efficiency of performance. Load and Performance Analysis of GIS portals is important and needs to be done properly - concurrent user capacity is an important issue.

In our analysis, GoogleEarth and USGS National Map are high-performing Portals and adopt high-level standards for portal operations and are robust in design and infrastructure. NICMAPS performance is good because, we feel, it is hosted on a good and powerful hardware architecture that does not "choke" performance. MapmyIndia also has good performance and has adopted internal Portal design standards that serve very useful applications.

It is not clear on what design and standards the portals of Bhuvan, Karnataka-GIS, Surveykshan are available but their performance is not upto the mark. NSDI Portal has considerable improvement of design and infrastructure required.

165.10. **Interoperability** is related to producing GIS portal results in standard compatible web browsers, GIS engines, operating systems, software and devices and are based on the latest web and mobile standards. Interoperability design relate to structural and semantic markup with XHTML; CSS based layout with layout elements; separating among structures, presentation and behavior in web pages, scripting based on W3C DOM Standard and ECMAScript and geo-modelling across GIS engine platforms are state-of-art. In the GIS domain, OGC has defined a set of inter-operability GIS Apps standards that could form base for National GIS inter-operability.

In our analysis, we have not been able to see this important GIS Portal characteristic of inter-operability, in holistic manner, in any of the GIS portals that we have analysed – though inter-operability related to markup, web-browsers are seen in GoogleEarth, USGS National Maps and MapmyIndia. We feel that inter-operability is poorer, in our assessment, in Bhuvan, Karnataka-GIS, NSDI, NICMAPS & Surveykshan Portal – though most of them "claim" to comply to OGC standards.

166. In our view, National GIS must reflect high-level of technology usage – it must not and should not be lacking in technology ingest. National GIS must provide best of and authoritative data and applications services across the country and BE a Decision Support System (thereby, has to be substantially much more that just display and basic queries). Content of National GIS Portal cannot be just a "map/image data collection" but be a systematic seamless, standardized, updated GIS database across the country. The National GIS Portal design needs to be robust and stable to offer highest quality services with speed and accuracy. High-level testing and quality assurance is utmost important.

National GIS will require a quantum jump from the existing philosophies, approaches and design, content and technologies, development and operations that have been adopted in the Portals that we have studied. NATIONAL GIS HAS TO MAKE A QUANTUM-JUMP – leading India ahead quickly into an operational GIS Decision Support capability in next 2-3 years BUT also sustaining the national capability in GIS activities for next 10-15 years, at the least.

In our view, fresh and new efforts to organize National GIS Asset/Application Services/Portal will be required BUT the lessons learnt from NICMAPS, Bhuvan, NSDI, Surveykshan can certainly be incorporated, as much as possible. At same time, there is a lot to learn from USGS National Map and GoogleEarth – in terms of standardisation, reliability, robustness and keeping it simple and performing – all efforts must be made to assimilate these learnings and build upon the National GIS for India.

TABLE – 4.1(A): ASSESSMENT OF GIS PORTALS – USGS NATIONAL MAP, GOOGLE EARTH AND MAPMYINDIA

No	Categories	USGS- National Map	Google Earth	MapmyIndia
1	CONTENT	**Well-standardised, seamless, whole USA GIS data available.** **Spatial-** Base Data Layers - US Topo Availability (3 layers),Geographic Names (10 Layers), Structures (10 Layers), Transportation (14 Layers), Government Unit Boundaries (18 layers), Map Indices (10 Layers), Hydrography (NHD) (13 Layers), National Land Cover Database (NLCD) (27 Layers), Elevation Availability (4 Layers), Elevation Contours – Small Scale (1 Layer), Imagery – 1 meter (1 Image), Imagery – 1foot (1 Image), Reference Polygon (Layers 12) Natural Hazard - USGS US Hazard (15 Layers), USGS Stream Flow & Weather Station (5 Layers), FEMA National Flood Hazards (32 Layers), NEXRAD Weather (1 Layer), NGA US National Grid (102 Layers) Other Feature Data- Scanned Topo Maps from USA Topo (1 Image), USGS Ecosystem (5 Layers), USGS Protected Area Owner (PADUS) (1 Layer), USGS Protected Area Conservation Status (PADUS) (1 Layer), USGS GAP Land Cover (3 Layers), FWS Wetlands, BLM Public Land Survey System (PLSS) (14 Layers), National Park Services (NPS) Boundaries (4 Layers)	**Standardised images, basic map data for whole world.** **Spatial**- Borders Layer(Polygon, Point) like International Borders, Country Names, Coastal Lines, 1st Level Admin Boarders(State/Provinces), 1st Level Admin Names(States/Provinces), 2nd Level Admin Regions(Countries) Label Layer(Point) like Populated Places, Islands, Geographic Features, Water Bodies, Coastal Names, Places Layer (Point), Roads (Centre-Line) Layer(Line) Parks/Recreation Layer(Polygon) like Parks, Golf Courses Water Body Outlines Layer(Polygon) Local Places Names Layer (Point), Transportation Layer (Point) like Airports, Rail, Subway, Bus, Waterway Traffic (point) Layer IMAGES-Base Satellite Imagery: Landsat image	**Seamless, standardised, basic maps for whole nation data available.** **Spatial** -Base layers Administrative Boundaries(Polygon)- All India State Boundary including, District Boundaries – (Reported 640 in number), Sub-district Boundaries – (Reported 5924 in number), Town Boundaries defining municipal limits - (Reported 7933), Ward Boundary for towns, Villages, both as points and boundaries reported. Address database / Postal Boundaries(Point)- Urban cities, Localities for every city, Sub-localities within localities, House numbers for specific cities. Transportation network(Line)- road network data covering over 2 million road kilometers connecting every village and town, railway network (Reported ~70,000 kms). Traffic layer only for Bangalore, Delhi, pune, Mumbai. Point Of Interest(Point)- Restaurants, Hotels, Recreation Places, Travel & tourism, Commercial and Shopping places, Community Services, Religious places, Medical Facilities, Transportation services, Residential Apartments etc.
		Non-Spatial- NA	**Non-Spatial-** NA	**Non-Spatial-** NA

No	Categories	USGS- National Map	Google Earth	MapmyIndia
		User-Ingest-Bookmarks, ArcGIS Services, KML data layer (Point, Line, Polygon)	**User-Ingest**- Google Earth contains User-Ingest data. It is also possible for the user to add data through the tools. Available User-Ingest layers - User created Photos linked from Panoramio, 360 Cities, Everytrail, Gigapan Photos, Webcams.travel, Wikiloc websites; User created 3D models linked from Google sketchup website- Photorealistic layer and User populated Utilities like Parks,/ Recreation Areas, Water Body Outlines, Places coming under categories like (Bars/ Clubs, Coffe Shops, Dining, Lodging, Banks/ ATMs, Gas Stations, Grocery Stores, Major Retail, Movie/DVD Rental, Pharmacy, Shopping Malls, Fire, Hospitals, Libraries, Post Offices, Police Stations, Places of Worship, Government Buildings, Museums, Schools)	**User-Ingest**- MapmyIndia contains User-Ingest data. it is possible by Add place tool.
			Geo-Linked Data- Ocean related data linked from respective websites. Layers in-cludes-- Explore Ocean, ARKive:Endangered Ocean Species, Cousteau Ocean World, Marine Protected Areas, Dead Zones, Ocean Sports (Surf, Dive, Kite Surfing Spots) Weather related data which includes Image of Cloud pattern from US Naval Research Laboratory and Weather condition and Forecasts data from weather.com websites Information from various websites which includes photos, videos, Imagery layer like Discovery Networks, Earthquakes, Google Earth Community, NASA(Astronaut Photography of Earth, Satellite Imagery, Earth City Lights), National Geographic Magazine(Feature Article & Photographs), Rumsey Historical Maps(Map Finder),European Space Agency(Earth beauty, Phenomena seen from space), Wikipedia, DigitalGlobe Featured Imagery, Spot Imagery, DigitalGlobe Coverage(DG Coverage-(2010,2009,2008), Cloud Cover(0-10%, 11-50%, 51+%)	**Geo-Linked Data-** NA

No	Categories	USGS- National Map	Google Earth	MapmyIndia
			Others- Apart from Earth, google also contains other planet data. Mars Data-Spacecraft Imagery of Mars, Mars Gallery, Historic Maps, Rovers and Landers, Travel Guide to Mars. Moon Data- Featured Satellite Images, Place Names, Moon Gallery- Apollo Missions, Guided Tours, Historic Maps, Human Artifacts. Sky Data- Current Sky events, Backyard Astronomy, Featured Observatories, Historic Sky Maps, Sky Community.	
2	**VISUALIZATION**	**Map Viewer** - Map viewer has zoom slider, Scale bar, map scale and coordinates of cursor location. Map viewer can be viewed in full screen. Active tool information can be seen. There are options available to switch the base map. FAQ & portal policies has mentioned at the left bottom of map viewer. Progress bar (Loading) appears at the left corner at the bottom which shows which layers are updating while performing any query.	**3D/ 2D Map viewer**-Map viewer displays both 3D and 2D data. Status bar shows Lat/ Long, Elevation, Scale bar, eye altitude, Overview map. "Tour Guide"- user can see images and videos of map display area. In order to get full area display in the screen, user can hide the table of content. User has privilege to customise the 3D view in Google earth. The available customising options include Texture colour, Label /Icon Size, Graphic mode, Lat/ Long display mode, overview map Size etc.	**Map viewer**- Map viewer displays 2D data. There is no option to hide the search window in order to view maps with full user screen. There is some option to link with Apps, Explore, Add a place directly.

No	Categories	USGS- National Map	Google Earth	MapmyIndia
		TOC -Layers are well organised in respective group. Layers are allow to reorder in respective group. TOC can be hidden to have full screen window. TOC is a single container where portal layer, user added layer & marked as favorites can be accommodate. Groups can be collapsed and layers need to switched on to view on map. Mouse hover on layers gives a tool tip showing the display scale of the map.	**Layer Pane -** Layer Pane is the container of all the available layers in Google Earth. User finds it easy to operate on the layer. All the layers are arranged hierarchically. Hierarchy exists upto 4 levels.	**Navigation Tool**- Zoom slider is present apart from this we can do operations like pan, zoom in, zoom out on map using mouse scroll button And it also contains Scale bar.
		Navigation Tools- Pan, zoom box, previous extent & initial extent are available. Navigation tools works very smoothly - maps and geographical names does not jerk	**Navigation Tools**- 3D/2D Navigation tools are available like Rotate/Tilt with indication of North arrow, Pan, Street view, Zoom slider with Zoom-in, Zoom-out facility. There is also an option to change the settings to control the Navigation behavior like fly speed, mouse wheel Speed etc.	
3	**SERVICES**	**Identify & locate coordinates**- Information of location, coordinates & elevation of particular point can be viewed in box. Information Box will appear on the map which will have relevant information as query. Coordinate display can be change. This allow user to choose coordinate of his choice.	**Overlay**-User can overlay images of different formats (jpg, bmp, tiff, tga, png, jpeg, gif, ppm, pgm) with "Add Image overlay" tool. Information about image can be described by adding Weblink and Images. We Can add Kml, Kmz , COLLADA model files, GPS files	**String Search**- It is possible to search map features by entering string of characters. The corresponding map features are displayed. We can search by using full address or business type, locality name, pin code. We can also take print of map of our interest in pdf format.

No	Categories	USGS- National Map	Google Earth	MapmyIndia
		Measure-Area & distance cab be measured by drawing polygon & line. The results appears unit such as mile, kilometer, feet and so on. Drawn shape gives an option to download data (Polygon), zoom to that location, find out the elevation & and create buffer around it. These options makes tools more user friendly.	**Ruler- Measurement-** User can measure distance between two points and multiple points on the ground using "Show Ruler" Tool. We can get various measurement units in Cm,m,Km,In,Ft,Yard, Miles, Nautical miles, smoots formats.	**Driving Direction**- It allow to user get traveling routes by five points. User can see some category(Hotel, Restaurant, petrol pumps, Attractions, coffee shops, ATMs) along with routes. Print can be possible for getting driving direction.
		Buffer- Buffer can created around any shape (line, point, polygon). Buffer can be create around the layers available on the portal. (Polygon, Line & Point). Range ring allow user to create buffer rings around the point. User can define the buffer distance around the shape in different unit. The count of rings and distance can be defined by user	**Record-**User can "Record tour"- the simulation of the data and Images with voice recording. User can save and share the recorded video. User custom options like Time adjustments, Fly options, Camera Tilt angle, range, speed etc.	**Use Interface (Add place)**- It allows user to add place by some specific user detail (Place name, Building house no, city, state, locality, pin code, phone no, website, email address, category, small description, add photo) after adding place user get code of add feed and user can search by that code also.

No	Categories	USGS- National Map	Google Earth	MapmyIndia
		Add Data- Portal allows to add external data to map window through 'Add Data' tool. User can add services from ArcGIS Server, WMS & WMTS. Also user can add KML files to map. There is Catalog Service Web (CSW) tool to add other services to map.	**User ingest Tools**- User can create Point, Line and Polygon data in Google Earth through "Add Placemark", "Add Path" , "Add Polygon" tools. Here we also have an option to add 'Name', 'Description' (Weblink and Image), for the added item. User can also Change Style and color of label and icon. User options to Customise icons for place-marker, defining opacity option, other styling options for polygon, and line are available. We can also get the measurement of Length drawn while creating the line. Lat long and time information can be record-ed with added content with just a single click in the available property called "Snapshot view" Place pane is the single container of the user added data. User can easily organise the data into containers (folders). User can Save the content as KMZ /KML file into there local system or post data to google Earth Community and also Adjusting the Transparency of the added data.	**Geographical search**-It allows locating Specific category with specific features such as **Eat & Drink-** Fast food, pubs & bar, coffee shops, Indian Restaurants, continental res-taurants, oriental restaurants, Ice cream & desserts, road side dhaba, juice shop, other restaurants **Utilities-** ATMs, petrol pumps, banks, post office, parking, library, auto repair, Money changers/forex, photo studio, public conve-nience, banquet and marriage hall, cremato-rium, burial grounds. **Shopping-** malls, liquor and wines, flow-ers, books, customer electronics, grocery, furniture **Entertainment-** cinemas & multiplex, art & theatre, Auditorium/convention centers, water park, Indoor game **Health and Wellness-** chemist & medical store, blood bank, hospitals, pathological labs, clinics/Dispensaries, Health centers, Gym, Spa, Beauty parlors, Veterinary hospital **Accommodation-** Budget hotel, premium hotels **Religious-** Hindu temple, church, Gurudwara, Islamic, Jain temple, Buddhist sites **Emergency-** police station, Ambulance Services, Fire station **Education**- School, Colleges Universities, Couching Centers, play school, Vocational college **Tourism-** Attraction, Museums, historical places, lakes & beaches, Sanctuaries and parks as in the map display area identified by geographic location.

No	Categories	USGS- National Map	Google Earth	MapmyIndia
		Query Builder-User can build query on available service layers. Here user can build query by using operators(Mathematical, Logical).	**Search -** User can Search for places, Get directions, view list of recent searches(History), Copy search results to the Google Earth My Places folder, Copy search results to the clipboard as KML and Print search results. Search operation can be done using Post Code, Street Name, Town, Neighborhood, City, Long/Lat values. Results of Get directions can be viewed for Cars, Bus, bike or by walk routes. Results can be saved and printed. Elevation along the boundary of the searched place can be seen as a graph**.**	**Map widgets**- It allows user to get script of map that can be used in other application. Script for map widgets, direction widgets (by two point from and to), local search widgets (by what and where), full search widgets (by Location, map direction, local search) are available.
		Download Data-Data (Layers) can be downloaded on local system. Data can be downloaded by defined bound box (User defined/coordinate extent), predefined polygons and map extent. Data can be downloaded in ArcGIS format (.gdb) and shapefile. User can directly use these file to perform their analysis.	**Save and Share** - User Can "Save image" in Jpeg format; "Print" the current view and also has an option to send "Email" Attachment of current view of the screen as a Image or KML. Posting into Google Community Forum requires Sign In. User is provided with an options to Email, i.e. through Microsoft outlook or with Gmail.	**Traffic Service**- There is an option to know traffic information we can also switch on\off this layer.
		Print- Map can be printed in available formats such as JPEG, PDF, PNG, KML & JSON. User can print map with 2 easy steps, select print type & user can write title & description of the map.	**Historic Images** - Google earth provides user satellite images from previous years through "Historic image" Tool.	

No	Categories	USGS- National Map	Google Earth	MapmyIndia
		Annotation- User can add any shape or text to map with annotation option available on the portal. Shape & Annotation can be removed when it is not required. Also it can be exported in shapefile and KML. Creating annotation help user to make area of interest. Created polygon and relevant text can be seen on local system by exporting.	**Universe Data** - User has an option to view Earth, Sky, Mars, Moon data. Google earth also has an option to Show Sunlight across landscape	
			Switch to Google Maps -"View in Google maps"- Google earth display area can also be viewed with Google maps.	
4	**APPLICATION SECTORS**	**NA**	**NA**	**NA**
5	**GENERAL**	**Design/ Architecture-** Information of location, coordinates & elevation of particular point can be viewed in box. Information Box will appear on the map which will have relevant information as queried Coordinate display can be change. This allow user to choose coordinate of as requirement.	**Design/ Architecture** - Search, User added Content and Layers are in single Panel with Collapsible button format. Switching On/Off of Label layers, makes user to view the data clear and without ambiguity in viewing different type of data. There is no delay or difficulty in rendering of the layers in the portal. Online Help Content provides images and video.	**Design/Architecture**- Design of search tool is simple and quite user friendly. Admin boundary cannot be distinguish clearly. Font colour of the boundaries are not properly represented.
		Text-Portal has made available different types of grids with scales and quadrangle. Portal has few layers which are available on small scale to avoid being clumsy. To view these layers small scale grids has designed.	**Text** - There is option to view Labels (Text) according to there national language.	**Text**- Text size vary at different zoom levels. And text font size are proper and readable.

TABLE – 4.1(B): ASSESSMENT OF GIS PORTALS – BHUVAN, NSDI, PROTOTYPE K-GIS, SURVEYKSHAN AND NICMAPS

No	Categories	Bhuvan	NSDI	Prototype K-GIS	Surveykshan	NICMAPS
1	**CONTENT**	**Very Limited nation-wide standardised data; Data is mostly 50k and is sketchy, patchy and different time-periods.** **Spatial (Whole Nation)**- 250k Administrative Layers-Country, State, District, Taluk Infrastructure- 50k Road, Rail Waterbodies-River, Reservoir, Tank(2015) Land Use Land Cover 50K (2005-2006 ,2011-2012), Land Use Land Cover 250K (2004 - 2014), Wasteland 50K (2008-2009), Geomorphology 50K (2005-2006), Lineament 50K, Waterbodies(2004-2015), NOAA/MODIS derivatives, Glacial Lakes/Waterbodies Parliament, Assembly, DEM Layer, HillShade, Settlement Location, Surface waterbodies, Image Products (Whole Nation) - CartoDEM 2005, Resourcesat-1: AWiFS, LISS III Ortho, Land Vegetation - OCM2: NDVI Global/Local 2014.	**Only Basic Maps and Metadata** **Spatial** - Country boundary with all state, Map Index(Grids) Boundaries- State, District, Taluk Contour, Habitation, Hydrography, Landcover, Railways, Roads, Utilities Layers This Layers are present only for states like Maharashtra, Andra Pradesh, Delhi, Karnataka.	**State-wide seamless, 50k scale, standardised 53 layers of data + region-specific project data.** **Spatial (Whole State)** – 50k Admin Layers, Cadastral, Ward, Village, Grampanchayat, City, Assembly, Parliament, District, State, Taluk 50 k Land Degradation, Wasteland 2009, Slope, Soil Irrigability, Runoff Potential, Land Capability, Soil, Ground Water Prospectus, Lithology, Geomorphology, Landuse 2006, ForestDensity, ForestType, Tanks, Waterbodies, Settlements Area, Structures, Canal Network, Drainage, Road, Railway, Power Stations, Power Networks, Wells, Minerals, Settlement Location, Watershed, Forest Status, Forest Range, Forest Division, Forest Circle, Project layers-IRDP (Bellary), Urban BaseMap For Cities 2K Asset Layers-AssetPolygon, AssetLine, AssetPoint	**Mainly based on SOI topographic maps; not seamless and not for whole country.** **Spatial (Whole Nation) - 50k I**nternational boundary, State boundary, India UTM grids, District, Taluk. Habitation, Hydrography, Roads, Railways, Landcover, Utilities, contours.	**Limited layers fro whole nation, mostly 50k scale, sourced from various agencies** **Spatial (Whole Nation) -** Administrative - State, District, villages, Block Boundaries ESRI: TopoMap, Hybrid (World Boundaries & Places), Hybrid (World Transportation), Hybrid (World Imagery 15cm-60cm), StreetMaps, Aerial (World Imagery 15cm-60cm) Bhuvan: Satellite Imagery NIC: Terrain, Satellite Imagery [AWiFS (56M), LISS (23.5), PAN (5.8M)], 3 Base Maps (Scale Range 1:40 to 1:40000)

No	Categories	Bhuvan	NSDI	Prototype K-GIS	Surveykshan	NICMAPS
		Limited areas - Village, Panchayat boundary, Erosion (2005-06), Salt affected(2005-06), Ground Water prospects, Flood Annual layer, Flood Hazard, Landuse/ Cover(10K), Urban Sprawl, Watershed boundary, Urban Landuse (10k), Landslide hazard zones, Potential Fishing Zones, Wetlands, Mangroves, Forest boundary(Circle, Division, Range, Section, Beat) High Resolution (1m) city images- 225 cities only				
		Non-Spatial (For many states) - Limited Census data parameters of-2001 census available in main Bhuvan module Limited Census data parameters of-2011 census available in some state modules	**Non-Spatial** - Metadata from different agencies. NSDI Metadata mainly concentrate on categories of Metadata like - Data Identification Information, Abstract Describing the data, Citation, Contact Information, Dataset Topic Category, Image Data, Language, Metadata Date Stamp. Most of data content is blank.	**Non Spatial** (For whole state) -Village Demographic & Occupation data (2001 & 2011)	**Non-Spatial**- NA	**Non Spatial (Whole Nation) -** Census Data (2001)

No	Categories	Bhuvan	NSDI	Prototype K-GIS	Surveykshan	NICMAPS
		User-ingest - **Volunteered Geographic Information (VGI) interface is provided but there is no data and very few data instances**. -Civic Amenities (41), Governance Assets (7), Human Resources & Livestock Assets (2), Natural Resources Assets (8), Productive Asset (9) Public Layers (KML, shp, fly, WMS, WFS, Tiff, img, elevation layer) link provided	**User-Ingest** – Not provided	**User-Ingest** - Through Markup tool online. Very limited data instances	**User-Ingest** - There is no option to add user ingest data.	**User-Ingest -**NA
		Geo-Linked Data-Rediff Maps as base maps, PFZ, CHL, SST from ICONS, Weather Information from MOSDAC, Cyclone data from IMD, Industrial Pollution from CPCB.	**Geo-Linked Data**-Bhuvan (Satellite and Vector layers as a WMS Service)	**Geo-Linked Data-** ESRI, Bing maps as base maps.	**Geo-Linked Data-** NA	**Geo-Linked Data-**ESRI as base maps.

No	Categories	Bhuvan	NSDI	Prototype K-GIS	Surveykshan	NICMAPS
5	VISUALIZATION	**Bhuvan 2D- Map viewer & Navigation Tools – Basic visualisation tools that are inconsistent, not robust and standardised.** A single click operation to display full India extent is not possible but has to be done in multiple click steps and this becomes quite cumbersome and tedious. There is in-consistency of this tool as in some screen this facility is provided and in some screen the facility is missing. However, Help screen mentions this utility BUT it does not function as such in all screens. Geo Search using place names or lat, Long gives erroneous locations (Mysore search identifies location far way from Mysore; 77.56 and 12.36 gives location in a different co-ordinate).	**Basic visualisation tools.** **Login** -User has to Register to access the portal. With the credential- Login and Password, one can login into the portal. Fax No, even though it is mentioned as non-mandatory field, User is prompted to enter the Fax-No	**Basic visualisation tools** **Map Viewer** -Map Viewer opens with full screen by default. It has TOC which can be open with drop down button available on it. Different basemaps are made available on portal which are integrated in map viewer. There are two drop down tabs are available where tools are categorised in as standard and advanced. Map navigation tools are with transparency bar. Map Viewer contains, progress bas, index window, cursor location, scale bar, map scale. At the bottom of the map viewer window, result panel resides.	**Basic visualisation tools** **Map Viewer -** Map viewer is capable of displaying 2D information. TOC is fixed and has 3 tabs in it; Home, Thematic, Search. Home tab is the container of all the data layer. Other two tabs doesn't show any of the capabilities. Layers are bounded with the bound box value; User can operate only on those layers which has activated at that bound box value. Status bar shows the name of the tool which is highlighted, a progress bar appears when layer is rendering and also displays other information like Map scale, Map display area in meters, Box bound value XYMin & XYMax in DMS format, cursor movement shows Lat & Long values in DMS format.	**Basic visualisation tools** **Map Viewer -** Map Viewer has basic map navigation tools like Zoom Slider, Scale Bar, Map Scale. Map always appears in full screen. Portal opens with Indian boundary with state boundaries and union territory and the capital of each state. Active tool can be recognised by seeing the underline beneath the tool. Map Viewer contains tools and Base Maps. Base Maps can be selected by clicking the tabs. External Base Maps has also integrated with NIC portal such ESRI, Bhuvan. Appearance of Map Viewer is simple and elegant. It does not appear complex.

No	Categories	Bhuvan	NSDI	Prototype K-GIS	Surveykshan	NICMAPS
		Overview Map shows panning India frame which is not useful because inset box overview map should show full India extent with moving red box of display extent WMS Manager- Search catalogue which is having options like “LULC50K” and “Wasteland50K” populates all the available dataNo filtration is happening according to the options given. .			Map area displays scale bar and North Arrow along with the Map layers. An external link to contact for maps Hard/Soft copies is present	Help menu, Change Password & Logout option appears at the right hand side top corner. Portal’s tools and services are well symbolised.
		Bhuvan 3D- Basic 3d visualisation module. Map viewer- Always give an error message in “Skyline Globe” viewer Most of the Sections have only 1 layer view at a time. User doesn’t know at what scale layer is visible Difficulty in finding the location of the layer and thus zooming is not possible.	**Map Viewer** - It displays 2D data has a Zoom slider, Status bar contains Lat/ Long information on cursor movement and Map Scale. Larger map area is visible by hiding the Table of Content. In Table of Content, Layers can be reordered. Fit to layer and Layer transparency options are available for each layer.	**TOC** - Layers well organised. They have grouped in Admin layers & geological layers. Also small pockets of project layers have been arrange in different group. Layers can be seen by collapsing the group and can be visible by switching on. Layers can be reordered and zoom to their respective scale level. Also information of respective layer is available.	**Layer Book Tool -** This tool opens a new window with the Header description as “Legend”. But there is only information of the layers present with its scale info. Other Legend component like symbol and colour of the layer are not present.	**TOC -** Clicking ‘Map Content’ Table of Content’ appears. Layers are well integrated in table of content in defined category. Categories can be collapse. Also Base Maps has integrated in Table of Content. Table of Content has option to view the legend of respective layer.

No	Categories	Bhuvan	NSDI	Prototype K-GIS	Surveykshan	NICMAPS
		In "Add Layer "- WMS Services shows wrong location and data is not added. Options like add KML, Shp, imagery are not working. In "GIS Tool" - "Find Object" Layers doesn't contain any data to perform given operations. "Buffer" doesn't show proper buffer circles/ areas "Thread Dome" doesn't show any of the Parameters given in help document.				Transparent option is available along with each layer. Small tool appears with table of content which allow the map content box minimize/maximize and hide.
			Navigation Tool - Navigation tools like Pan, Zoom-In, Zoom-out, Interactive Zoom ,Zoom to Previous extent and Next extent are present.	**Navigation Tools** - Portal has incorporated basic navigation tools which can help to move map at ease. Map can be panned easily to all four directions. Also it can be zoomed in/out and previous & next can be saved till session is on. Anytime map can be viewed at full extent.	**Navigation Tool -** Navigation tools like Pan, Zoom-In, Zoom-Out, (Zoom to) Window area, Fit (initial extent), Previous view, Next view are present.	**Navigation Tools** -There are basic but useful navigation tools appears on the portal such as full extent, moving map right, left, up, down, last/ previous extent, zoom slider, pan and zoom in/ out. Panning is very smooth and it does not jerk.

No	Categories	Bhuvan	NSDI	Prototype K-GIS	Surveykshan	NICMAPS
					Select Map Element Tool - This is used to select map element. Ctrl key can be used to select multiple map elements. The significance of this tool in the portal is unknown as the portal provides only WMS service, Query operations cannot be performed.	
3	**SERVICES**	**Disaster Service (Drought) – (really not a "GIS service") a simple visualisation tool – querying is not possible; Disaster modelling/analysis not possible.** This service contain NDVI, NDWI, Soil Moisture Index, SASI data for whole India "Analysis" part shows district wise intra seasonal graphs of selected years only. No current year information is available (Available till 2012) and No other GIS information is available	**i-information** -This tool is used to identify information about the selected layers in the Map. A result window appears with all the attributes. It is observed that this tool works only for 2 layers(Map Index & State boundary)	**i-information** -This tool is used to identify information about all the layers which intersect at that point. Layer can be selected from the dropdown list and attributes of the particular layer can be viewed.	**Copy to Clip board, Print & Advance Print Tools -** Copy to clip board tool gives a screen shot of the Map area. Print tool facilitates user to customise the print properties of that Map area. We can save file in different format. Advance Print tool provides additional facility to select the area to print and also option to include boarder and comments. Print can be saved in Pdf format. However doesn't show legend and space to enter comment is very less.	**i-information** -This tool helps user to identify the layer of map. The results of identify tool appears in same box. Points identifies entire layers of the map and result can be seen in the box. Through result window, identified location can be zoomed in. Separate identify box appears along with point

No	Categories	Bhuvan	NSDI	Prototype K-GIS	Surveykshan	NICMAPS
		Crowed Sourced data which is available has not been categorised properly. (Ex: Damaged Feature-Building shows picture of crop) Legend for LULC layer throws an error. Help shows wrong information **Disaster Service (Forest Fire)**- Forest fire service shows current fire location on daily basis and burnt location (INFFRAS Rapid Response based on IRS P6 AWiFS Satellite data). It also contains Achieved forest fire locations form 2000-2012. There is no GIS based analysis available in this service. Even with the maximum zoom of the village layer it is difficult to make out the village name from the map. "Burnt Area" doesn't show any of the information like "Area(ha)" etc.				

No	Categories	Bhuvan	NSDI	Prototype K-GIS	Surveykshan	NICMAPS
		Disaster Service (Landslide)- Landslide disaster service contains Early Warning system, Landslide inventory, Landslide hazard zones. Information which are available are very limited and contains only for 3-4 places. Difficult to view Landuse data over satellite image as it is coloured map.				
		Disaster Service (Flood)-Flood related data can be found in this service like Recent floods, Historic floods, Flood hazard zone etc. Only few flood affected places can be found. As on April 26, 2015, GIS-Ready data for J&K Flood of April 2015 is very limited and Portal contains patchy flood-area maps BUT no query or relief-operations or damage-operations or real-time flood management decision-making is possible.	**Measure distance** -Measure distance gives correct measurements. User can measure distance between two points, in different units like Km/m, Miles/Feet, nautical miles.	**Measure** -Shapes can measured with available tool on the portal. The shape can be line or polygon.	**Measure distance & Measure Area Tool-** These tools shows distance between two point and multiple points. Results are represented in meters and square meters respectively.	**Measure-** Measure & Draw tools appears in same box. Line and predefined polygon with customised polygon can be use to measure the length/area. Unit can be measure in Meter kilometer, feet & mile Point, line & polygon can be drawn. Color of shape can be defined as well as width of the boundary. Text can be added and font and the style of text can be defined.

No	Categories	Bhuvan	NSDI	Prototype K-GIS	Surveykshan	NICMAPS
		In "Historical flood"- Layer '2007 Bihar' area has map which is not matching with the legend. Legend is static display, doesn't change with the map. In "Aggregated flood" - Layers like 'Flood', 'Tsunami', 'Cyclone' doesn't contain any legends and there is no option to perform query operation on the layer. Difficult to understand display map and No other layer information is available, like "Area" etc. **Disaster Service UI**- Help- Help content is not relevant to this module Print- Print is just a Screen dump				

No	Categories	Bhuvan	NSDI	Prototype K-GIS	Surveykshan	NICMAPS
		Ocean Services – (really not a "GIS service") a simple visualisation tool – querying is not possible; Ocean modelling/analysis not possible.	**Long/Lat** -User can view Lat/ Long in 2 different formats- Decimal degree and Degree Minutes and map scale is also displayed with this.	**Location of coordinates, Scale Bar, Map Scale & Progress Bar**- The latitude & longitude of mouse cursor can be seen at the left bottom of the portal.		**Locator-** Portal offers to locate user desired location three ways. User can locate their location by simply entering the name of the location. Also it allows to locate the place by entering pincode.
		Ocean Services which contains potential fishing zones data which is only available for few coastal areas(AP, Orissa& West Bengal) Which doesn't give current date data. Other data which are available is CHL(Chlorophyll) and SST(Sea Surface Temperature). These information are linked from INCOIS Ocean data available are very limited, not available for all the coastal area and not current date information		Also portal has map scale and scale bar. Progress bar appears at the middle top part of the portal while any movements taking place on the portal.		Portal has integrated ESRI geolocator where user can single line address. Map automatically zoomed to defined point.

No	Categories	Bhuvan	NSDI	Prototype K-GIS	Surveykshan	NICMAPS
		Open Data Archive Services - (really not a "GIS service") a simple data download tool. This Service facilitates the user to select, browse and download data from the portal. Available products are categorized into Satellite/ Sensor, Theme/Products and Program/Projects. Selection of area to download has options like bounding box, Mapsheet, Tiles, Interactive drawing.	**Upload Context** -User have an option to upload file or Url. Context file which is saved from the portal(gml) can be uploaded, this provision is not there for any other external files.	**Basemap** -Basemaps are available on the tabs. The basemaps are created with existing data of admin layer. The topo basemap opens with portal and other basemap can be accessed by clicking on the tabs. Also ESRI & Bing basemap can added to the portal.		**Search**- Any location can be searched by name. The admin layers need to define before to enter the name of the location. Location of map can be also searched by various shapes which user can draw.

No	Categories	Bhuvan	NSDI	Prototype K-GIS	Surveykshan	NICMAPS
		Thematic Service – (really not a "GIS service") a simple visualisation tool – querying is not possible but just selective display Thematic services is collection of thematic maps under different projects. upto 10k thematic layers are available(not seamless). However recent/current thematic layers are not available. Following are the observations Data with satellite images can't be viewed - this is a major gap in functionality. Option to overlay doesn't have any significance as Query (identify) operation for the layer which is overlayed on the map is not possible. Shows result for only 1 layer and overlayed layer doesn't have swipe option to compare	**Search Metadata** - User has two options to view metadata -"Administrative" and "Spatial" Administrative- In this option user can view metadata either by selecting State & district or Place name or by selecting the agency & product. Spatial-User have an view metadata according to the spatial query he does. In this user can select Lat/long by an option called Drag on map, As user Clicks it on map lat, long will be added automatically into Lat, Long box. There is a dropdown which displays Mapcode in the selected area to view metadata information. In Spatial search - Lat/ Long labels are not properly arranged.	**Search** -Search tool box is located at the top of the portal which helps to search the names of places. Search tool works as a GIS data engine. As the name type in it, the available list of the place will appear below search box.		**AOI-** AOI is gives a option to user to define their area of interest. AOI can be defined on the basis of district and block. In map viewer, only area of interest map will appear. This makes map viewer window lighter and little fast panning.

No	Categories	Bhuvan	NSDI	Prototype K-GIS	Surveykshan	NICMAPS
		Weather Services - – (really not a "GIS service") a simple visualisation tool – querying is not possible; real-time Weather modelling/ analysis not possible. Weather service displays weather data like temperature, atmospheric pressure, wind speed and direction, relative humidity which is collected through ISRO's Automatic Weather Station (AWS), located across the country. This name of service is not displayed in Bhuvan main page. In "Current weather information" layer, Temperature Information is displayed wrongly in some places. Ex: GS Yelburga Koppal shows -40/-40 Deg C dated 4/15/2015.	**Save Context** - This Tool downloads an OGC complainant gml (xml) file which gives information about layer like type of services, its Source, Name, Title and Format.	**Spatial Query** tool is available on Advanced tab. User can opt query by choosing available layer from the TOC. The tool box which shares with TOC will be active once the query is in use. The result can be seen in Result Panel with relevant attribute.		**Elevation-** This tool gives information of particular location's elevation information. There are three ways lines can be drawn on the map in order to see the elevation. Separate elevation box appears with graphical interpretation of elevation.

No	Categories	Bhuvan	NSDI	Prototype K-GIS	Surveykshan	NICMAPS
		Climate & Environment – (really not a "GIS service") a simple visualisation tool – querying is not possible; EIS or environmental modelling/change analysis not possible. This services says it delivers the products related to Terrestrial Sciences, Ocean Sciences, Atmospheric Sciences, Model Derived Products, Cryospheric products but only documentation and metadata information are available in this section and GIS maps are just a replica of data from "Open Data Archive Services" Data which are present are very elementary and contains old (2013) data which cannot be considered as decision support application.	**Toggle Bhuvan WMS** -User can view Satellite imagery as a service from Bhuvan. Vector layer can be overlayed on the satellite images.	**Attribute Query** - Attribute query resides in Advanced tool tab. The box appears where attribute query can take place. This box is designed well to execute the query. This query involved only attributes of the layer and results can be seen in Result Panel.		**Snapshot-** This operation helps user to save map in on their local system. Tool gives option to choose area of interest with square box. Map can be saved in JPEG and PNG format. Portal has option to zip the file while saving it.

No	Categories	Bhuvan	NSDI	Prototype K-GIS	Surveykshan	NICMAPS
		Create a Map/GIS – an elementary map-drawing tool online; not reliable user-design. Bhuvan Mapper is a service where only Registered user have the facility to map the places using point, line and polygon and can be put under well defined categories. User will be able to search for location and have options to edit (delete, move, change direction), undo, redo and save.	**Help** -Help Menu shows information about the portal, Profile and Map viewer. However these content doesn't match with the portal design and its functionality.	**Buffer** -Drawn line or polygon can be easily buffered with available tool on the portal. Also it gives option to buffer existing shapes of the layers from TOC		**Print**- Layers appearing in the map can print directly with print tool. User can define the title of the print. Map can be saved in PDF and can be print later or can be print directly if the printer is connected to the system
		State Portals Services – basically the available data is "cookie-cut" to states and basic visualisation is possible; – (really not a "GIS service") a simple visualisation tool – querying is not possible; No state decision-making is possible.		**Markup** -User can add their own markups and make it available to public. Markup can be in point, line & polygon shape and also can change the color of it.		**Bookmark-** There are predefined bookmarks available with portal. The list of cities available in the bookmark, by clicking on the name map zoomed to that location.

No	Categories	Bhuvan	NSDI	Prototype K-GIS	Surveykshan	NICMAPS
		The layers present are extracts of the layers from main Bhuvan portal. However few state contains few additional layers like census data-2011, Polling Booths of Election 2014, Revenue boundary for few villages, Choropleth maps of district and village wise categorizing Population on (Age-06, Literacy & SC) of census 2011 data. Print- Legend is static and shows wrong description. Layers when added shows data present outside concerned district. Potential Fishing Zone doesn't populate any information. No state specific information is made available apart from the replica of the data which is already present.				
				Print -User can print their work in map viewer window. User can define their extent or can have map extent to print.		**Legend-** This gives the symbolic information of layer. Portal has maintained separate box to view the symbology of the layer.

No	Categories	Bhuvan	NSDI	Prototype K-GIS	Surveykshan	NICMAPS
						Swipe Spotlight- This tool helps to differentiate vector data and topographic images. Layers can be separated by two ways: Spotlight: The topographic image beneath vector data can be seen in circular shape. Swipe: The tool available on the portal helps to separate the topographic image from vector data by simply holding and dragging the mouse.
4	**APPLICATION SECTORS**	**Though claimed as "applications", these are just visualisation tools and no Decision Support is possible in Agriculture areas.** **Agriculture (Pest/ Disease Surveillance)-** This application displays point location of pest/ disease affected area. This application just populates the online available data(source: newspaper, online reports) through filtering. No real time and authenticated GIS data is available.	NA	NA	NA	NA

No	Categories	Bhuvan	NSDI	Prototype K-GIS	Surveykshan	NICMAPS
		Agriculture (Plantations)- Agriculture plantation application shows location points of Tea plantation (only Assam and West Bengal) and Rubber plantation of Tripura, field photos which are present is of year 2011. The norm Agriculture plantation doesn't really include all kinds of agriculture plantations in India. "Agricultural Plantation Rubber" - Query(identify) Shows no information other than the layer name. Relevant attribute information of the layer is not available. Very poor and no data at all and no GIS integrative application is possible. A message "Click within area of s1" is always displayed which is irrelevant to context				

No	Categories	Bhuvan	NSDI	Prototype K-GIS	Surveykshan	NICMAPS
		E-Governance - (Decentralized Planning). **Though claimed as "applications or planning" tool, these are just visualisation tools of SISDP data and possible user Asset data BUT no Decision Support at panchayat level was possible using the module.** This Application is mainly based on NRSC- SISDP (Space based Information Support for Decentralized Planning) project, where 1:10K thematic layers are visualised. This application provides SIS-DP project status webpages; allows area selection for visualization and displays maps; Area Profile report module claims to provide detail report on identification details BUT there is very limited data for reports AND report generation takes too much of time (more than an 1hr);				

No	Categories	Bhuvan	NSDI	Prototype K-GIS	Surveykshan	NICMAPS
		Asset Mapping – module claims to map user-assets into 5 categories BUT the user mapped assets are not available for next session and one is not able to identify the added/available asset information AS THERE IS VERY LITTLE asset data; Activity Planning – claiming to allow citizen and PRI's can plan an BUT is in very elementary level and hardly useful; Implementation & Monitoring – claims viewing approved plans BUT there is no data available. Only names of schemas can be found. Module has basic visualisation tools. Portal hangs many times- Shows poor designing. Search in full extent view shows Jammu and Kashmir and Kerala - erroneous result. Query tool present under personalisation is misleading as it doesn't allow any operator based GIS query or GIS spatial query BUT just allows string search in few layers.				

No	Categories	Bhuvan	NSDI	Prototype K-GIS	Surveykshan	NICMAPS
		Though claimed as "applications", these are just visualisation tools and no Decision Support is possible in Irrigation planning/ monitoring and management areas. **Irrigation -** Irrigation Section contains implementation and monitoring of Accelerated Irrigation Benefit Program (AIBP) which is central govt sponsored project. As it is project just visualisation of "patterns" is available. Value added GIS data are not found related to real irrigation GIS.				
		Though claimed as "applications", these are just visualisation tools and no Decision Support is possible in Forest Management areas.				

No	Categories	Bhuvan	NSDI	Prototype K-GIS	Surveykshan	NICMAPS
		Forestry - This application displays Forestry information of Himachal Pradesh, Karnataka states where few headings like change monitoring contains forest cover monitoring of 2011-2012 data and some forest boundaries Boundaries from different projects SHOWS different mis-matched boundary. MOEFCC has layers which are replica of the data present in other modules of forestry and contains few additional data like National Parks, Sanctuaries and few industrial pollution points, Mining areas. In “Know your forest” section Selection operation for Circle, Division, Range, Sector, Beat doesn’t show filtered data. Ex: When certain ‘Circle’ is selected, following ‘Division’ list doesn’t show data for that ‘Circle’ instead it shows all ‘Division’ names. Proper hierarchical administrative set-up in menu is not included - poor design.				

No	Categories	Bhuvan	NSDI	Prototype K-GIS	Surveykshan	NICMAPS
		In "Greening India mission" Layer 'Waterbodies' is not matching with the satellite image. Mis-match of layers and geometric super-imposition errors. "In Greening India mission" Layer "landscapes" doesn't have any relevant information. Ex: Himachal Pradesh forest landscape contains relevant data. Confusion for the user to find correct information				
		Though claimed as "applications", these are just visualisation tools and no Decision Support is possible in Urban Planning or Management areas – master plan generation/plan monitoring and violation mapping; change analysis; revenue and tax administration etc not possible.. `				

No	Categories	Bhuvan	NSDI	Prototype K-GIS	Surveykshan	NICMAPS
		Urban (Municipal GIS) -Municipal GIS contains information only for Ludhiana, Punjab. Here we can search house by ward, locality name or House no. Very limited data is available in GIS node layers. Municipal GIS doesn't contain any GIS related decision supporting app which could be implemented in Municipal boundary level. "Search by House no" spelling of Lot of spelling mistakes and errors in module. Sections mentioned under amenities contains incomplete information like Bank-it contains location information but name of the bank is not available.				

No	Categories	Bhuvan	NSDI	Prototype K-GIS	Surveykshan	NICMAPS
		Urban (Urban Information System)- This "Application" is just a reshow of the Thematic service **Urban (Urban Growth Monitoring)** - This Application shows the urban growth patterns of VERY FEW cities over 20-25 years using mapping done for these cities using satellite data. While display is possible no decision-making and queries are possible. **Rural (Ground Water)** - "Bhuvan- Bhujal" application has 2 layers ground water prospects and structures out of which only ground water prospects layer is queryable and structure layer doesn't even has legend information. How can this be used for groundwater applications by users?				

No	Categories	Bhuvan	NSDI	Prototype K-GIS	Surveykshan	NICMAPS
		Special Application-International Disasters – basically a display and visualisation satellite images of few countries (Asia Pacific regions) where disaster has occurred and Indian images are generated. **IRS Pass Quick Looks**-contains satellite images from ResourceSat-1, ResourceSat-2, OceanSat-2, CartoSat-1 with different sensors and user can view satellite images with reference to the path of IRS pass date. **MANU (Mapping the Neighbourhood in Uttarakhand)** - Is a quick link provider of existing services like Bhuvan Mapper, Bhuvan 3D viewer, Disaster Services, Discussion forum. Contains user added data which is not monitored and it contains junk data and useless data.				

No	Categories	Bhuvan	NSDI	Prototype K-GIS	Surveykshan	NICMAPS
		Sports in India- Contains just stadium location of various games and it shows outdated sports events information. **School Bhuvan- Information which are available** are very elementary and doesn't cover proper information (Ex: Agriculture - doesn't cover all Rice growing area, wheat growing areas, Power plants etc..). Looks like sketchy atlas data and can in no way be useful for students.				
5	**GENERAL**	**Design/ Architecture** - There is poor and un-systematic design adopted – design robustness and consistency is lacking. Things are different in different functions and behave differently at different modules. Ex: Add Layer, i(identity tool) etc.. Serves different purpose in different modules, which is confusing for the users. Database is not rigid and is not standardised – looks just like a "collection of whatever data is available.	**Design/Architecture** –Poor design and limited architecting work has been done. Portal is best viewed in Mozilla Firefox. Help Menu shows information about the portal, Profile and Map viewer. However these content doesn't match with the portal design and its functionality. Few contents in Help menu is not visible in Google chrome and IE	**Design/Architecture** – Moderate design robustness and consistency is maintained. Data is consistent and well-seamed for whole state and is standardised. The name of the login user can be seen on the portal Portal allow to change password and to give feedback to portal admin. Pleasing colors have been used to designed the portal.	**Design/Architecture** - There is no Help tool. New GIS user finds it difficult to understand the tools without user manual.	**Design/Architecture-** Design of portal is definitely user friendly and not complex. Services available on portal is easy to understand & operate. They are symbolic in appearance. The Map Viewer Window is full screen by default so it enhances the viewing area. All layers have assigned scale and it appear/ disappears as it zoom in/ out.

No	Categories	Bhuvan	NSDI	Prototype K-GIS	Surveykshan	NICMAPS
		Data is also not continuous and “mashed up” different times data is provided and no consistency. In few modules tools like zoom in, Zoom out, Pan etc are provided in others its not present.		Portal allow user to update personal details.		
		Text- Full name of the fields not defined and many places spelling mistakes. Ex: RF , JFMC boundary User finds it difficult know the layer name.		**Text** -Portal has used different types fonts, size & color to defined the layers or landmarks available on it.		**Text-** The text format designed as admin hierarchy. Most of them are same font and size but with different color
		Others - Attribute Query with operators like ‘AND’, ‘OR’, etc is not possible. Legend for all the layers not available/possible		**Others** -KGIS portal is not fast as expected but it is stable. Multiple layers take time to load.		**Others**- Portal has good Help Menu. Portal has integrated external base map to increase analysis skill of user

TABLE – 4.2: SUMMARY OF GIS PORTALS EVALUATION

Parameters	GoogleEarth	USGS	Bhuvan	NICMaps	MapmyIndia	NSDI	Prototype K-GIS	Surveykshan
Content and Quality	Mainly images of ~2013-15 upto 0.6m images – seamless for whole India; co-registered basic map features and POI data	Good quality GIS-Ready layers, seamless Landsat/ Spot images, consistent, authoritative, compliant to FGDC standard	IRS Image content – mainly 2.5m or 5.8m and 55m images; varied GIS content from various projects – un-standardized	Basic GIS layers and IRS images – seamless for nation; co-registered and internal standards	Good quality limited layers; validated and local standard	Mainly Metadata but limited content; Consistency is poor, local standard	53 layers of state seamless, validated; IRS 2.5m images and 0.6m images, local standard	SOI topographic map content – limited states and internal standard
Ease of Use	Very easy to use – widely used by citizens	Clear dashboard; Consistent functions; Easy to Use; Good help	Complex dashboard; inconsistent functionality; Difficult to use; constant hangups	Simple to use (as of April, 2015 NIC portal is not available as it is under maintenance)	Simple dashboard; Consistent functionality; Easy to use	Simple dashboard; in-consistent functionality; constant hang-ups	Simple dashboard; consistent functionality; moderate ease of use	Can improve considerably
Performance	High and Reliable	Good-performance	Poor to moderate in reliability	Good performance	Good-performance	Poor reliability; Slow performance	Slow performance	Slow
Applications for Decision Support	Citizen and market-Applications	Mainly Display and Query; Image Overlay; Feed Services	Mainly Display; Limited querying; Integrated GIS Applications absent	Mainly display and some limited query; Integrated GIS Applications absent	Routing and limited LBA	No	Only Display and different Query. Integrated GIS Applications absent	No
Data Download Services	Download not possible except user-added data. However, Pro Version allows be download of vector data and images	Easily Possible to download GIS-Ready data	GIS-Ready is not possible for download	Not possible	Not Available	Metadata listing or Maps cannot be downloaded	Available for Maps and attributes in GIS-Ready format	No

Parameters	GoogleEarth	USGS	Bhuvan	NICMaps	MapmyIndia	NSDI	Prototype K-GIS	Surveykshan
Image Services	Display Available upto 0.6m images of 2013-15 vintage	High quality upto 0.5m; Yearly data update	Display of images - limited to 2.5m; 2010 vintage	Mainly IRS images of 23m and 2.5m of 2010-12 vintage; 55m AWiFS of 2015 vintage	No images	Through Bhuvan WMS	Display of 2010 2.5m images and limited 0.6m images	No
Design and Architecture	Very Good	Very good	Design and configuration standards needs to substantially improve	Quite Good	Quite Good	Can be substantially improved for state-of-art design	Moderate design – considerable cope for improvement	Can substantially improve
Mobile Apps	Available on Mobile platform too as an app	No	Does not easily work – testing difficult	No	Yes	No	Claims of Display and Data Capture on mobile platform – not tested	No
Portal Standards and Inter-operability Technology	Internal Standards adopted;	FGDC Standards - OGC and ISO compliant	NNRMS Standards – but difficulty for inter-operability	Internal Standards	Internal standards adopted	NSDI Standards of Metadata; OGC compliant claimed – need to be tested	Internal Standards	Internal standard
Most Positive Element	Most widely used in India; Robust and reliable; “Limited” but reliable content	Authoritative seamless GIS Portal for USA	First Portal of NNRMS maps and IRS Images - mainly data display	Seamless image/basic GIS data for whole nation;	First Private-sector Map Portal of India; Reliable Services	First Attempt for Indian Metadata in 2003 onwards	First Attempt of a State towards a State-GIS Portal	First view of SOI topographic maps

5. National GIS Standards

168. It has been earlier stated that National GIS implementation will fundamentally require:

168.1. National GIS Standards – a suite of technical standards and protocols for National GIS that will allow easy GIS Asset organisation/maintenance, GIS services of Data and Applications on a standards-based GIS Portal

168.2. an authoritative National Spatial Framework (NSF) as a nation-wide, uniform GIS template.

169. Based on the analysis that we have conducted of the international scene of GIS Standards, the comparative analysis if Indian GIS Standards and also the analysis of various GIS Portals, in the ensuing sections, we propose a set of National GIS Standards that addresses content, GIS database and quality standards and also some basis maintenance parameters.

170. In the subsequent and separate sections, NIAS also outlines details of the National Spatial Framework (NSF) and proposes a basic National Spatial Foundation Dataset (NSFD) – a standardized basic GIS-Ready data product of National GIS.

5.1. ELEMENTS OF NATIONAL GIS STANDARDS

171. NIAS has identified the following categories of National GIS Standards:

171.1. National GIS Content Standard – which basically includes what content needs to be included in National GIS.

171.2. National GIS Database Standard (including Quality) – which defines the details of GIS database related standards for the National GIS and includes data quality parameters

171.3. National GIS Services Standard – basically outlining GIS Data services, GIS Applications services and GIS Portal services.

5.1.1. NATIONAL GIS CONTENT STANDARD

172. National GIS has to be authoritative – thus, content is most important and core to the wide usage of the National GIS across wide spectrum of users. The National GIS content (called National GIS Asset) is proposed in a seamless manner to include:

172.1. Nation-wide GIS content at best possible content-detail as available (for easier comprehension, it could be 1:50000 or 1:10,000 scale). (NIAS agrees with the National GIS Vision document that in a digital GIS domain, scale is a “misnomer” AND WHAT IS RELEVANT is information content or depth/granularity of GIS content; BUT one has to recognize that scale is the most common form of reference made by GIS users in India)

172.2. City-GIS Content (equivalent to 1:2000 scale and better) for all 7000+ cities and special coverage areas (say, some Disaster areas; Tourism spots etc)

173. In the National GIS vision document[34], the GIS Asset includes ~41+ GIS Features and a wide range of ~25+ sectoral geo-tagged attributes/tabular data from census, demographics, planning and development, infrastructure and other sectoral datasets of ministries/states.

174. NIAS has consulted a range of users to determine their GIS data requirement and also what they expect from National GIS. Ministry of Panchayati Raj; Ministry of Urban Development; Ministry of Rural Development; NDMA; (erstwhile) Planning Commission; State Power Departments; State Agriculture Departments; State Rural Development Departments; NGOs etc.

175. NIAS has also studied content details of contemporaneous GIS – Gujarat GIS; Karnataka GIS; NICGIS; Bhuvan; MapmyIndia etc and also content in international GIS Portals - USGS National Map Portal; Google Maps etc.

176. NIAS has also studied in detail international approach to come to agreements and consensus on the content models/standards, such as GeoSciML (http://www.geosciml.org/) for exchange of geological and bore hole data; the Weather Information Exchange Model (WXXM) (www.eurocontrol.int/services/weather-information-exchange-model-wxxm); the Land Cover Meta Language (LCML) (www.iso.org/iso/iso_catalogue/catalogue_tc/catalogue_detail.htm?csnumber=44342) and the various INSPIRE thematic data models (http://inspire.ec.europa.eu/index.cfm/pageid/2/list/datamodels). These are very progressive source of knowledge on content modelling and standards.

177. Based on the above assessments, consultations and evaluations, NIAS proposes National GIS Asset content to include:

177.1. 41 Minimum Primary Content – which more or less matches with what National GIS Vision identifies

177.2. 43 Essential Additional Content – which are identified afresh based on our in-depth consultation and study

178. The ~84 features of National GIS Asset content could be categorized/grouped into following 17 categories – categorization and groupings are important to stack similar/related datasets into particular group and to un-clutter the content list:

178.1. Boundary – including all required boundary spatial data.

178.2. Cultural features – including a variety of cultural features

178.3. Hydrology content – including details of all hydrology features

178.4. Urban and Settlement content – all city and urban information

178.5. Environmental content – forest and environmental data

[34] Ibid 1

178.6. Geological content – details of geology and minerals

178.7. Landcover/ Landuse content – landuse and landcover information

178.8. Land ownership information – cadastral and Urban Property information

178.9. Terrain information – DEM, Slopes

178.10. Soils information – at Association and/or Phase level

178.11. Images – including satellite images and images from aerial/UAV/other platforms

178.12. Public Assets/Amenities – all public assets and amenities data in form of points

178.13. Met data – details of average meteorological data from met stations

178.14. Ocean state data

178.15. PFZ data

178.16. Points Of Interest (POI) – details of points of interest

178.17. Citizen data that can be obtained through crowd-sourced methods

178.18. Geographical names – a standardized list of Geographical names

179. The detailed listing of the proposed National GIS Asset content is given in **TABLE 5.1**.

180. In our assessment, almost 50% of the Minimum Primary Content of National GIS would be derivable using satellite images. Similarly, about 25% of Essential Additional Elements of National GIS would be derivable from satellite images. Further, satellite images could be used to update almost 50-60% of information. This shows the importance of high-quality and high-resolution satellite images for National GIS programme.

181. Naming Convention for National GIS content need also to standardised so that the name is easily understandable typology and this needs to include:

181.1. A short acronym of the Layer (say, “Luse” for Landuse/Landcover or “Geom” for Geomorphology or “Soil” for Soil layer and so on)

181.2. Details – say scale of Layer as 250k, 50k, 10k, 4k and 2k (as same layer may be occurring at different scales)

181.3. Source of content of how its is sourced (say, “SOI” for SOI layers, “NUIS” etc – same layer may also be obtained from different sources)

181.4. Year of Content generation (say, “2014” and so on)

182. Coding schemes for National GIS content must follow the source coding schemes (say, Village codes as per original Census village codes; Ward codes as per original ward numbers; Landuse codes as per original Landuse legend and so on). Thus, one will have to develop a National GIS Coding Standard for all the content layers – approaches of consensus that international efforts have adopted can be also adopted for National GIS. In this regard, it must be mentioned that the coding standard adopted by NIC GIS and NNRMS Standards could be utilised and further modified for National GIS Content Coding Standard. Some guidelines suggested for coding are:

182.1. Coding needs to be obviously "unique" and this has to be developed while implementation

182.2. Coding schemes must be akin to original attribute (say Landuse code "Agriculture" or Slope code "%value" and so on) and avoid using code translation methods (say code numbers to names or names to code numbers)

182.3. Codes should be easily understandable by any user – especially when content is exchanged

182.4. Codes must form a part of Exchange Dataset and for Portal Access Services

183. The Content legend and its defined symbolization and coloring of features - details of symbolization and legend compliant specifications are required as part of a National GIS Content Symbology Standard or SLD. This standard can be used so that maps can be rendered with specified symbology. The ability to define styling rules requires a styling language that the client and server can both understand.

184. A National GIS Content Thesaurus needs to be developed that should include details of content Category, Name (as per Naming Convention), Codes (as per Coding scheme) and Definition (a definition or explanation of that content with good details for common understanding).

185. In National GIS, integrating real-time sensor feeds and web-feeds sources to geo-tagged data will be premier activity – especially for real-time monitoring applications, situational awareness and dashboard applications. The OGC Sensor Web Enablement (SWE) standards (http://www.opengeospatial.org/domain/swe) can be adopted by National GIS to publish and embed live sensors data – geotagged to sensor networks and fuse sensor feeds in a spatial and time context.

186. For POI data, OGC efforts (www.opengeospatial.org/projects/groups/poiswg) – where encoding standard of points of interest data with an abstract data model and JSON and XML Schema implementations of that data model is easy and can be adopted.

187. The National GIS Content Standards, National GIS Coding scheme, National GIS Thesaurus must be public domain documents available in real-time access to anyone who wishes to access it.

5.1.2. NATIONAL GIS DATABASE STANDARDS

188. The term "GIS database " can be used to describe many different parts of the spatial data elements of an overall GIS system – coordinates, spatial features, attributes, accuracies and limits etc. Database design and standardizing can be thought of as the logical design of the base data used for storage, access and rendering/serving. In the relational model, these could be the tables and views. In an object database, the entities and relationships map directly to object classes and named relationships. In a GIS, it is a combination of both that is linked to the spatial referencing system and characterize points, lines and polygons to user-defined features.

189. As has been mentioned earlier, the National GIS content includes images, survey data, thematic maps, geo-tagged data, crowd-sourced data etc. The National GIS Database Standards – consisting of about 28 parameters have been identified for the different granularity/scales and the values (at 3-sigma limits) identified. The standards parameters correspond to image, thematic maps, GIS database and outputs/deliverables.

190. A good GIS Database Standards – detailing the design process of producing a data model of the GIS Content is essential. A logical data model can define all the needed logical and physical design and physical storage parameters - which can then be used to create the GIS Database. A fully attributed data model must be defined so that detailed attributes for each entity is included.

191. The **TABLE – 5.2** shows the National GSI Database Standard parameters and their values. Much of these parameters have been adapted from NNRMS Standards, NICGIS Standards, Karnataka-GIS Standards and have been tuned to National GIS needs. The values for these parameters have been further refined based on the GIS experience of NIAS team and the simulation exercises carried out to determine limits of precision required.

5.1.3. NATIONAL GIS SERVICES STANDARDS

192. National GIS services must enable sharing of GIS-ready maps, perform and share applications, render GIS data etc – all of this on the National GIS Portal without use of any addition resources by the user. National GIS Portal must be able to bring GIS Assets and GIS Apps to the hands of GIS experts and common people who might not otherwise have any experience with GIS.

193. The dynamic capability of the National GIS Services is most critical. Most users would access GIS information through dynamic mapping applications that can run inside the web browser. These dynamic applications must be able to provide highly functional mapping and analytical GIS functions to users. These can also be built as the National GIS Dashboards. Dynamic applications of the Portal must also allow fuse data from many other GIS websites into a single national GIS view and provide fused tools to perform focused analysis and, in some cases, even to perform simple updates to a central GIS database.

194. The following core services standards are identified for National GIS Services:

194.1. National GIS Metadata Standard

194.2. National GIS Catalog Standard

194.3. National GIS Map Services Standard

194.4. National GIS Map Tiling Services Standard

194.5. National GIS Feature Services Standard

194.6. National GIS Portal Encoding Standard

194.7. National GIS Exchange Standard

194.8. National GIS Web Coverage Services Standard

194.9. GeoRSS simple standard

194.10. National GIS SMS ingest standard

194.11. National GIS Applications standard – focusing on critical Decision Support of governance – at central/state/district/local levels; citizens – for citizen services and also commercial/enterprises applications.

5.1.3.1. NATIONAL GIS METADATA STANDARD

195. National GIS Metadata Standard must define the schema required for describing geographic information and services as Metadata. The Standards must provide information about the description, source, generation, identification, extent, quality, spatial and temporal schema, spatial reference and distribution of National GIS. The cataloguing of datasets, clearinghouse activities, and the full description of datasets along with geographic datasets, dataset series, and individual geographic features and feature properties.

196. A National GIS Metadata Standards is required to organise and discover Metadata – including, descriptive information applied to each Content with common set of terms and definitions for documenting National GIS Content. The Metadata should include the following details:

196.1. Identification Information - basic information about the Content

196.2. Organisation information – which organisation is responsible and has generated the Content

196.3. Generation Information - how the Content has been generated– like from survey, from satellite images, from UAV sources etc.

196.4. Accuracy for Content – in terms of absolute value for positional, thematic and elevation or (any other) accuracies

196.5. Data Quality Information – a broad assessment of the quality of the spatial content – if it has been determined.

196.6. Attribute Information - information about the coding attribute

196.7. Access Information - information about accessing/ordering the spatial data set.

196.8. Disclaimer Information – any guidelines for usage and limits for use or Disclaimers

196.9. Cost information for the spatial data

197. NIAS suggests that National GIS Metadata Standards can be an Indian definition based on ISO 19115:2003 Metadata Standards[35], which defines:

197.1. mandatory and conditional metadata sections, metadata entities, and metadata elements;

197.2. the minimum set of metadata required to serve the full range of metadata applications (data discovery, determining data fitness for use, data access, data transfer, and use of digital data);

197.3. optional metadata elements - to allow for a more extensive standard description of geographic data, if required;

197.4. a method for extending metadata to fit specialized needs

[35] Geographic information – Metadata http://www.iso.org/iso/catalogue_detail.htm?csnumber=26020)

5.1.3.2. NATIONAL GIS CATALOG STANDARD

198. National GIS catalogue must be a schematic database that enables publish and search collections of Metadata National GIS Catalogue Standard are required to support the discovery and binding to registered information resources within an information community and these catalog could contain image Metadata, GIS-Ready Metadata, geo-tagged Metadata and feeders from other online services/feeds.

199. The National GIS Web Catalog standard must specify the schema, interfaces, relationships and a framework for defining National GIS Content and Apps. Catalogue services must support the use of several data-base query languages to find and return results using National GIS Data Dictionary and encodings.

200. The OGC Catalogue Services Interface Standard[36] is a robust standard that specifies a design pattern for defining interfaces to publish and search collections of descriptive Metadata of geospatial data, services and related information objects. In this standard, HTTP protocol binding for many environment are available - Web (CS-W), ebRIM and CSW profiles for (older) ISO 19115:2003 and ISO/TS 19139:2007.

201. NIAS recommends that the OGC Catalog Services Standards could be adapted for National GIS into a National GIS Catalog Services Standard.

5.1.3.3. NATIONAL GIS MAP SERVICES STANDARD

202. A Web Map Service (WMS) is a standard protocol for serving geo-referenced map images over the Internet that are generated by a map server using data from a GIS database. OGC has a very widely refereed and utilised standard for WMS[37] and the National GIS Map Service Standard is best to be compliant with OGC WMS so that the service standard can provide a simple HTTP interface for requesting geo-registered images and maps from the National GIS Portal. Such a request defines the National GIS content and area of interest to be processed/served. The result for the request can be a geo-registered web-compliant map or images (returned as JPEG, PNG, etc) that can be displayed in a standard browser application. OGCs WMS interface also supports the ability to specify whether the returned images should be transparent so that layers from multiple servers can be combined or not.

203. Similar to OGC WebMap Service, National GIS Map Service must specify a number of different request types but the 2 most popularly used are GetCapabilities - returns parameters about the WMS (such as map image format and WMS version compatibility) and the available layers (map bounding box, coordinate reference systems, URI of the data and whether the layer is mostly opaque or not) and GetMap - returns a map image. Parameters include: width and height of the map, coordinate reference system, rendering style, image format. Optionally, WMS may also include GetFeatureInfo - if a layer is marked as 'queryable' then you can request data about a

[36] OpenGIS® Catalogue Services Specification (http://portal.opengeospatial.org/files/?artifact_id=20555)
[37] OGC Web map Service Standard - http://www.opengeospatial.org/standards/wms

coordinate of the map image; DescribeLayer and GetLegendGraphic - return an image of the map's legend image, giving a visual guide to map elements.

204. In rendering National GIS Maps the Layer Legend and its defined symbolization and coloring of features is very important. National GIS must include in National GIS Map Services, details of symbolization and legend compliant specifications so that maps can be rendered with specified symbology. The ability to define styling rules requires a styling language that the client and server can both understand. Thus, National GIS Content Standard must generate a National GIS Content Symbology Standard which can be used in Map Services.

205. It is also important for National GIS Map Service to specify how individual GIS Service describe and provide National GIS content – basically the specific grouping of one or more GIS Content in a portable, platform-independent format for storage in a National GIS database and for transmission between GIS clients. This also needs to be specified in the National GSI Map Services standard.

206. NIAS recommends that National GIS Map Service be based on OGC Web Map Service specifications and SLD specifications.

5.1.3.4. NATIONAL GIS MAP TILING SERVICES STANDARD

207. A Web Map Tile Service (WMTS) is a standard protocol for serving pre-rendered geo-referenced map tiles over the Internet – which impacts performance considerably because it can overcome CPU intensive on-the-fly rendering by using pre-rendered map tiles. Map tiling improves distribution of images and maps and trades the flexibility of custom map rendering for the scalability possible by serving of static data (base maps) where the bounding box and scales have been constrained to discrete tiles. The fixed set of tiles allows for the implementation of a tiling service using a web server that simply returns existing tiles. The fixed set of tiles also enables the use of standard network mechanisms for scalability such as distributed cache systems.

208. The tiling system to be adopted must be compatible with National GIS Spatial Framework and address the 2 levels of National GIS Asset.

209. OGC has a Web Map Tile Service (WMTS)[38] for web based distribution of cartographic maps and is specified after considering earlier work of Google Maps and NASA OnEarth. This OGC standard includes both resource (RESTful approach) and procedure oriented architectural styles (KVP and SOAP encoding) in an effort to harmonize this interface standard with the OSGeo specification.

210. NIAS recommends that National GIS Tiling Service can be based on OGC Web Map Tiling services specifications.

5.1.3.5. NATIONAL GIS FEATURE SERVICES STANDARD

211. National GIS Portal Services will need an interface allowing platform-independent requests for GIS features. The National GIS Feature Service should enable National GIS Content to be created,

[38] OGC Web map Tile Service - http://www.opengeospatial.org/standards/wmts

modified, fused and exchanged through the Portal. Rather than sharing geographic information at the file level using File Transfer Protocol (FTP), for example, the feature service offers direct fine-grained access to National GIS Content at the feature and feature property level. Web feature services allow clients to only retrieve or modify the data they are seeking, rather than retrieving a file that contains the data they are seeking and possibly much more. This feature service is important to render thru WMS individual features and provide critical GIS capability to the national GIS Portal – rather than make it a "static image" rendering that cannot have GIS characteristics for editing, querying etc – thus, one can think of Feature Service as "database rendering " of a map – which is critical for National GIS Decision Support Services of extensive querying and applications services. Many other mapping portals may use a WMS interface but return only an image, which end-users cannot edit or spatially analyze. Thus, National GIS Feature Service is very important.

212. ISO specifies the Geographic information -- Web Feature Service[39], which is originated from OGC® Web Feature Service (WFS) Interface Standard[40] and enables clients to query servers containing collections of vector geographic features. The ISO 19142 Standard is widely used and adopted on GIS Portals.

213. NIAS recommends that National GIS Feature Service standard be based on ISO 19142/OGC WFS Standards.

5.1.3.6. NATIONAL GIS PORTAL ENCODING STANDARD

214. National GIS Portal Services will require encoding of syntax for expressing projections, datum, selection, sorting/indexing and query expressions. These could be individually required or maybe modular to be used together. National GIS Portal will have to deal with abstract query elements from which service specifications can be nested into a sub-query element that finally implements a query operation OR allows a client to specify a list of resource types, an optional projection clause, an optional selection clause, an optional sorting clause in the subset of resources that satisfy the selection clause. This pattern which will be an ad-hoc query pattern since the Portal may not still be aware of the query until it is submitted for processing. This is in contrast to a stored query expression, which is stored and can be invoked by name or identifier. It would be appropriate to create a XML and KVP encoding of a system-neutral representation of a encoding syntax – which can be easily validated, parsed and transformed into a server-specific language required to retrieve or modify object instances stored in some persistent object store.

215. ISO 19143:2010[41] defines the XML encoding of a standard set of logical predicates: and, or and not; a standard set of comparison predicates: equal to, not equal to, less than, less than or equal to, greater than, greater than or equal to, like, is null and between; a standard set of spatial predicates: equal, disjoint, touches, within, overlaps, crosses, intersects, contains, within a specified distance, beyond a specified distance and BBOX; a standard set of temporal predicates: after, before, begins, begun by, contains, during, ends, equals, meets, met by, overlaps and overlapped by; a predicate

[39] ISO 19142:2010 Geographic information -- Web Feature Service at http://www.iso.org/iso/iso_catalogue/catalogue_tc/catalogue_detail.htm?csnumber=42136

[40] OGC Web Feature Service - http://www.opengeospatial.org/standards/wfs

[41] ISO 19143:2010 Geographic information -- Filter encoding at http://www.iso.org/iso/iso_catalogue/catalogue_tc/catalogue_detail.htm?csnumber=42137

to test whether the identifier of an object matches the specified value; encoding of metadata that allows a service to declare which conformance classes, predicates, operators, operands and functions it supports.

216. NIAS recommends that the National GIS Portal Encoding Standard be based on ISO 19143:2010 Geographic information -- Filter encoding.

5.1.3.7. NATIONAL GIS EXCHANGE STANDARD

217. National GIS Exchange Standards are essential for storage of National GIS Content modelled in accordance with the Data Dictionary and including both the spatial and non-spatial content and for neutral interchange and exchange of National GIS Content and its transport and migration.

218. NSDI Exchange standards are obsolete as they are based on older SOI DVD data and are not GIS compliant.

219. On other hand, ISO 19118:2011 Geographic information – Encoding[42] and compliant OGC Geography Markup language (GML) specifies requirements for creating encoding rules based on UML schemas, requirements for creating encoding services, and requirements for XML-based encoding rules for neutral interchange of data.

220. NIAS recommends that National GIS Exchange Standard be based on ISO 19118:2011 Geographic information – Encoding BUT it would be appropriate to value-add to the ISO Standard to include online images, transfer services or transfer protocols.

5.1.3.8. NATIONAL GIS WEB COVERAGE SERVICES STANDARD

221. National GIS Portal will have to offer retrieval and serve multi-dimensional GIS Content as “coverages” – that is, digital geospatial information representing space/time-varying phenomena. Unlike static maps which rendered as images/pictures by the Portal or unlike features which display as discrete features, a coverage service is essential to serve National GIS Content with their attributes/descriptions. Such a service would require rich syntax for requests on national GSI Content to return with original semantics (instead of pictures) which may be interpreted, extrapolated, etc. and not just portrayed.

222. OGC Web Coverage Service[43] is based on the coverage model of the GML Application Schema for coverages which has been developed with the goal that coverages handled by a WCS can be more easily interchanged with other OGC services.

223. NIAS recommends that national GSI may consider OGC Web Coverage Service for basing its National GIS Coverage Service, if essential.

[42] ISO 19118:2011 Geographic information – Encoding at http://www.iso.org/iso/home/store/catalogue_tc/catalogue_detail.htm?csnumber=44212

[43] OGC Web Coverage Service at http://www.opengeospatial.org/standards/wcs

5.1.3.9. GEORSS SIMPLE STANDARD

224. National GIS must use the GeoRSS standard for encoding location as part of a Web feed or "channels" of content - such as news articles, real-time point data, geo-blogs and other aggregators into web browsers. The feed data has a location-tag - geographical points, lines, and polygons of interest and related feature descriptions. GeoRSS feeds would be required to be consumed by National GIS Portal for map generators.

225. National GIS could use GeoRSS-Simple – which is a very lightweight format that supports basic geometries (point, line, box, polygon) and covers the typical use cases when encoding locations and is more generic for embedding into GIS.

5.1.3.10. NATIONAL GIS SMS INGEST STANDARD

226. Smartphone and text-phone Simple Messaging Service (SMS) data would have to be ingest into National GIS and this will require extended SMS encoding and interface to facilitate communication of location content between in a LBS (Location-Based Service) on National GIS Portal applications.

227. OGC Open GeoSMS Encoding Standard[44] facilitates communication of location content using SMS feature to achieve interoperable communications while still maintaining human readability of the content.

228. NIAS recommends that National GIS could use the OpenSMS Standard for basing its National GIS SMS Ingest Standard.

5.1.3.11. NATIONAL GIS APPLICATIONS STANDARD

229. National GIS Applications Services requires web/mobile GIS processing capability as rules for standardizing how inputs and outputs (requests and responses) for GIS processing services, such as polygon overlay, clips, buffers, distance measurement, line-of-sight, visibility proximity etc can be performed on National GIS Portal. GIS processes could include algorithms, calculations or models that operates on national GIS content. This capability is extremely important for establishing various Decision Support capabilities for National GIS.

230. Of course, GIS processes would vary for each of the Applications planned for each ministry/ department and thus, definition of the GIS Applications requirements is essential. National GIS Applications should be first defined and then the Applications Standard for each application would have to be specified. The standard must also defines how a client can request the execution of a App Process, and how the output from the App is to be handled on WMS/WFS. It defines an interface that facilitates the back-end series of GIS functional processes and binding of National GIS Content to those processes.

231. OGC has a Web Processing Service (WPS)[45] and the same could be referred to for defining National GIS Applications Standard.

[44] OGC OpenSMS Encoding Standard at http://www.opengeospatial.org/standards/opengeosms

[45] OGC Web Processing Service (WPS) at http://www.opengeospatial.org/standards/wps

TABLE – 5.1 RECOMMENDED NATIONAL GIS CONTENT

No.	CATEGORY	NGIS ASSET CONTENT					
		Minimum Primary Content			Essential Addtional content		
		CONTENT	Details	Possible Source	CONTENT	Details	Possible Source
1	**BOUNDARY**	National	External boundary of India	SOI Toposheets and 2.5 mt satellite images for Southern India boundary updation	Ward Boundaries	Ward boundaries for each city	City Municipalities, Urban Authorities, TPD
		State	State boundary - SOI	SOI Toposheets	Heritage Site/ Archaeological site boundary	Boundaries of heritage and ASI notified sites	ASI or State Heritage/Culture departments
		District	District boundary - SOI	SOI Toposheets			
		Taluk and Block	Sub District boundary	SOI Toposheets/ State Revenue tables			
		Panchayat	Panchayat Boundaries	Aggregated from SOI toposheets, Village Maps or from NIC, Census or RD&Panchayat Taluk Maps			
		Village	Village boundaries	State Survey Settlements and Land Record Taluk maps or NIC GIS maps abstracted from the village maps			
		Census EB	Census Enumeration Block Boundaries	Abstracted from village boundaries or from Census of India			
		Parliament constituency Boundary	Parliament constituency Boundary	NIC GIS maps abstracted from the village maps and Election Commission			

No.	CATEGORY	NGIS ASSET CONTENT					
		Minimum Primary Content			Essential Addtional content		
		CONTENT	Details	Possible Source	CONTENT	Details	Possible Source
		Assembly constituency Boundary	Assembly constituency Boundary	NIC GIS maps abstracted from the village maps and Election Commission			
		Metro/Urban Development Authority Boundary	Metro Region/ Development Authority boundary	Metro Region/ Development Authority			
		Watershed and Command area boundaries	Watershed - Region, Basin, Catchment, Sub catchment, Sub watershed, Mini watershed Boundary	Soil & Land Use Survey of India			
		Forest boundaries	Forest Circle, Division and Range boundaries	Forest Survey of India and State Forest Dept.			
		Marine and Ocean Boundaries	Boundaries of EEZ, other marine assets etc	Min of Earth Science			
2	**CULTURAL FEATURES**	Rail lines	Rail Lines Gauge Wise	SOI Toposheet Supplemented by Indian Railways			
		Railway Station	Rly Station Point Locations	Survey of India Toposheet , Indian Rlys			
		Roads	All roads (EW/NH/ SH/DR/ODR/VR/ FWR/Tracks)	SOI Toposheet, NHAI, NRRDA			

No.	CATEGORY	NGIS ASSET CONTENT					
		Minimum Primary Content			Essential Addtional content		
		CONTENT	Details	Possible Source	CONTENT	Details	Possible Source
3	HYDROLOGY CONTENT	Surface water bodies	All surface water bodies with attributes	SOI and 2.5m Pan and LISS 3 23.5 m IRS data MOWR			
		Drainage	Rivers, Streams, Canals others from satellite images and also from SOI maps	Survey of India Toposheet & PAN + LISS III Merged			
		Canals	All Canal systems	Survey of India Toposheet & PAN + LISS III Merged SLUSI Maps			
		Ground water prospects	Groundwater Prospect	MORD/NNRMS and CGWB			
		Groundwater Well Locations	Point Location of Wells	Department of Mines & Geology & Central Ground Water Board			
4	URBAN AND SETTLEMENT CONTENT	Settlement Points	Point Location of settlements	Survey of India Toposheet	Hamlet Points	Point location of Hamlets/habitation as defined by Census	Survey of India Toposheet & 2.5/1m satellite images
		Built-up Areas	Built-up polygons of built-up areas	Survey of India Toposheet &2.5/1m satellite images	Urban Property	Point of Polygons of Urban Property	City Municipalities
		Urban Landuse as per NUIS	Urban area landuse maps as per NUIS for all cities landuse/ building-level information	TCPO and State Town Planning Deptts. And fresh mapping from HR satellite images			

No.	CATEGORY	NGIS ASSET CONTENT					
		Minimum Primary Content			Essential Addtional content		
		CONTENT	Details	Possible Source	CONTENT	Details	Possible Source
5	ENVIRONMENTAL CONTENT	Biodiversity/ Vegetation richness	Vegetation richness and biodiversity maps	DBT/NNRMS, Satellite Images	Environmental Hot-Spots	Points/Areas of environmental hot hotspots/ pollution areas	Env Dept/C&I
		Wetlands	Wetland maps available	MoEnF/NNRMS	Vegetation outside Forests	Forest Types maps	FSI, State Forest Depts.
		Coastal wetland	Coastal wetlands	MoEnF/ NNRMS, Satellite Images	Water Quality Measurement points and data	Point locations of measurement points	SPCB/CPCB
		Forest Cover	Forest types and Densities maps of FSI	FSI, Satellite Images	Air Pollution Monitoring Points	Point locations of air-pollution stations; Average Daily SPM, NOX, CO measurements	SPCB/CPCB
		Glaciers	Glacier Maps	MoEnF/ NNRMS, Satellite Images			
6	GEOLOGICAL CONTENT	Geomorphology	Geomorphic Maps	GSI	Mineral Locations	Mineral Point Locations	GSI, State Deptts of Mines and Geology
		Lithology	Lithology Maps	GSI	Mine Locations	Locations of Mines as per GSI/MOM data	MOM/GSI
		Structures	Structures Map information	GSI			
7	LANDCOVER/ LANDUSE CONTENT	Wastelands	Wastelands Mapped also as part of LULC	MORD/NNRMS	Coastal Landuse	Coastal Landuse	NRSC, Min of Env.
		Landuse /landcover	Landuse/Landcover	NNRMS, NRSC, Satellite Images			
8	LAND OWNERSHIP INFORMATION	Land Ownership	Land ownership or Cadastral maps	States/NRLMP	Urban Property	Boundaries of Urban Properties	City Municipalities

No.	CATEGORY	NGIS ASSET CONTENT					
		Minimum Primary Content			Essential Addtional content		
		CONTENT	Details	Possible Source	CONTENT	Details	Possible Source
9	**TERRAIN INFORMATION**	Slopes	Slope from SOI topographic maps or Cartosat 2.5m stereo	SOI, NRSC	DEM (Specific areas)	DEM from 1m stereo or Ground Survey	~0.5m stereo images or Engineering data (??) or Special LIDAR surveys from aerial flights or UAVs
		DEM (~10m accuracy)	DEM from SOI topographic maps or Cartosat 2.5m stereo	SOI			
10	**SOILS INFROMATION**	Soils Association	Soil association / series	NBSSLUP	Soil Phase level	Phase level Soil data - maybe for limited areas	NBSSLUP/State Soils Department
		Land Degradation	Degraded lands maps	SLUSI			
11	**IMAGES**	Satellite Images	55m Wifs every month; 23m LISS every 3 months; 5.8m LISS every year; 2.5m/1m images - every year; 0.3m as required	NRSC, Commercial Images	Special Images	Images from special UAS or aerial images	Special campaign mode images for specific areas - cities, disasters, forests etc
					Geo-tagged photos	Geo-tagged pictures/photos that can be of any feature reference	Special campaign for geo-tagged photos or from crowd sourced methods

No.	CATEGORY	NGIS ASSET CONTENT					
		Minimum Primary Content			Essential Addtional content		
		CONTENT	Details	Possible Source	CONTENT	Details	Possible Source
12	**PUBLIC ASSETS/ AMENITIES**				Government Properties/Assets	Government Offices; Post Offices; Police Stations; Fair Price Shop; Farmer Kendra; Market Place; Milk Dairy; Co-operative Society; Banks; Bus Stand; Fire Station; Library; Forts etc	GPS Surveys and Dept. Asset Data attributes
					Water Supply & Sanitation Assets	Points of Tank/ Pond/Lakes/ Reservoirs; Bore Well; Open Well; Mini Water Scheme Tank;. Over Hand Tank; Control Valve; Public Tap; Public Toilet; Check Dam etc	
					Educational Assets	Schools, Colleges, universities, ITI, Hostels, Anganwadis etc	
					Health Assets	PHC, HC, Dispensary, Nursing Homes, Hospitals etc	
					Community Features	Temples, Mosques, Churches, Gurudwara, Other religious places, Burial grounds, Veterinary Centres etc	

No.	CATEGORY	NGIS ASSET CONTENT					
		Minimum Primary Content			Essential Addtional content		
		CONTENT	Details	Possible Source	CONTENT	Details	Possible Source
					Power Assets	Transformers, Sub-Stations, Street-Poles, Street-lights etc	
					Roads/Rail Assets	Points for Roads, Bridges, Railway Station, railway Crossings etc	
					Communication Assets	Telephone Exchange; Communication towers, Ports, Lighthouses etc	
					Tourism	Tourism Sites, Hotels, Tourism points, Tourist Information Centres etc	
					Heritage sites	Points of archaeological and heritage sites etc	
					Others	Any other Asset points that can be identified	
13	**MET AND CLIMATE DATA**	Met Data Collection points	Location of points	MoES	Average Daily Met Data -	Average daily met data - temp, rainfall etc	MoES, States
14	**OCEAN STATE DATA**				Ocean state data - winds, waves	Average wind and wave data - monthly ???	MoES
15	**PFZ DATA**	PFZ	Daily Potential Fish Maps	MoES			

No.	CATEGORY	NGIS ASSET CONTENT					
		Minimum Primary Content			Essential Addtional content		
		CONTENT	Details	Possible Source	CONTENT	Details	Possible Source
16	POINTS OF INTEREST				Food/Hotel	Coffee Shops; Restaurants; Road side dhaba; Juice shop; Hotels; Guest House	From GPS Survey with attributes
					Utilities	Banks; ATMs; Gas Stations; Grocery Stores; Major Retails; Libraries; Post Offices; Crematorium; Burial grounds; Auto repair; Photo studio; Others	
					Entertainment	Movie Theatre; Auditorium; Resort; Theme Parks; Stadium etc	
					Health & Wellness	Pharmacy; Hospitals; Blood bank; Pathological labs; Clinics/ Dispensaries; Health centers; Gym; Spa; Beauty parlors; Veterinary hospital;	
					Shopping	Shopping Malls; Commercial; Grocery; Furniture etc	
					Emergency	Police Stations; Ambulance Services; Fire station etc	

No.	CATEGORY	NGIS ASSET CONTENT					
		Minimum Primary Content			Essential Addtional content		
		CONTENT	Details	Possible Source	CONTENT	Details	Possible Source
					Tourism	Museums; Historical places; Memorials; Sanctuaries and parks; Beach etc	
					Education	Schools; University; College; Vocational college etc	
					Buildings	Govt Building; Commercial; Prison; Court;	
					Transportation	Airports; Rail Station; Subway; Waterways; Traffic Junction; Traffic Light; Rotunda; Bus station; Traffic Direction; etc	
					Recreational	Park; Golf Course; Playground; Gym etc	
					Religious	Praying place	
17	**CITIZEN DATA**	Crowd soured data	Points and attributes populated from Citizens	From GPS SmartPhone data sources			
18	**GEOGRAPHICAL NAMES**	Geographical names	Names of Geographic Objects and Land marks	To be compiled			

TABLE – 5.2 NATIONAL GIS DATABASE STANDARD

No.	Parameter (All values at 3 σ)	NATIONAL GIS	
		NATION-WIDE (1:50000 / 1:10000)	CITY-GIS (1:10000 /1:1000)
A]	**IMAGE CONTENT**		
1	Base Image	2.5 m OR 1 m	1 m OR 0.3 m
2	Image Content	55m-WiFS; 23 m LISS; 5.8m LISS; 2.5m PAN; 1m PAN	5.8m LISS; 2.5m PAN; 1m PAN; 0.3m PAN or special image resolution
2	National Spatial Framework for Image	1:50K National Spatial Framework (SOI to establish) AND 1:10000 updated National Spatial Framework (SOI to establish)	City-wise sub-Spatial Framework dove-tailed into 1:50K/1:10K National Spatial Framework
3	Projection for images	UTM	UTM
4	Datum for image	WGS 84	WGS 84
5	Tiling Frames	3' X 3'	Customised
6	Planimetric Accuracy (2 pixel) in m	Always better than 5 m	Always better than0.5 m
7	Band-to-Band Registration for XS data (0.25 pixel) in m	Always better than 1.25 mts	-
8	Image Bits	Minimum 8 bits	Minimum 8 bits
B]	**MAP CONTENT**		
1	National Spatial Framework	1:50K National Spatial Framework (SOI to establish) AND 1:10000 updated National Spatial Framework (SOI to establish)	City-wise sub-Spatial Framework dove-tailed into 1:50K/1:10K National Spatial Framework
2	Minimum Map Frame size for incorporation to National GIS	3' X 3' tile or village-unit or ward unit	Customised
3	Map to Spatial Framework Registration tolerance (0.25mm of scale)	12.5 m OR 2.5 m	2.5m to 0.25 m
4	Map Projection	UTM	UTM
5	Datum	WGS 84	WGS 84
6	Position (Planimetric) Accuracy of Map in m	50 m OR 10m	1 m
7	Minimum Spatial Unit (MSU) (3 x 3 mm of scale) in sq mts	900 m to 9m	9 m to 1m
8	DEM Z-Spacing as 1mm of scale in m	10 m	1 m
9	DEM Z-Accuracy in m	5 m	0.5 m

No.	Parameter (All values at 3 σ)	NATIONAL GIS	
		NATION-WIDE (1:50000 / 1:10000)	CITY-GIS (1:10000 /1:1000)
10	Accuracy of Classification/ Mapping	90/90	90/90
11	Coordinate System	Geographic	Geographic
12	Coordinate Movement Tolerance (CMT) for ingest to National GIS database (0.125mm of scale) in m	1.25 m	0.25 m
13	Weed Tolerance (WT) for ingest into National GIS databse (0.125mm of scale) in m	1.25 m	0.25 m
14	Sliver Polygon Tolerance (SPT) (LESS-THAN MSU) in m	<900 m	<9 m
C]	**GEO-TAGGED DATA**		
1	Geo-tag registration to Spatial framework	12.5 m OR 2.5 m	1m
2	Super-imposed Points for geo-tag	Allowed	Allowed
3	Geo-tag point to Spatial Framework Registration tolerance (0.5 mm of scale)	25 m OR 5 m	5m to 0.5mm
D]	**CROWD-SOURCED DATA**		
1	Point registration to Spatial framework	As received from crowd-source	As received from crowd-source
2	Super-imposed Points for geo-tag	Allowed	Allowed
3	Point to Spatial Framework Registration tolerance	As received from crowd-source	As received from crowd-source

6. National GIS Spatial Framework

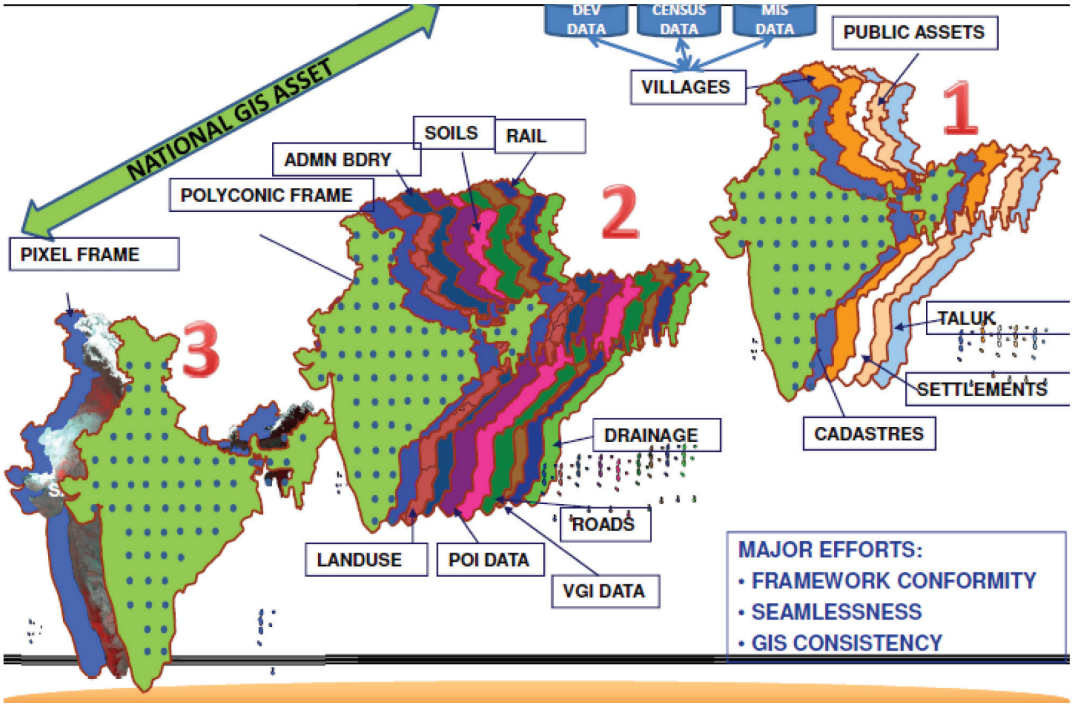
232. The National Spatial Framework (NSF) is a critical and essential element to develop an authoritative and reliable National GIS Asset. Just like for a building, the "foundation" is critical – if one gets the foundation in error then the building does not have longevity and impacts intended use. Unlike a project GIS for small area, in National GIS the frame of India (as a whole nation) has to be correctly and accurately positioned and represented – in terms of coordinates, distances, area etc.

233. In the National GIS system, unlike when one develops a small-project specific GIS, India (as a nation) has to be correctly and as-accurately represented – in terms of its coordinates, distances, area etc. This needs to be done by geographic referencing all information (like in an Atlas the coordinate grid does). While this looks easily doable – the complexity comes in when different "primary source" data are put together.

6.1. FOUR "DATA-FRAMES" IN NATIONAL-GIS

234. For National GIS, content will come from any of these 4 basic sources:

234.1. Satellite image – the satellite image is on a "pixel-frame" with a Earth-reference lat-long coordinate system super-imposed based on satellite ephemeris and ground control corrections – thus, each pixel of the image is given a geographic coordinate referenced.



The 3 "data frames" for National GIS – pixel-frame of satellite images, administrative frame and SOI/survey geographic frame

234.2. Data/Maps based generated using the geographic frame of SOI OSM maps – thus maps generated in this manner also get a geographic lat-long coordinates referenced

234.3. Ground surveys (using instrument like GPS/TS and Smartphones etc) – by which lat-long coordinates of the instrument positioning devices (commonly using positioning satellites – GPS, Glonass or in future IRNSS) – thus any survey data gets geographic coordinates referenced

234.4. Administrative frame of India - villages/taluk/district/state/nation on which all administrative data and governance are associated. This does not really have an inherent or its own basic geographic lat-long frame UNLESS processed with the former 3 to associate coordinates referencing system.

In our study of GIS data of different Indian (as well as foreign portals), we have seen the in-consistency in large measures. For example, Bhuvan administrative boundaries DO Not match with Surveykshan administrative boundaries; Bhuvan's 1:50k wasteland DO Not match with 1:10k landuse; NICGIS has its own roads that DO NOT match with Bhuvan roads; GoogleEarth points-of-interest data DO NOT match with Bhuvan points; MapmyIndia rail-lines do not match with Bhuvan rail-lines……and so on are many examples.

6.2. CO-REGISTERING FOUR "DATA-FRAMES" – CRITICAL STEP FOR NATIONAL-GIS

235. For National GIS, it is extremely important to be able to spatially cross-reference across these 4 sources – else, there would be in-consistency and mis-match in geometry and juxtaposition of features. The coordinate systems of these 3 sources should not compound to differences in locations of same features, distances and area measurements – LEADING TO USER CONFUSION. By developing and making available a NSF – which could be a "one-time effort", such errors, inconsistency etc can be avoided and reliability and robustness of National GIS ensured.

236. If this is not taken up in a serious manner for National-GIS, users of National-GIS services (when accessed by citizens, government and other users) would be "confused" and soon dis-enchantment can happen. What will be the confusion like (subject to limits of National GIS Standards), here are some possibilities:

236.1. Indian administrative shape and contours could appear different and thus, its area and distances and coordinates would be different than what is known. India as a country has a specific geographic reported area (3.29 m sq kms) and this has to be depicted for the nation in National-GIS. So will it be for states and districts – as each has a reported area and these have to conform.

236.2. Distances measured between features in India in National GIS cannot be different from actuals (except for margin of errors) and need to conform – say, GIS cannot have different distances from 2 points or cities and so on. National GIS has to ensure this.

236.3. Points from different data sources (say, Delhi "point" as on satellite images and Delhi "point" as in a landuse map must match; roads must match with official NHAI/SOI

roads; rail-lines must match with official Railway departments/SOI rail-lines and so on)

236.4. Any survey from Positioning/TS on ground must be referenceable to the actual point on National GIS within accuracy limits. So when a Post-office or a school or an ATM is surveyed on ground, it must be located on National GIS to its true position after verification.

236.5. Land ownership boundaries (or cadastral maps) will be "force-fit" into the National-GIS frame at its lowest unit of a village by satellite image geo-referencing and then "aggregated into the taluk/district/state units. This will have local errors in ownership boundaries but will be sufficient for planning, development, administrative decision-support and less suited for legal transactional decisions.

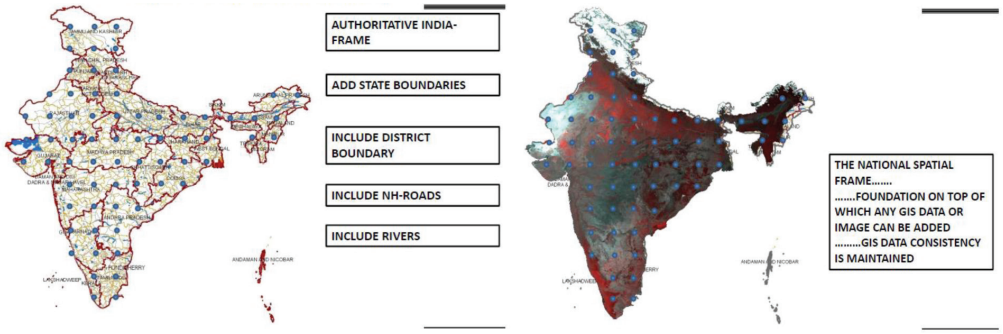
237. To avoid the above, the key is to develop a NSF where a "one-time effort" is made to standardize the reference of satellite-image based coordinates; SOI OSM based coordinates and GPS/TS based coordinates. For this one time exercise, it would be essential to use a SOI topographic map's geographic frame for precise national boundary (this is presently available on 1:50k); the best-accurate Indian administrative boundary frame (state/district/taluk boundaries – this is available in 1:50k SOI OSM maps); the best-resolution satellite-image for India (which is corrected using GCPs – would be good to use ~1m images as they are available) and "fuse-integrate" these 3 together to create the basic foundation frame – so that this foundation can easily assimilate the features coming out from satellite images or features of SOI OSMs and the administrative frame. It would be essential to use a set of Ground Control Points (precision measured coordinates in this frame) that can be super-imposed on the precision Indian boundary layer and create cross-referencing to satellite images and for local referencing – thus also ensuring in the GIS that a "tight pinning-down" of the frame to Indian land-mass. Integrating village boundaries will be easy into the taluk boundaries (of the administrative boundary frame) and thus creating a seamless village layer for the country. When any local survey is done, the GCP frame will provide a cross-referencing to the survey points to the NSF – thus the data will "sit properly".

238. **This way the NSF will become the basic frame for any GIS data in National GIS BUT more importantly ensure that all GIS data are co-registered - and should form the base of all Image, OSM and survey activity – so that any GIS data emanating from these follow the same spatial reference. This NSF (which will be a set of features in GIS Ready form with additional metadata on National Tie Points) AS A TEMPLATE should be freely and easily available to anybody to use – thereby ensuring that other GIS data can also be ingest into National GIS.**

6.3. DEVELOPING THE NSF FOR NATIONAL-GIS

239. National GIS will require the development of a rigid National Spatial Framework (NSF) definition – which initially can be defined equivalent to 1:50k SOI Open Series Maps (with the available geodetic framework) and up-scoped to 1:10k National Spatial Framework (as and when the next depth of boundary data and geodetic framework is available). **The National GIS Spatial Framework should be able to bring a cross-correlation between the 3 datasets – administrative, satellite images and the SOI/survey data into a "common" National GIS foundation.**

240. While WGS-84 datum can be standardised, it is important that the geographic projection be adopted for National GIS. This would enable maintaining the "centrality" of projection measurements and metrics (of area, perimeter, shape etc) and at the same time enable delivery in any projection on the fly to the user, as a service. This would also enable the dove-tailing to the International Terrestrial Reference Frame (ITRF) globally (thereby positioning India geographically in correct position of the global frame).



A "common" spatial framework between satellite images, administrative maps and SOI/survey data – linked through a standard geo-referencing points

241. NIAS proposes National Spatial Framework as an accurate spatial referencing of an authoritative India Frame (including international boundary, state boundary, district boundary and taluk boundary of India) so that Earth coordinates of India are referenced as precisely to the India Frame. Referencing satellite images and ground survey data is easier as they have their own coordinates – which if linked to coordinate system of NSF, the referencing is easily achieved. In this manner, the 4 sources of information can be cross-referenced suing the NSF at any time and ingest of any GIS data into National GIS can be easily achieved using NSF.

242. The NSF will would require the establishment of a network of National GIS Spatial Reference Points (SRP), akin to a Ground Control Point (GCP), across the country. The network can be of estimated as 8-10 Reference Points per district – thus about 5000 Reference Points. In addition, there can be 2 Test Points for each district – thus about 1300 points. A total of ~6000-7000 points are estimated covering the whole country for the National Spatial Framework GCP network which will be:

242.1. determined by precise Positioning measurements – for which use of high-order Virtual Referencing System (VRS) Position fix and a denser lower-order Positioning observation can be conjugated.

242.2. identifiable on satellite images of 1m so that image coordinates are "linked in" to the Spatial Frame and cross-referencing across images can be achieved.

242.3. marked/referenced on the SOI OSM national boundary frame so that the administrative boundaries are "linked in " to the NSF.

242.4. be used to ingest ground survey and crowd-sourced data so that these ground data is "fixed in" to the Spatial Frame.

242.5. be always used to cross-reference (during ingest) the Image, Administrative and Frame and Survey Data and crowd-sourced data into National GIS.

243. **Indian satellite images from IRS system (and even from foreign satellite images) must be made available to users referenced and co-registered to the NSF as a value-added product from NRSC/Satellite Operators (it should not be left to every user to undertake the co-registering operation as it will be an un-necessary overhead on users and also result in variable-processing accuracies). This must be a part of the Indian Remote Sensing Data Policy (RSDP) as a commitment to Indian users.**

244. Thus, NSF would include the following 3 "frame-features:

244.1. National GIS SRP – set of GCP points (with image chip for reference and precision coordinates)

244.2. National GIS India administrative frame – international boundary + state/district/taluk boundaries

244.3. Satellite Image frame (atleast 5.6m BUT 1m would be good)

245. **NSF must be available as a template product from National-GIS and must be licensed to use for any user BUT form the foundation for National GIS. NSF must be the basis of verifying "compliance check" before any ingest of GIS data to national GIS Asset (apart from National-GIS standards check).**

6.4. NATIONAL SPATIAL FOUNDATION DATASET (NSFD)

246. The NSF could easily be used to make the National Spatial Foundation Dataset (NSFD) product – a basic 1st generation derivative product from national GIS. This NSFD should include:

246.1. NSF – the basic template

246.2. Seamless NH/SH/District Roads (referenced to NSF and as per National GIS Standards)

246.3. Rivers/Drainage (referenced to NSF and as per National GIS Standards)

246.4. Lakes/Ponds/Reservoirs (referenced to NSF and as per National GIS Standards)

246.5. State Capitals/District HQ/Taluka HQ points (referenced to NSF and as per National GIS Standards)

246.6. Satellite image (say, 1m images AND coarser)

246.7. Any other data (as required)

247. The NSFD should be a product deliverable for any specified geographic area – a rectangular area, a named area like a district/village etc or for large geographic areas like command areas, urban regions etc. In our view, the NSFD product will be in great demand as a basic template for further GIS activities – whether surveying, mapping, GIS database etc.

248. **The NSFD could be available as a National GIS product with utmost ease and on non-discriminatorily basis to anybody in India to use – thereby ensuring that all derived GIS data can be is referenced to National GIS.**

7. Technologies for National GIS – An Assessment

249. National GIS implementation will require India to develop and acquire technological capability in key areas of GI - a suite of technical capabilities that India must have in the areas of Surveying and Data Collection – be it from ground survey equipment, precise positioning systems, Satellite Imaging and Data collection, Aerial Imaging and data collection and other emerging metric systems; modern mapping systems – including web-mapping, geo-tagged data mapping, 2d and 3d mapping products etc; building and managing GIS databases – including clustered GIS warehousing and mining, embedded geospatial databases etc; GIS Applications and total GI systems development technologies. These technologies should ultimately enable Indian government, private and individuals to "build" the most appropriate National GIS system to provide effective GIS applications services and also for easy usage/access to National GIS data and GIS Applications.

250. National GIS must also assess futuristic applications that would be "demanded" from National GIS and also envision the broader GI eco-system in India that will come to fore in next 10-15 years and create a roadmap of GIS applications development – identifying the key areas, the data required, the technologies required and also the market dynamics and policy scenario that will drive in next 10-15 years.

251. NIAS believes that there is an urgent need for India to define and assess key and critical technology and applications elements that would be important for National GIS – so that the ultimate goal of India to maintain and provide efficient GIS services and emerge leadership in global arena in GIS is possible. This assessment template needs to be the foundation for any user to build GI and participate in National GIS.

252. NIAS has undertaken a tentative mapping of the GIS technologies of importance and in tune with the envisaged needs in the country. A broad assessment is given in **TABLE – 7.1**.

253. India also needs to implement the GI Policy[46] that can be the next-generation thrust of National GIS and that which can promote the growth of the GIS technology and its wide usage and importance for National GIS.

[46] Ibid 2

TABLE – 7.1: IMPORTANT TECHNOLOGIES FOR NATIONAL GIS

Category	Technology	Brief Description	Relevance to National GIS
Imaging	Satellite Imaging	Satellite imaging is a major input for any GIS activity- either directly as images which forms the spatial content of GIS or indirectly for mapping different features in temporal domain. Today satellite images are available in PAN or XS from 1KM, 55m, 23m, 5.8m, 2.5m, 1m from IRS satellites in India. Digital globe and other commercial satellite provide data upto 0.5m resolution. Most of the mapping requirements of about 1:4000 can be met with satellite images. Satellite imaging is the only method of frequently updating map information for change analysis applications Satellite images are also fundamental for display and visualization application in a GIS portal.	Satellite imagery based mapping is the most optimal source of data for mapping at National level. The satellite imaging will support generation of GIS databases at 1:50000, 1:10000 scales with appropriate contents and accuracy stipulated in the NGIS standards. as envisioned in NGIS, the satellite data can support both National level as well as settlement (urban) level GIS databases. Satellite imaging provides periodic updation as well as a source for temporal reference. The NGIS standardized processes, contents and accuracies will regulate GIS outputs for jobs undertaken by private enterprise.
	Aerial Imaging	Aerial photography is the taking of photographs of the ground from an elevated position. Platforms for aerial photography include fixed-wing aircraft, helicopters, multirotor Unmanned Aircraft Systems (UAS), balloons, blimps and dirigibles, rockets, kites, parachutes, stand-alone telescoping and vehicle mounted poles. Large scale Precision mapping at scales greater than 1:2000 can be mapped with wide application in urban and settlement level mapping, cartography (particularly in photogrammetric surveys, which are often the basis for topographic maps), land-use planning, archaeology, movie production, environmental studies, surveillance, commercial advertising, conveyancing, artistic projects and Environmental Site Assessments for property analysis. Types of aerial photography include **Oblique, Vertical, Combinations and Orthophotos**	Aerial Imaging support large scale (1:2000) Products offer an alternate data source for mapping and support large scale GIS data base development for settlement/ urban areas. This source will assets in mapping features such as buildings, urban properties, transportation terminals etc.

Category	Technology	Brief Description	Relevance to National GIS
	Drone Imaging	Drone systems are a high technology products designed for low-altitude acquisition and production of 3-dimensional spatial and metric information for territory high-precision cartographic surveys. At the standard flying height of 150 meters above ground level, we can get a image output of 5 cm. Drone images are helpful during critical factor for decision making and measures implementation.	In National GIS Drone images can be used for large scale mapping. It can be useful in disaster management, Geological Survey, Urban Planning Survey, Crowd Management and Flood mapping.
Surveying/ Positioning	Electronic Distance Measurement (EDM)	A surveying instrument that utilizes an infrared or laser beam to measure the distance from the source point to a defined target point. The data obtained from the EDM is stored in a data collector and later downloaded for processing using computer drawing software. It can achieve an accuracy of +/- (1 mm + 1 ppm) to +/- (10 mm + 5 ppm). Simple hand-held EDMs are widely available; more sophisticated versions are usually incorporated in a total station.	EDM is useful in National GIS for topographic surveying or to set out features (such as roads, houses or boundaries). They are also used by archaeologists to record excavations and by police, crime scene investigators, private accident reconstruction and insurance companies to take measurements of scenes, Mining, Building Constructions.
	GPR	Ground-penetrating radar (GPR) is a geophysical method that uses radar pulses to image the subsurface. GPR uses high-frequency (usually polarized) radio waves and transmits into the ground. The depth range of GPR is limited by the electrical conductivity of the ground, the transmitted center frequency and the radiated power. Engineering applications include nondestructive testing (NDT) of structures and pavements, locating buried structures and utility lines, and studying soils and bedrock. One of the other main applications for ground penetration radars to locate underground utilities, since GPR is able to generate 3D underground images of pipes, power, sewage and water mains.	In the context of NGIS the GPR technology utilization is limited to requirements at urban settlement level involving large scale databases such as 1:4000 upwards. its application are useful in governance with relation to implementation and monitoring utilities such as Water, Power, sewage and communication network services. With regard to its utility has relevance in utility network mapping at large scales >2000 as well as positioning accuracy in settlements and urban areas.

Category	Technology	Brief Description	Relevance to National GIS
	Airborne LIDAR	Airborne LIDAR system, which integrates a laser scanner, a Global Positioning System (GPS) and an Inertial Measuring Unit (IMU), has become a reliable technique for collecting data of the earth surface Using airborne LIDAR technology, a dense (3-4 points per square meter horizontal) and accurate (5-10 cm vertical) DSM (Digital Surface Model) can be obtained **Airborne Lidar Bathymetry:** Airborne LiDAR bathymetry is used to measuring the depths of moderately clear, near-shore coastal waters and lakes from a low altitude aircraft using laser beam Airborne LiDAR can estimate of ground elevation every few square meters. **Airborne Lidar Topography:** Airborne LiDAR topography can be used to collect elevation data through elevation model, conventional ground surveys, photogrammetric and from remote sensing. Airborne lidar topography is an active sensing system which uses light and laser light to measure distance. For accurately measuring the distance, Airborne LiDAR topography system uses global positioning system(GPS) technology. The technology is capable to collect elevation data with an accuracy of 15 cm **Airborne LiDAR Hydrography:** With the help of Airborne LiDAR hydrography technology we are able to use scanning technology to survey coastal waters, seabed depths and topographic features accurately.	In National GIS we can use LIDAR image to prepare 3D data in terrain information. Information from LIDAR can be useful in the fields of Agriculture, Archaeology, Biology and conservation, Geology and soil science, Mining, Surveying, Transportation Sectors

Category	Technology	Brief Description	Relevance to National GIS
	Mobile Mapping	Mobile mapping is the process of collecting geospatial data from a mobile vehicle typically fitted with digital camera, radar, laser, LiDAR or any number of remote sensing systems. Such systems are composed of an integrated array of time synchronized navigation sensors and imaging sensors mounted on a mobile platform. The primary output from such systems include GIS data, digital maps, and georeferenced images and video.	Applications areas of mobile mapping are Aerial mobile mapping, Emergency response planning, Internet applications, Road mapping and highway facility management. In the context of NGIS the applications which could be relevant are **Emergency response planning-**Mobile mapping systems allow rapid collection of data to allow accurate assessment of conditions on the ground. **Road mapping and highway facility management-**GPS combined with digital camera systems allow rapid update of road maps. The same system can be utilised to carry out efficient road condition surveys, and facilities management. Laser scanning technologies, applied in the mobile mapping sense, allow full 3D data collection of slope, banking, etc
	Ground Positioning Technology using Satellite	It is a system of satellites that provide autonomous geo-spatial positioning with global coverage. It allows small electronic receivers to determine their location (longitude, latitude, and altitude) to high precision (within a few metres) using time signals transmitted along a line of sight by radio from satellites. The signals also allow the electronic receivers to calculate the current local time to high precision, which allows time synchronisation. United States' Global Positioning System (GPS), Russian Federation's Global Orbiting Navigation Satellite System (GLONASS) and Europe's Galileo	Positioning Technology can be used for farming, construction, mining, surveying, package delivery, and logistical supply chain management. Major communications networks, banking systems, financial markets, and power grids depend heavily on GPS for precise time synchronization. Positioning devices allows advances scientific aims such as weather forecasting, earthquake monitoring, and environmental protection. Positioning techniques can be used for amenities, Met and Climate Data, Pollution Measurement point.
	Crowd Sourcing/ Volunteered geographic information (VGI)	Volunteered geographic information (VGI) is the harnessing of tools to create, assemble, and disseminate geographic data provided voluntarily by individuals. Some examples of this phenomenon are WikiMapia, OpenStreetMap, and Google Map Maker.	This can be used for getting public-feedback, Complaints, Public-Interface data which can be obtained through GPS-enabled mobile device.

Category	Technology	Brief Description	Relevance to National GIS
Mapping	3D GIS	3D GIS includes 3D visualization and surface analytic methods, enabling users to input image, vector or elevation data to analyze surface change and inquire the data or calculate the visible range of a specific point in 3D environment. Furthermore, a simulation of the real world or a surface model can be obtained by overlaying image data, vector data and surface data.	3D GIS Applications includes Landscape and Urban Planning, 3D Routing, 3D Thematic Mapping, Noise Analysis, Flood Simulation, Underground Utilities Modeling, Utilities Modeling, Building Information Model (BIM) Integration, Visualizations, Virtual Cities, and 3D PDFs,
	3D Printing	3D Printing is a technique that deposits material layer by layer using a head similar to that of an inkjet printer. 3D Prototyping enables you to output high-quality terrain, urban and subsurface maps in hours at very low cost. Rapid prototype technologies are a natural fit for 3D topographic or terrain mapping, because of the models geometric complexity, and their lack of a need for any special structural integrity.	3D printing is under used as a design and communication tool in many sectors. In particular colour 3D printing could be much more widely used as a communication tool in the Urban Planning, Energy, Environment, Marine and Coastal, Transport and Water engineering sectors.
	Web Mapping	Web mapping is a process of designing, implementing, generating and delivering maps on the world Wide Web. The technologies utilized in web mapping are Spatial databases and WMS servers. Types of web maps include Analytic web maps, Animated web maps, Collaborative web maps, Online atlases, Realtime web maps, Static web maps	Web mapping is used in National GIS for delivering Apps, Dashboards.
Applications	Database Engine	A database engine (or storage engine) is the underlying software component that a database management system (DBMS) uses to create, read, update and delete (CRUD) data from a database. Most database management systems include their own application programming interface (API) that allows the user to interact with their underlying engine without going through the user interface of the DBMS.	In National GIS Database engine is used for storage and retrieval

Category	Technology	Brief Description	Relevance to National GIS
	GIS Engine	GIS Engine is a collection of GIS components and developer resources that can be embedded, allowing you to add dynamic mapping and GIS capabilities to existing applications or build new custom mapping applications. GIS Engine can be used to Rapidly build GIS-enabled applications, Create and draw graphic features, Perform geographic operations, Solve and perform network analysis, Effectively visualize and analyze, etc	Can be used to prepare GIS content layer and for serving layers through applications.
	Mobile GIS Technology	Mobile GIS technology extends the traditional indoor GIS manipulation to the outdoor work and provides a mobile outdoor operation platform for field surveyors to collect, modify, and measure the spatial data in an easy and effective way.	In National GIS mobile GIS technology can be used for developing mobile applications. Mobile GIS applications provides Map viewing and map navigation systems, Data collection and maintenance systems, Survey systems.
	Identity Access Management (IAM)	IAM technology can be used to initiate, capture, record and manage user identities and their related access permissions in an automated fashion. These are techniques which is used for ID Management login, AAA (authentication, authorization, and accounting), role-based access control (RBAC), RADIUS (Remote Authentication Dial-In User Service), onboarding and offboarding, single sign-on (SSO), federated identity management (FIM), privilege creep etc.	In National GIS Identity Access management is used for Security management.
	Data Security	Data security refers to protective digital privacy measures that are applied to prevent unauthorized access to computers, databases and websites. Data security also protects data from corruption. Data security technologies includes Disk encryption, Hardware-based mechanisms for protecting data, Backups, Data masking, Data erasure.	In National GIS data security techniques are used to protect data.

Category	Technology	Brief Description	Relevance to National GIS
	Data Analytics Technology	Data Analytics is a process of examining data to uncover hidden patterns, unknown correlations and other useful information. Analytics often favors data visualization to communicate insight.	In National GIS it can be used to create Dashboards, Real-time monitoring, Reports of GIS data
	Cloud GIS	GIS Cloud is a service that allows users to host, manage, and access their geospatial data in the cloud. GIS Cloud also allows for creation, editing, and publishing of maps from the geospatial data. The GIS Cloud API allows developers to access and integrate the data and functionality of GIS Cloud into other applications. Some example API methods include creating maps, editing maps, deleting maps, creating and listing layers, and listing features. **Cloud Services** include SaaS (Software as a Service), PaaS (Platform as a Service), IaaS (Infrastructure as a Service). **Deployment models** include Private Cloud, Community Cloud, Public Cloud, Hybrid Cloud. Some of the **GIS Cloud software** are Map2Net, ArcGIS Online, GIS Cloud, MapBox, Mango Map, CartoDB and MapInfo Stratus.	GIS Cloud can be used as a tool for cadastre and land management, logistics processes such as planning and optimizing delivery routes, planning and managing telecommunication network infrastructure, retail planning and in industries such as public service, electric, water and gas, agronomy, military, real estate, marketing, ecology, science, etc.

8. RECOMMENDATIONS

254. Standardisation, Spatial Framework and robust practices/process are key for the success of National GIS In our view, the National-GIS STANDARD must be a public-domain statement/ document of the content, layer definitions, GIS parameters and values, database schema and other "constraints" governing the naming, contents, quality of content, operations of software and hardware, service definitions etc for National GIS; Spatial Framework is the "co-registered" foundation dataset of India on which the National-GIS is organised and robust practices/processes are a set of validated/verified/tested steps and actions that are taken up for National-GIS. ***This has been lacking and is a major gap in the Indian GIS portals that we have evaluated – thus, most times making the GIS data just suited for visualization and not for serious GIS Decision Support***.

255. Globally, we have seen large-scale varied GIS standardisation efforts – some are driven by specific business interests (GoogleEarth and MapmyIndia); some are national efforts (US-FGDC; INSPIRE etc) and some are multi-lateral efforts driven by varied interests (ISO and OGC). In our view, these standards have developed over a great ADVANTAGE that these nations have – they have standards-declared GIS Content available in public/commercial domain. Thus, most of these standards focus more on services – both data and applications, exchange and inter-operability etc and less on GIS content creation. We see that INSPIRE does focus on GIS Content and this is a positive effort to create a common content base across Europe from the individual national content.

256. In India, the efforts at GIS Standards saw great thrust in mid-1990s in the NRIS Standards – which focused on a project-specific GIS standard of NRIS programme; in 2002 in NSDI Metadata and NSDI Exchange standards – these were more for data sharing and exchange across data generators. The most comprehensive effort on creating a robust GIS database standard was the NNRMS Standards efforts in 2005 (which in turn drew from earlier NRIS Standards) – the focus was still on GIS database aggregation from different GIS projects BUT did, for first time, cover the content standardisation. A variant from the 2005 NNRMS Standards has been the 2006 NUIS Standards – again project-specific for NUIS project. It is a glaring gap that after 2005/2006 there have been a major gap in Standards activity oin India and these have "flourished" within smaller organizational and project efforts (NICGIS has its own standard; Surveykshan has its own standards; Bhuvan is largely based on NNRMS Standards but has extensively migrated to its own standard etc).

257. ***Thus, a major gap in India has arisen over the past 10 years - the "common seamless" nature of GIS for India users has not at all been addressed holistically – leading to varied levels project GIS; the spatial frame to represent "one India" has been missing – thus GIS data are based on varied India frame and cannot be used across as they are not co-registered; different GIS parameter standards are used – thus data cannot be cross-utilised and quality suffers***.

258. It is strongly recommended that National GIS Portal must provide best of and authoritative data and applications services across the country and BE a Decision Support System. It is through the

National GIS Portal that users will make smarter governance decisions, develop relationships and increase citizen engagement. Here are some important points to be borne in mind for National GIS:

258.1. National GIS **cannot** be a "collection of whatever map/image data is available" – a systematic GIS Asset needs to be designed with layer/image definitions, feature definitions, schema definitions – which are seamless across the nation uniformly, standardized as per a National GIS Standard and constantly updated as per an update cycle.

258.2. National GIS needs a well-designed Data Dictionary and considerable effort is required to develop this – but once developed for all National GIS content features, the dictionary will be the foundation of all data development, exchange and integrated analysis. National GIS cannot have content without such a well-designed Data Dictionary.

258.3. A bane of many a GIS project is the poor quality of data available – unless and until care is taken to define quality standards, measure quality of data and ingest only data of highest quality, National GIS will fail in its objective to be that one-source authoritative data. Further, poor quality data will result in poorer GIS analysis in National GIS and lead to poor decisions – this has to be avoided at all costs.

258.4. Images – be they from satellites/air-platforms/ground, are the fundamentals of a National GIS Portal – the more detailed and latest images the better is the use of the Portal. Robust image management techniques and fusion techniques are important. A dedicated effort to source latest and detailed images and publish them on National GIS is called for.

258.5. National GIS must have well-designed and robust National GIS services – both, GIS Data Services that allow access and download of GIS-Ready data AND GIS Application services for different users (agriculture/urban/rural/governance/citizens……) which needs to be a set of decision-tools packaged into a GIS Application Decision Support module. Thus, National GIS must have large number of such GIS Application Services that cater to different segments and allow users access to these applications. National GIS Applications must be built on National GIS Asset and must be encouraged for any registered user to develop/host on the National GIS Portal – thus, GIS Applications services must be democratized in its development, usage and operations.

258.6. Most of the Indian Portals are poor in inter-operability and need robust standards adoption.

259. India needs to have a National GIS Standards and a National Spatial Framework (NSF) as a top priority……NIAS has recommended specific actions:

259.1. First, develop the NSF that has been proposed. NSF needs to be the basic frame for any GIS data in National GIS BUT more importantly ensure that all GIS data are co-registered - and should form the base of all Image, OSM and survey activity – so that any GIS data emanating from these follow the same spatial reference. ***NSF must be available as a template product from National-GIS and must be licensed***

to use for any user BUT form the foundation for National GIS. NSF must be the basis of verifying "compliance check" before any ingest of GIS data to national GIS Asset (apart from National-GIS standards check).

259.2. Make available the NSFD as a National GIS product and easily and non-discriminatorily available to anybody in India to use – thereby ensuring that all other GIS data is referenced to National GIS.

260. Discuss, finalise the National-GIS Standards proposed. The Standards must address the content-list and description of National-GIS; the GIS parameters and values and feature schema of National-GIS. We have identified the standards and the same can be starting point BUT a national effort needs to be made to assimilate the NIAS proposal as a national Standard. The following National GIS Standards have been identified by NIAS (there could be many more identified – especially in National-GIS Applications where Decision-Support standards are required for each user-case based on its definition):

260.1. National GIS Content Standard – identifying a well-analysed set of content for National GIS, including 43 essential and 41 additional content for National-GIS. It would be important to have a National GIS Content Thesaurus – that defines the class-categories and enables a common understanding and also links the categories to the purpose and use of the classification system.

260.2. National GIS Database Standards – identifying the database parameters and values for parameters for National GIS database.

260.3. National GIS Services Standards, including:

260.3.1. National GIS Metadata Standard

260.3.2. National GIS Catalog Standard

260.3.3. National GIS Map Services Standard

260.3.4. National GIS Map Tiling Services Standard

260.3.5. National GIS Feature Services Standard

260.3.6. National GIS Portal Encoding Standard

260.3.7. National GIS Exchange Standard

260.3.8. National GIS Web Coverage Services Standard

260.3.9. Georss simple standard

260.3.10. National GIS sms ingest standard

260.3.11. National GIS Applications standard – focusing on critical Decision Support of governance – at central/state/district/local levels; citizens – for citizen services and also commercial/enterprises applications.

261. The National-GIS Standards must be open public-domain document that is accessible and available to one and all.

262. It is recommended that a robust/best practice/process be defined for critical actions n National GIS – National-GIS Asset creation process; ingest process; quality check process; Applications services process and so on. The more clearly and detailed the processes are defined, the smoother would be the implementation.

263. The National GIS Standards that have been defined by NIAS are on principles of "open standards" and will be easily "inter-operable" across platforms and systems and are totally neutral to any technology (thus, not being tied with any particular GIS or System technology).

264. As a national system, the possibility of an integration (if the need arises and is warranted by government) of an appropriate sub-set of the National GIS to global systems is possible mainly meeting nation's commitments in multi-lateral and UN frameworks. It is important to consider this in advance at design stage. While at no time the full National GIS is expected to dove-tail into global systems, it would be prudent to plan and develop a separate dove-tailed GIS system of essential and necessary elements for the UN/multi-lateral integration, if at all required.

265. The National GIS Standards needs to be compliant with international ISO TC211 standards – especially as India is already committed to ISO standardisation efforts through the Bureau of Indian Standards (ISO is a multi-lateral body for standardisation and India is represented by BIS).

265.1. The BIS has already set up a link-committee for GIS Standards and this link-committee could be the national-platform for user consultation and inputs for National-GIS standards.

265.2. National-GIS should also regularly refer and interface with other on-going GIS Standardisation efforts (like studying what other nations are doing; GSDI, OGC, ICA, CEOS/GEO etc) – even recognising that these may have a "specific characteristic" but nonetheless could be useful to leverage and build on to the National GIS Standards.

265.3. The National-GIS Standards activity must adopt core "change management" processes to undertake any changes and modifications to the National GIS Standards – with rigorous testing and compliance and certification procedures. It must be ensured that there are contractual obligation on the part of participating vendors/developers to adhere to all relevant and applicable National GIS Standards.

265.4. It would be appropriate to have a Expert Standing Committee for National GIS Standards – consisting of technical experts in the nation. Such a formal national-level technical standing committee can be tasked to help National-GIS to define, develop, review, update the National GIS Standards.

266. A concerted effort needs to be taken to make aware, promote, encourage and generate/organise these GIS Standards, NSF and GIS Process documents and also encourage for using these to be able to integrate into the common platform of the National GIS. All government/enterprise and other private agencies would comply with these standards and NSF so that practices within their own processes will be able to contribute to and benefit from National GIS.

267. There is an urgent need for India to define and assess key and critical technology and applications elements that would be important for National GIS – so that the ultimate goal of India to maintain and provide efficient GIS services and emerge leadership in global arena in GIS is possible. NIAS has identified a suite of technical capabilities that India must have in the areas of Surveying and Data Collection – be it from ground survey equipment, precise positioning systems, Satellite Imaging and Data collection, Aerial Imaging and data collection and other emerging metric systems; modern mapping systems – including web-mapping, geo-tagged data mapping, 2d and 3d mapping products etc; building and managing GIS databases – including clustered GIS warehousing and mining, embedded geospatial databases etc; GIS Applications and total GI systems development technologies. These technologies should ultimately enable Indian government, private and individuals to "build" the most appropriate National GIS system to provide effective GIS applications services and also for easy usage/access to National GIS data and GIS Applications.

268. National GIS must also assess futuristic applications that would be "demanded" from government, citizens, enterprises and also envision the broader GI eco-system in India that will come to fore in next 10-15 years and create a roadmap of GIS applications development – identifying the key areas, the data required, the technologies required and also the market dynamics and policy scenario that will drive in next 10-15 years.

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NIAS team has also referred to a host of internal assessment and internal documentation that have given insights to how to addressed National GIS Standards, Spatial Framework, Technologies and These have been useful in evolve our own analysis and particular references are generated by USGS (Julie Binder Maitra), INSPIRE, OGC (Mark Reichardt), NASG, ISO, NNRMS, NSDI, NUIS, K-GIS, National Vision Document – apart from inputs from many private sources and media. These have all helped in a proper understanding of the issues related to National GIS

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ANNEXURE-I

RECORD OF CONSULTATION MEETING

RECORD OF CONSULTATION MEETING ON STANDARDS AND FOUNDATION DATASET FOR NATIONAL GIS

1. As part of the DST Sponsored Project on National GIS Standards, Framework and Technologies, a Consultation Meeting was held at NIAS on September 11, 2014 to discuss the draft report that NIAS has prepared for the project. The NIAS draft report had already been circulated to participants. The list of participants in the meeting is given in **Annexure-I**.

2. The agenda for the meeting is given in **Annexure-II**.

3. Mr K R Sridhara Murthi, NIAS welcomed the dignitaries and participants for the meeting. He mentioned that the consultation meeting is an important activity for obtaining views and inputs on the draft report and also for sharing ideas on GIS standards. He mentioned that NIAS always lays emphasis on open consultation – thereby subjecting its works to scrutiny and also enable improvements and assimilation of ideas. To that extent, this particular Consultation Meeting is important – as it is a step towards finalizing the NIAS report for the DST sponsored project.

4. Dr Baldev Raj, Director, NIAS welcomed the 71 delegates to NIAS and mentioned that GIS is an important tool for governance and development – thus, GIS standards also become important for National GIS. He remarked that NIAS has been on this project for almost 10 months – he appreciated the efforts of Dr Ramamurthy, Former Director of NIAS and under whom the project was initiated. He mentioned that NIAS is fortunate to have the association of Dr Kasturirangan, Former Chairman of ISRO and Former Member of Planning Commission – who has been pioneering and steering the space, RS/GIS and S&T activities in the country. Both Dr Kasturirangan and Dr Ramamurthy are renowned for their role in Indian Mapping and GIS – together they have crafted NSDI and National GIS. Dr Baldev raj mentioned that Standards are important for the progress and development in any field – western nations standardize each and every process and thus are successful in large-scale activities. He noted that Indian efforts in Standards are very poor and all efforts are through BIS in India. However, process standards are what is required, he remarked. With GIS becoming and enabling technology, its applications require tremendous amount of detailing of standards and process documents – NIAS is making this effort of preparing the Standards under the lead of Dr Mukund Rao in NIAS. He mentioned that the draft document prepared by NIAS team would be a good material for discussion and consultation. He hoped that at the end of the Consultation Meeting, key issues and inputs would have been generated – which will help NIAS to finalize the Standards document.

5. Dr Rajeevan, Adviser & Scientist-G, MoES, represented Secretary Dr. Shailesh Nayak. He shared his thoughts on practical implementation of GIS in data like Climatology, Meteorology. He mentions that most of the data which are available at MoES are not GIS ready and not user friendly. He is looking forward at GIS Technology to give solutions in extreme events (cyclone, flood etc.) and

also able to asses vulnerable situations like sea level rising, Change in temperature etc which causes Global Warming.

6. Dr. Akhilesh Gupta, Adviser & Scientist-G, Head-SPLICE, DST represented Prof K Vijay Raghavan, Secretary, DST. He expressed his appreciation to NIAS team for the excellent work done in bringing out the draft and also technically analyzing various aspects of GIS Standards, GIS Spatial framework and GIS Portals. He mentioned that DST has been given the responsibility of NGIS and is keenly pursuing for mission-mode implementation. He mentioned that DST considers standards and spatial framework as crucial foundation for NGIS and thus the report will be extremely useful for NGIS implementation. He recalled that NIAS had also submitted an excellent report on GI Policy in 2012 which, along with standards report, provides a volume of work in preparing for NGIS. He mentioned that once the report on GIS Standards is submitted then same would be adopted by DST in an appropriate manner for NGIS. He commended NIAS for building such excellent technical capability – in particular the efforts of Dr Mukund Rao to steer such high-level technical work in support for NGIS.

7. Dr V S Ramamurthy, Emeritus Professor, NIAS noted that GIS technology is a crucial one for governance and recalled the past efforts of DS and DOS in shaping NSDI into action. He also mentioned that India has not made that progress in GIS as it should have – though best efforts have been made by a set of people in the interests of the country – but parochial thinking and one-upmanship has retarded any progress that was possible. He also expressed surprise that even in 2015 National GIS – which is need of hour is attracting debate and concerns from some quarters – in his opinion NGIS must be implemented at top priority setting aside any partisan thinking. He humorously illustrated the obstacles in acceptance of technology from higher authorities (citing mobile phone case) even though technology becomes part of routine in common man's life. He highlighted importance of GIS Quality and data reliability and authoritative as important aspects for NGIS.

8. Dr K Kasturirangan, Emeritus Professor, NIAS Outlined his vision for NGIS in a keynote talk. He mentioned that Indian economy is on growth path with GDP at 8% and also that large-scale investments are being made in many critical sectors of development in the country. He observed that India is aiming high growth-orientation with considerably enhanced outlays for Agriculture, Infrastructure, Education, Rural Development, Health, Urban Governance, skill development, irrigation etc. With such a level of growing economy, developmental activities in India will demand a new paradigm and new Governance regimes – moving from the traditional allocation systems to determining equitable systems. He mentioned that governance would require a scientific mapping of the needs/aspirations/desires and limitations of the beneficiaries and society, especially the most disadvantaged; transparent systems of inclusivity of citizen participation and entitlements; guaranteed development/service delivery with high-level of accountability of governance systems and a very effective (feed-back) and responsive redressal system. He also mentioned that GIS will also be an arena of technological and developmental edge for countries. In the transforming world, nations that will possess a sound and progressive system of geographical information management will lead and chart ways in their own national and international arena far ahead of those that would use more traditional forms of information management. It is in this context that India envisioned in 2011 a National GIS which will provide the GIS data and GIS Decision Support for better governance and development support, private enterprise growth and also for citizen's

access. He also traced the path of mapping, imaging and GIS through the past 200 years and noted the emergence and roles of SOI, IMD and GSI – which have done yeomen role to nation-building. Over past 30-40 years he noted the modern developments of RS and GIS – starting from the traditional mapping systems of SOI/GSI etc that were prevalent and then the emergence of satellite images and GIS systems that NNRMS and NRDMS and subsequently into NSDI that DOS and DST initiated. All of these have strengthened the national capacity in EO and GIS and it is because of these strengths that we are now at the stage of considering the National GIS, which will enlarge the scope of foregoing activities, bring the benefit of standards and create synergies. He mentioned that it is important that India have a good programmatic definition of National GIS and necessary approvals are obtained for implementation. Dr Kasturirangan also noted that the new government has made new ideations – like, Digital India, Infrastructure, Smart Cities etc and greater focus to energy, employment, rural development and farmers etc. National GIS has to be an important element of these national initiatives and all efforts must be made to align and orient National GIS to these programmes.

9. Dr Kasturirangan also mentioned that Standards and Spatial Frameworks are extremely important for National GIS. Not much efforts has been done in a holistic manner – though NNRMS has brought out Standards in 2005. But many GIS Portals have emerged – it would be good to assess these standards and portals and learn from them for National GIS. The most important need is to ensure that uptodate GIS-Ready data is available for any part of the country; GIS DSS and governance support is the key driver and a technological excellence is achieved for the country – these must be the primary goals of National GIS. He commended the role of NIAS in taking up such a technical assessment of GIS Standards and Portals and also for such an open and transparent consultation of experts, from different agencies, as this would only make the effort very successful and inclusive and the report from NIAS will be extremely useful.

10. NIAS team then made the following presentations:

10.1. Dr Mukund Rao gave an overview of the DST Sponsored project and gave an introduction of the study elements. He mentioned that the focus was on GIS Standards, GIS Spatial Framework, GIS Portals in the context of NGIS. He mentioned that towards defining these, NIAS team had made an exhaustive analysis of international standards and portals, domestic standards and had evaluated 6-7 GIS portals accessible in India. He mentioned that NIAS team had consulted OGC, INSPIRE, FGDC, ISO and many other international agencies to understand what they are doing and also to learn from their efforts. NIAS team had also been assessing various portals. Thus, the recommendations that are drafted are from these interactions and learnings.

10.2. Ms Shilpa gave an overview on assessment of International GIS Standards. She made an introduction to different standards like FGDC &USGS-National Map, INSPIRE, OGC, ISO/TC-211 etc. She highlighted some of the key differentiators of the standards approaches and also standards content of these initiatives. Ms Shilpa also gave a comparison of these standards and drew attention to learnings for National GIS - with respect to different standard parameters like content, metadata, quality, image, application services etc. She mentioned that India has a different character and here standard CONTENT is lacking – thus standards have to focus on content initially and

later issues related to metadata, applications, exchange etc would be important (unlike in USA and other places where content is already well standardized and available). Thus, she highlighted what should be included in NGIS Standards.

10.3. Ms Shilpa also presented an assessment of GIS portals that NIAS team had studied - USGS-National Map, Google Earth, Bhuvan, NSDI, MapmyIndia and Karnataka GIS Portal. She noted that content in all these Portals varied extremely – pointing to the fact that all Portals use different and their own content and no national content exists or is used. She also observed that most of these Indian Portals used whatever GIS data they had (or generated over many years) into Portals – this created un-standard and un-framework data making overlay and geo-match extremely difficult and data accuracy/ reliability issues. She also highlighted the capabilities of different Portals – all of them were mainly visualisation Portals and NONE OF THEM HAD DSS CAPABILITY – which is fundamental to NGIS. She also noted that most Portals lacked good architecture and infrastructure for good performance. She gave a summary and key learnings form this portal analysis with respect to different parameters – content, applications, architecture etc.

10.4. Dr Mukund Rao continuing his presentation on standards gave an overview study of Indian GIS standards. He explained the many years of national efforts at evolution of Indian standards - NNRMS, NUIS, NSDI, K-GIS. He noted that past efforts of Standards were mainly from "data generators" point of view and mor3e focused on exchange and less on content standards and applications (though NNRMS Standards addressed this for first time in India). He highlighted the NGIS standards in the context of Content (250k:50k:10k); Metadata; Schema/Data Dictionary/Data Models; Spatial Framework; Quality; Image; GIS Services (Data and Apps); Mobile GIS Services; GIS Portal Standards and Interoperability. He noted that NNRMS Standards will have to be upgraded considerably for NGIS; NSDI is mainly metadata standards; NUIS is specific to cities; K-GIS standards are quite updated and near to NGIS needs. He also mentioned that a National effort at Standards is required and it must be used by all – a platform needs to be created for such an evolving standards effort.

10.5. Dr Mukund Rao presented the recommendations of the Standards to be adopted for NGIS:

10.5.1. The recommendations included the NGIS Content list – as a Basic GIS Asset and specific City-GIS Asset list. The NGIS Content categories recommended included - Boundary – including all required boundary spatial data; Cultural features – including a variety of cultural features; Hydrology content – including details of all hydrology features; Urban and Settlement content – all city and urban information; Environmental content – forest and environmental data; Geological content – details of geology and minerals; Landcover/ Landuse content – landuse and landcover information; Land ownership information – cadastral and Urban Property information; Terrain information – DEM, Slopes; Soils information – at Association and/or Phase level; Images – including satellite images and images from aerial/UAV/other

platforms; Public Assets/Amenities – all public assets and amenities data in form of points; Met data – details of average meteorological data from met stations; Ocean state data; PFZ data; Points Of Interest (POI) – details of points of interest; Citizen data that can be obtained through crowd-sourced methods; Geographical names – a standardized list of Geographical names. A total of 153+ Primary Features would have to be part of NGIS – the list of features was also presented. A suite of about 32 Additional features were also recommended for NGIS – these could be included, if possible.

10.5.2. Content Metadata Standards must define feature naming conventions, data dictionary and GIS thesaurus – recommendations were presented for standardising these 3 elements. It was suggested that NSDI Metadata Ver 1 can be adopted for NGSI with suitable modifications as proposed.

10.5.3. NGIS Database Standards were defined including National Spatial Framework; Minimum Map Frame size for incorporation to National GIS; Map to Spatial Framework Registration tolerance (0.25mm of scale); Map Projection; Datum Position (Planimetric) Accuracy of Map in m; Minimum Spatial Unit (MSU) (3 x 3 mm of scale)in sq mts; DEM Z-Spacing as 1mm of scale in m; DEM Z-Accuracy in m; Accuracy of Classification/Mapping; Coordinate System; Coordinate Movement Tolerance (CMT) for ingest to National GIS database (0.125mm of scale) in m; Weed Tolerance (WT) for ingest into National GIS database (0.125mm of scale) in m; Sliver Polygon Tolerance (LESS-THAN MSU) in m;

10.6. Dr Mukund Rao also proposed National GIS Portal Standards and recommended NGIS portal architecture keeping in mind the NGIS DSS capability that is needed. He mentioned that important NGIS Portal standardisation – must include - GIS Content Publishing and Discovery: publishing and search and locate GIS content and Metadata in National GIS; GIS Content portrayal and display – defining the way National GIS data would be portrayed or displayed on various platforms and provide Map Services; GIS content management – access rules, content management schemes and GIS Processing and Applications – undertaking GIS processing on GIS Asset OR access to readily usable GIS Apps. He also noted that the best way to look at NGIS Portal Standards was to define - National GIS Catalog Standard; National GIS Map Service; National GIS Tiling Services Specification' National GIS Feature Service standards; National GIS Exchange Standards; National GIS Applications Standard; National GIS Coverage Service and National GIS SMS Ingest Specification. These could be adapted and learn from ISO (or OGC) standards for Metadata, Applications and Services.

10.7. Dr Rao made a detailed presentation on importance of NGIS Spatial framework. He mentioned that all earlier work of NNRMS, NSDI, NUIS , NIC, SOI etc gets negated because a common spatial framework has not been used and each used its own spatial frame at different scales/details/accuracies. Thus, it was impossible to co-register any of these data sets across each platform – they could be used independently but cannot be cross-correlated. He mentioned that yet another problems of these efforts were that they used different INDIA/STATE/DISTRICT boundaries – thus their boundary

representation were also not accurate and thus could not be cross-used as they "represent India/states/districts as they really not are". He showed with GIS examples how an un-standard spatial framework can create mis-match of features (roads, rail lines, points etc and also boundaries); mis-match of administrative boundaries and also represent in-accurate coordinates, distances, areas. He stressed that for NGIS to be AUTHORITATIVE and RELIABLE a standard spatial framework is required and MOST ESSENTIAL.

10.8. Dr Rao called for using one authoritative national boundary – and for its 1st level of geo-reference; next an authoritative state-boundary can be ingest into the geo-referenced national boundary (using geo-location points) to create state frames; district-boundaries can be ingest into state-boundaries and finally village boundaries ingest into district boundaries. This will maintain sanctity of administrative boundaries and the administrative hierarchy of India. Second, he proposed that satellite images must be referred to this spatial frame and always co-registered to National GIS Spatial Framework. These 2 elements, along with major roads, rivers, railines, can form a part of freely downloadable and available NGIS FOUNDATION DATASET – which anybody can use to create GIS content. Once this frame is used, registering all GIS content will e easy and possible. This is most essential.

10.9. Dr Rao also gave an assessment of important technologies in the context of National GIS. He highlighted the following as critical technology elements for NGIS - Satellite Imaging; Aerial Imaging; UAV Imaging/Data; Electronic Distance Measurement (EDM); GPR; Airborne LIDAR; Mobile Mapping; Positioning using Satellite; Crowd Sourcing/ (VGI); 3D GIS; 3D Printing; Web Mapping; Database Engine; GIS Engine; Mobile GIS Technology; Identity Access Management (IAM) ; Data Security; GIS Analytics Technology; Cloud GIS.

11. Dr Prabhuraj, Director, KSRSAC made a demonstration of the proto-type K-GIS Portal that has been developed by KSRSAC. He mentioned that the Portal is now available for internal GOK usage and that the Portal has 53+ state-wide GIS layers and easy-to-use display and basic query capabilities. GIS Applications DSS are being developed by KSRSAC and it was mentioned that the Portal would be soon upgraded for more capabilities and content. The demonstration showed the details of GIS content available for whole state of Karnataka and also basic tools for querying spatial and attributes.

12. Detailed discussions were held and following points were highlighted:

12.1. Standards are important but consumption and use should drive standards – and not by generators. Thus, NGIS Standards should be user-driven. It is also important to evolve step-by-step the NGIS Standards as assimilation within users is also important and this can be a slow process – but the NGIS Standards goal must be achieved.

12.2. Content listing is most important – the broad proposal from NIAS of Primary and Additional features were endorsed and it was suggested that this list could be modifieable as and when required. NGIS Content must not become rigid and unchangeable.

12.3. Spatial Framework proposed by NAIS and concept of NGIS Foundation Dataset was

endorsed and it was suggested that this product of NGIS must be released immediately. Even while NGIS gets approved, SOI could initiate steps for this.

12.4. The GIS portal analysis of NIAS team was appreciated. It was noted that NGIS Portal must not be a data-bank but must be a live/active and evolving GIS database. It must be on Foundation data and always standards compliant. It was suggested that methods for compliant ingest needs to be worked out for NGIS.

12.5. While OGC has done pioneering work on Standards, it would be good to learn and adapt from these efforts – however, India must develop its own version of NGIS Standards.

12.6. It was highlighted that India is a part of ISO and committed to ISO-compliance as a national-doctrine and thus a good interface needs to be built with ISO standards efforts. However, it is important that India evolve its own GIS Standards based on ISO (just like Bharat emission standards) so it could shape its standards (and also learning from OGC efforts).

12.7. In this ISO context, it was suggested that once NIAS submits its report DST must take up further consultation, consolidation and development through the BIS Committee that has been stablished. The Committee may be charged with this TOR also.

12.8. NGIS must address in detail the critical technology that have been identified and efforts must be made to prepare a TECHNOLOGY ACTION PLAN FOR NGIS – that the nation must undertake. Separate efforts are required for this.

12.9. In the context of Digital India, the following was proposed as National GIS products strategy:

12.9.1. Release NGIS Foundation Dataset in 3 months and meet immediate visibility for Digital India.

12.9.2. Release Ver 1.0 of NGIS in 1 year and re-orient for Digital India goals

12.9.3. Release Ver 2.0 of NGIS in 3 years and meet Digital India goals also.

12.10. NGIS must go products-cycle mode and various GIS and DSS products must be planned. Even with NGIS Foundation dataset simple GIS products must be planned and rolled out. Similarly for various versions.

12.11. How to adapt already available GIS data and maintain legacy was also discussed and it was suggested that migration of GIS data needs to be addressed – a qualitative tag can be associated with legacy data for standards compliance.

12.12. Elevation data at about $\pm$ 1m elevation accuracy was discussed in detail. It was suggested that DEM and its derivatives from satellite images can be easily used – Indian satellites (or foreign satellite data, if Indian stereo data is unavailable) must cater to this need.

12.13. NGIS portal must not be just visualisation and display but must be query and app-oriented – providing strong decision-support interface and solutions.

12.14. NGIS Content must be authoritative and reliable with a tag of certification – thus quality, co-registration, legacy, formats etc must all be standardized and assessed for quality.

12.15. NGIS Portal must be of high-performance and reliability – thus adequate efforts to architecturing and design must be done for NGIS Portal. Low-level hardware must be avoided and good cloud and data-farm technology must be utilised.

12.16. Through the discussion we could understand that display of vector layer in portal is the slowest process and nobody share or publishes the document for portal standards.

12.17. A request was made in order to evaluate survekshan.gov.in GIS portal nd also NIC GIS Portal and include in NIAS report.

13. Dr Munshi gave an overview of OGC and its standards.

14. Dr Baldev Raj assured that NIAS team will address all above points, as possible, in final report. Dr Rao mentioned that the final report will be prepared – but any individual could submit any comments/suggestions till October 31, 2014 to NIAS. After this, NIAS team would start finalizing the report and submit it to DST.

15. The meeting ended with thanks to the Director, NIAS.

16. The final minutes issues with approval of Director, NIAS.

(Mukund Rao)
PI, DST Sponsored Project on NGIS Standards,
Spatial Framework and Foundation dataset
September 24/October 21, 2014

ANNEXURE-I OF ANNEXURE-I

PARTICIPANTS LIST – CONSULTATION MEETING

1. Dr Baldev Raj, Director, NIAS (baldev.dr@gmail.com)
2. Dr V S Ramamurthy, Emeritus Professor(vsramamurthy@nias.iisc.ernet.in)
3. Dr K Kasturirangan, Emeritus Professor, NIAS (k.rangan@nic.in)
4. Dr Rajeevan Nair, Adviser / Scientist-G,MoES (mn.rajeevan@nic.in)
5. Dr Akhilesh Gupta, Adviser/Scientist-G, Head-SPLICE, DST (akhilesh.g@nic.in)
6. Dr Swarna Subba Rao, Surveyor General of India (srswarna@gmail.com)
7. Dr Mukund K Rao, Project Investigator, NIAS (mukund.k.rao@gmail.com)
8. Dr Pradeep K Srivastava, Outstanding Scientist, ISRO (pradeep.310854@gmail.com)
9. Prof R Siva Kumar, Maj Gen (Retd), Pro Vice Chancellor (R&D) GITAM University, Hyderabad (rachapudi.sivakumar@gmail.com)
10. Dr Vandana Sharma, Deputy Director General & Head Remote Sensing & GIS Division, NIC (sharma.vandana@nic.in)
11. Maj Gen R C Padhi, Addl. Surveyor General & National Data Registry Coordinator, SOI (rcpadhi@gmail.com)
12. Dr Bhoop Singh, Head- NRDMS-NSDI, DST (bhoopsingh@nic.in)
13. Shri K R Sridhara Murthi, Professor, JNU (krsmurthy09@gmail.com)
14. Mr Yogesh Paithakar, Director, (RS), Central Water Commission (cwcrsd@yahoo.co.in)
15. Dr Jitendra Singh Tomar, Dy Director, Central Statistics office Ministry (tomar.ec2012@gmail.com)
16. Dr N P Singh , CMPDIL, Ministry of Coal (geomatics@cmpdi.co.in)
17. Maj K S Verma, ADMC, Bangalore (verma_kshitij@rediffmail.com)
18. Maj Tarini Shukla , ADMC, Bangalore (tarini.shukla@gmail.com)
19. Mr Anoop Aravind, Consultant, Ministry of Panchayat Raj (anoop.aravind@nic.in)
20. Mr G C Pathak, SI/T, CRPF, (gcp_1971@yahoo.com)
21. Shri Karnveer Singh Yadav, Deputy Commandant, CRPF (raokarm7102@gmail.com)
22. Dr Prithvish Nag, VC, MGKVP, Varanasi (prithvishnag@hotmail.com)
23. Dr N L Sarda, Professor,IIT Bombay (nls@cse.iitb.ac.in)
24. Dr M K Munshi, Chair,OGC India (mmunshi@opengeospatial.org)
25. Dr D K Prabhuraj, Director, KSRSAC (prabhuraj_1464@yahoo.com)
26. Dr Brijendra Pateriya, Director, PRSAC, (director@prsc.gov.in)
27. Dr Sandeep Tripathi, Chief Executive, ORSAC (orsac.od@nic.in)
28. Ms Bindu Manghat, SOI, New Delhi (bindu.manghat.soi@gov.in)
29. Mr H Hemanth Kumar , Fellow, KSCST (hemanth@kscst.iisc.ernet.in)
30. Dr S Vadivelu, Consultant, KSRSAC (vadivelus46@gmail.com)
31. Mr S D Baveja, RIDING Consultants , (sdbaveja@ridingsindia.com)
32. Col Rahul Kumar, Regional Director, Aeyzed Media Services Pvt Ltd (rk@srijanbs.com)
33. Lt Col MC Verma(Retd), Director, Directions magazine (mohan.verma@aeyzed.net)
34. Mr Rajesh C Mathur, Vice Chairman, NIIT GIS Limited (Rajesh.Mathur@NIIT-Tech.com)
35. Dr K S Rajan, Head, Lab for spatial Informatis, IIT, Hyderabad (rajan@iiit.ac.in)
36. Dr G Raju , Professor Jain University (raju_garuda@yahoo.co.in)
37. Mr Prashant Hedao, Visiting Scientist, IISc (prashant@ces.iisc.ernet.in)
38. Mr Nikhil Kumar, Director, Trimble Navigation (Nikhil_Kumar@Trimble.com)
39. Dr Basavarajappa H T, Professor of Earth Science (basavarajappaht@gmail.com)

40. Dr Zaffar Mohamed-Ghouse, CRCSI (Zaffar.Mohamed-Ghouse@ghd.com)
41. Dr S Mohammed Ghouse, Director Research, Venkateshwara College, Thiruvallur (ghouse967@hotmail.com)
42. Dr K Ashoka Reddy, Scientist, KSRSAC (ashoka_ksac2007@yahoo.co.in)
43. Mr Mahesh Reddy, GM,Technical services, (Mahesh.Reddy@intergraph.com)
44. Mr Shankar Narayana, Senior Director, Digital globe (snarayan@digitalglobe.com)
45. Mr Vishnu Boorla, Manager Technical Service, Intergraph SG&I India (vishnu.boorla@intergraph.com)
46. Mr M Rajathurai, Technical Manager - Geospatial and Utilities,Bentley Systems (m.rajathurai@bentley.com)
47. Mr Maneesh Prasad, Executive Editor, Directions Magazine India (maneesh.prasad@directionsmag.in)
48. Mr Sushmito Kamal Mukherjee, General Manager, Cyient (sushmito.mukherjee@cyient.com)
49. Dr M S V Rao, Product Manager II- Geospatial Platform, Bentley Systems (msv.rao@bentely.com)
50. Mr M N Manjunath, Managing Director, Geovista (mnmanjunath1@gmail.com)
51. Mr Satish Girinathan, NIIT-GIS, (Sathish.Girinatham@niit-tech.com)
52. Ms Tripti Agarwal , GIS Manager, Jana USP (tripti@janausp.org)
53. Mr Sanjeev Trehan, Trimble Navigation
54. Mr Kiran Hundi, Navayuga (kiran.hundi@navayuga.com)
55. Mr A S Rajashekar, Sr Project Scientist, KSRSAC (rajashekaras.cat@gmail.com)
56. Mr Salim I Shaik, Sr Project Scientist, KSRSAC (salim_sirsi@yahoo.co.in)
57. Mr B V Suresh, Sr Project Scientist, KSRSAC (sureshbv2008@gmail.com)
58. Mr C R Harsha, Sr Project Scientist, KSRSAC (harsh5691@gmail.com)
59. Mr K U Virupaksha, Sr Project Scientist, KSRSAC (viruchitradurga@gmail.com)
60. Mr Vilas Chavan, Senior Analyst, KSRSAC (chavanvilash@gmail.com)
61. Mr Siva Kumar S , Sr. GIS Associate, Jana USP
62. Mr Bharath H Aithal, Research Scholar,IISc (bharath@ces.iisc.ernet.in)
63. Mr. Chandan M C, Research Scholar,CES, IISc
64. Ms Krian Srivastava, Research Assistant, Christ University (ksrivastava5@gmail.com)
65. Ms R Shilpa , Research Associate, NIAS (shilpa.r1585@gmail.com)
66. Ms Diksha Bandil, Junior Research Fellow , NIAS (diksha.rsgis@gmail.com)

ANNEXURE-II OF ANNEXURE-I

CONSULTATION MEETING ON STANDARDS AND FOUNDATION DATASET FOR NATIONAL GIS

Date: September 11, 2014 **Venue:** NIAS Conference Room

09:00 – 09:30	Registration (Tea/Coffee)
09:30 –10:30	Opening session: • Welcome by NIAS (3 minutes) • Director's Address by Dr Baldev Raj, Director, NIAS (5 minutes) • Dr Rajeevan, Adviser and representing Secretary, MoES (10 minutes) • Dr Akhilesh Gupta, Adviser representing Secretary, DST (10 minutes) • Brief Address by Dr V S Ramamurthy, Emeritus Professor, NIAS (5 minutes) • Keynote Address – Dr K Kasturirangan, Emeritus Professor, NIAS (15 minutes)
10:30 – 11:00	Tea/Coffee
11:00 – 1300	Presentation by NIAS on study outcome – Standards, Foundation Dataset and Important technologies for National GIS Chair: Dr Swarna Subba Rao Rapporteur: Dr P K Srivastava • Overview of Study • International Standards in GIS – An Analysis • Assessment of GIS Portals • Status and Assessment of Indian GIS Standards • Proposed National GIS Standards, Spatial Framework and Technologies • Demonstration of GIS Portals Discussions
13:00 –13:45	Lunch
13:45 –14:30	Panel Discussion: National GIS Standards and Technologies (Tentative: Dr Swarna Subba Rao; Dr Vandana Sharma, NIC; Dr NL Sarda, IIT-M; Dr Bhoop Singh, DST; Dr Sandeep Tripathi, ORSAC)

14:30 –15:15	Panel Discussion: National GIS Spatial Framework and Foundation Dataset (Tentative: Dr Prithvish Nag, MGKVP; Dr Sivakumar; Dr PK Srivastava; Dr KS Rajan, IIIT; Maj Gen RC Padhi)
15:15 – 15:30	Wrap-up and Valedictory
15:30 – 16:00	High Tea

ANNEXURE-II

RECORD OF MEETING WITH SECRETARY, DST FOR PRESENTATION OF REPORT OF DST SPONSEDRED PROJECT ON NATIONAL GIS STANDARDS

1. A meeting was held in NIAS for presentation of report of DST- Sponsored project on National GIS to Prof Ashutosh Sharma, Secretary, DST and Dr K Kasturirangan, Emeritus Professor at NIAS on May 15th, 2015.

2. The list of participants in the meeting is given in **ANNEXURE-I**.

3. Dr Mukund Rao welcomed the dignitaries and presented an overview of the DST Sponsored project study at NIAS on NGIS. He highlighted the project background, scope which includes defining National GIS Standards, foundation dataset, spatial framework and important technologies for National GIS. He also outlined how a collective effort was taken to execute this project which included establishing an expert NIAS expert panel, organizing One-One consultation with ~20 different experts/agencies and also organizing a 1-day consultation workshop with Govt, Industries and academia which was held on September 13, 2014. He mentioned that a draft copy of the NIAS report was circulated in Sept, 2014 prior to the 1-day consultation workshop and was used as a basis for discussion.

4. Dr Mukund Rao made a detailed presentation including:

   4.1. Methodology adopted by NIAS. NIAS had undertaken an exhaustive analysis of international GIS Standards, national GIS Standards and this had helped obtain key learnings of the gaps and challenges for NGIS Standards. He also mentioned that NIAS had analysed 8 different GIS portals – 2 international and 6 national to study their functionality, data content and design aspects. This analysis had helped in coming to key learnings of the Portals and also helped in defining NGIS Portal standards.

   4.2. an overview of International scenarios in standards where a study analysis of various standards like FGDC, OGC, INSPIRE, ISO/TC-211, China was carried on with respect to different standard parameters like content, metadata, quality, image, application services etc. He also briefed the learnings from the analysis:

      4.2.1. US-FGDC has robust and well-defined standard and their documents are high-quality

4.2.2. Europe-INSPIRE has end-to-end focus and covers GIS content (akin to NGIS) to GIS Services thru Metadata and GIS data exchange. Documents are very good.

4.2.3. OGC focus on interoperability and openness and bringing across platform standardisation with focus on various application sectors.

4.2.4. ISO standards are driven by national government collaboration and are a slow process.

4.2.5. China claims that they have made effort in GIS standardization but one has to access the document to be able to make judgment.

4.3. overview study of Indian GIS standards. He explained the 20+ years of national efforts at evolution of Indian standards - NNRMS, NUIS, NSDI, proto-type K-GIS and noted that of past 10 years the standards efforts in India has slowed down. He noted that past efforts of Standards were mainly from "data generators" point of view and more focused on exchange and less on content standards and applications (though NNRMS Standards addressed this for first time in India). He mentioned that NSDI is restricted to Metadata and exchange. SOI DVD standards are obsolete. NUIS Standards are a subset of NNRMS Standards for urban sector.

4.4. presented assessment of 8 GIS portals that NIAS team had studied - USGS National Map, Google Earth, Bhuvan, NSDI, NICMAPS, Surveykshan, MapmyIndia and Karnataka GIS Portal:

4.4.1. Google Earth is robust, image and image-based vectors/points with lots of POI; very widely used in world; most content is 2012+ vintage. Not really a GIS with GIS-ready and GIS analysis capability.

4.4.2. USGS National MAP is a true GIS portal and has standard and well-organised GIS-Ready content but limited to display and queries. No GIS Applications. Very well designed and robust.

4.4.3. Bhuvan is more a data bank of IRS 2.5m 2012 images and whatever theme maps are generated by NRS from 2000 onwards - thus use different mapping standards and do not match and overlay well. Bhuvan data is not GIS-Ready. Bhuvan is mainly having visualization and very limited query (not even attribute queries). Design is poor and reliability is low. Functionality is non-conforming across modules.

4.4.4. NICMAPS has seamless, limited layer content and is on principles of a framework. Query and display utilities are quite good (from April, 2015 NICMASP is not available for access).

4.4.5. NSDI portal is mainly Metadata BUT there is no metadata populated and blank data. Very poor design and reliability is low.

4.4.6. Surveykshan has SOI OSM sheets data but not in GIS-Ready format. Only display functions mainly. Poor design and reliability.

4.4.7. MapmyIndia is seamless data for whole country limited to base basic layers. Not GI-Ready. Plus point is large POI data which is updated. Good display and queries for navigation and LBS. Well designed and robust/reliable functions.

4.4.8. Proto-type K-GIS Portals – seamless 53 layers for state with basis display and query functions. GIS-Ready data. Fairly good design, quite robust and quite reliable. No Applications capability.

4.5. Proposed National GIS standards:

4.5.1. National GIS content categories - Boundary, Cultural features, Hydrology, Urban and Settlement, Environmental, Geological, Landcover/ Landuse, Land ownership information, Terrain information, Soils information, Images, Public Assets/Amenities, Met data, Ocean state data, PFZ data, Points Of Interest (POI), crowed source data, Geographical names. List of primary and additional content was presented.

4.5.2. NGIS Database Standards including specifications for National Spatial Framework; Minimum Map Frame size for incorporation to National GIS; Map to Spatial Framework Registration tolerance (0.25mm of scale); Map Projection; Datum Position (Planimetric) Accuracy of Map in m; Minimum Spatial Unit (MSU) (3 x 3 mm of scale) in sq mts; DEM Z-Spacing as 1mm of scale in m; DEM Z-Accuracy in m; Accuracy of Classification/Mapping; Coordinate System; Coordinate Movement Tolerance (CMT) for ingest to National GIS database (0.125mm of scale) in m; Weed Tolerance (WT) for ingest into National GIS database (0.125mm of scale) in m; Sliver Polygon Tolerance(LESS-THAN MSU) in m.

4.5.3. Metadata Standards define feature naming conventions, data dictionary and GIS thesaurus – NSDI can be used as basis for National GIS metadata. It includes Identification Information, Organisation information, Organisation information, Accuracy for Content, Data Quality Information, Attribute Information, Access Information, Disclaimer Information, Cost information for the spatial data.

4.5.4. National GIS Service Standards include National GIS Catalog Registry and Search; dynamic mapping and data fusion; GIS Applications/ Modeling and GIS Data download should be possible. Important standardization include National GIS Metadata Standard, National GIS Catalog Standard, National GIS Map Services Standard, National GIS Map Tiling Services Standard, National GIS Feature Services Standard, National GIS Portal Encoding Standard, National GIS Exchange Standard, National GIS Web Coverage Services Standard, Georss simple standard, National GIS sms ingest standard, National GIS Applications standard.

4.6. demonstrated the criticality and necessity of National Spatial Framework (NSF) – the 4 sources of data for National GIS – images, SOI OSM maps, administrative data and survey/crowd-sourced data. He showed how a fixed point in different GIS portals vary because of the non-uniformity of spatial framework – in terms of the impact of variation as seen in Bhuvan, K-GIS and Google for few specific features – like length of Rajpath, Delhi; MG Road, Bangalore and area of Vidhan Soudha, Bangalore. He proposed one national spatial frame for India where a authoritative Indian boundary with ~5000 XY points which is used for creating the geographic fit. He also suggested that National GIS Foundation Dataset including National Spatial Frame with added state boundary, district boundary, village boundary and Satellite image to co-register with the spatial frame along with NH-Roads, Rail, Rivers. On top of this frame any GIS content which is coming from different sources can be registered properly.

4.7. assessment of important technologies in the context of National GIS. He highlighted the following as critical technology elements for NGIS - Satellite Imaging; Aerial Imaging; UAV Imaging/Data; Electronic Distance Measurement (EDM); GPR; Airborne LIDAR; Mobile Mapping; Positioning using Satellite; Crowd Sourcing/(VGI); 3D GIS; 3D Printing; Web Mapping; Database Engine; GIS Engine; Mobile GIS Technology; Identity Access Management (IAM) ; Data Security; GIS Analytics Technology; Cloud GIS.

5. Finally, Dr Rao suggested National GIS implementation in 3 steps, as follows:

5.1. Version-0.1 in 3 months where one “GIS NSF FRAME” for India (IMAGES + SOI BASE+ADMN FRAME+ GCP) can be organised and made available as a standards GIS frame for any suer to use.

5.2. Version 1.0 NGIS – from the National Spatial Foundation Dataset on NSF with basic seamless GIS-READY data for India (7 layers) + basic GIS applications

– more than just display and query and release of National GIS portal which contains basic governance DSS, simple citizen apps. This can be done in 6 months. This can be Digital India-GIS and aligned to government programme.

5.3. Version- 2 contains 2 sub phases (2 .1 & 2.2) with National GIS implementation in 24 months which includes ~84 layers seamless GIS asset (as per NGIS standard), incorporate ministry data, National GIS DSS applications for 24 ministries governance, citizens GIS-services, commercial applications platform and National GIS infrastructure – robust and state-of-art systems with National GIS training/orientation. The 2 phases can be delivery in 12 months each covering states.

6. Dr Prabhuraj, Director, KSRSAC made a demonstration of the proto-type K-GIS Portal that has been developed by KSRSAC. He showed the seamless 53 layers data and how basic queries can help some simple decisions.

7. Dr Ashutosh Sharma appreciated the work of NIAS team and congratulated NIAS for the excellent report. He also mentioned that he would talk to Dr Baldev Raj, Director, NIAS – who could not be present due to important engagement in Delhi. He requested Dr Rao to quickly finalise the report and submit it to DST

8. Dr Kasturirangan mentioned that NGIS is an important programme and not just a project. It needs a robust/empowered but slim organisation structure. One must see how a legal mandate for NGIS use and embedding into governance – that is how authoritativeness can be built upon. Dr Rangan also mentioned that best of advanced EO satellites, UAS technologies, positioning and surveying technologies, GIS engines etc must get supported to NGIS from national efforts. He also highlighted that the real challenge in NGIS is to cut-across established “silos” and create an over-arching frame of NGIS that will help governance and decision support. Dr Rangan also mentioned that industry involvement must get maximized to make NGIS successful. He stressed that benefits of NGIS must get aligned to government programme of Smart City, Digital India, Swachh Bharat, infrastructure, Land Acquisition management etc and focus must be to support maximal governance.

9. Dr Kasturirangan mentioned that a Policy would be essential for NGIS – he drew Secretary, DST attention to NIAS report on NGIS policy of 2012 and requested that the Policy and the technical standards would provide DST all background work for furthering approval of NGIS and its implementation.

10. The following points were raised by Secretary, DST and which were clarified in the meeting by the NIAS team:

    10.1. few important technical issues were queried by Dr Sharma and clarified by Dr Rao – organizational Structure for implementing NGIS; legality aspects of authoritativeness required for NGIS; Data Management (Who, How, Where) for National GIS Asset – especially integrating ministry data; Authorization (who certifies) of NGIS data; roles of SOI/NRSC and NIC in NGIS. These matters were clarified and explained to Dr Sharma.

    10.2. At a broad level, 30% of NGIS data can come from use of right high-res satellite images; 20% would come from fresh surveys and ground data collection; another 30% would come from ministry MIS data; 10% forms from the NSFD and 10% from crowd-sourced data. Much of the data is available and first effort would be to "stitch" them all into NSF and build Version 1.0.

    10.3. the 3-phased approach suggested by NIAS was appreciated and Dr Sharma mentioned that this needs to be adopted.

    10.4. Version- 1 must be a real good example of for Digital India-GIS. This needs to be adopted.

    10.5. the approaches of BISAG and KSRSAC in developing portals, where we understood the Gujarat contains portal as desktop application and KSRSAC as web app.

    10.6. Secretary, DST suggested to look at how supercomputing can be adopted for National GIS.

    10.7. Secretary, DST agreed to take up the NGIS Policy draft in NIAS report for further discussion, along with the Standards document.

11. Dr Rao also presented how NIAS would like to collaborate with DST to become its GIS/Mapping "think-tank" hub and address innovative and unique aspects of research and studies. This would enable DST to get constant assessment of global RS and GIS developments; assessment for Indian S&T eco-system; undertaking key technology-incubation, applications demo and policy analysis; constant technical reports and white-papers; shape Indian programmes and projects. Secretary, DST asked NIAS to submit specific proposals – which he would appropriately consider.

12. The meeting ended with vote of thanks to Secretary, DST and Dr K Kasturirangan. The minutes issues with approval of Dr Mukund Rao and Director, NIAS.

R Shilpa
(Research Associate, NIAS)

ANNEXURE-I OF ANNEXURE-II

LIST OF PARTICIPANTS

1. Dr Ashutosh Sharma, Secretary, DST
2. Dr K Kasturirangan, Emeritus Professor, NIAS
3. Dr Mukund K Rao, Principal Investigator, NIAS
4. Dr Prabhuraj, Director, KSRSAC
5. Dr S Ranganathan, Homi Bhabha Visiting Professor, NIAS
6. Dr M B Rajni, Assistant Professor, NIAS
7. Dr Chidambaran Iyer, Assistant Professor, NIAS
8. Dr Sharada Srinivasan, Professor, NIAS
9. Dr K Ashoka Reddy, Scientist, KSRSAC
10. Mr K U Virupaksha, Sr Project Scientist, KSRSAC
11. Mr A S Rajashekar, Sr Project Scientist, KSRSAC
12. Mr Janaki Balakrishnan, Associate Professor, NIAS
13. Dr Shoibal Chakravarty, Assistant Professor, NIAS
14. Dr Mr Hippu Salk Kristle Nathan, Assistant Professor, NIAS
15. Dr Anshuman Behera, Assistant Professor, NIAS
16. Ms R Shilpa, Project Scientist, KSRSAC
17. Mr Vilas Chavan, Project Scientist, KSRSAC
18. Ms Diksha Bandil, Project Scientist, KSRSAC

About The Authors and NIAS Research Team

Dr Mukund Kadursrinivas Rao. Dr Rao is an Information technology professional with >34 years of experience in EO, GIS and Space Systems. With a post-graduation in Geology, he has a MPhil in RS and GIS and a PhD in RS and GIS – his thesis is on automatic feature extraction using spatial and spectral information from high-res images. Presently, he works as an independent Consultant in the national and international scene and is also Adjunct Faculty in National Institute of Advanced Studies (NIAS).

Dr Rao is a well-known EO/GIS and Space technology expert and has been furthering EO, GIS and Space in India for more than 34 years. He has the unique distinction of vast experience in government and industry. He has served in ISRO for 24 years – where he worked in shaping the Indian Remote Sensing (IRS) programme and its applications and establishment of India's National Natural Resources Management System (NNRMS). He has worked for India's first GIS programme on Natural Resources Information System (NRIS); conceptualized India's National Spatial Data Infrastructure (NSDI) Strategy and Action Plan; architectured India's National Urban Information System design etc. Dr Rao led GIS Standards in India and is key person for NRIS Standards in 1990s; NSDI Metadata Standards in 2002; NNRMS Standards in 2005 and NUIS Standards. Under his coordination, the demonstrative NSDI Portal was developed in 2003 and he was instrumental for NNRMS Portal in 2004.

He has played a lead role in EO programme coordination for India and was involved in the EO-2025 strategy formulation and architecting/definition of a range of national level RS applications for various user ministries, including conceptualizing the NR Census programme. He has actively worked on defining policies for EO and GIS. He has been active in the international EO and GIS circuit with extensive involvement in CEOS, IAF, IAA, ISPRS, GSDI, UN-COPUOS, UN-CSSTEAP, IISL and many other fora.

Later for 6 years he has been with GIS industry – where he was CEO of GIS business initiatives. He brought in his technical expertise to development and implementation of GIS business in Indian environment – Power-GIS applications in India, Municipal-GIS for Indian cities, OneMap of Singapore, enterprise GIS for Ras-Al Khaimah and Ajman emirates in ME, Delhi state SDI initial design, India's NSDI metadata portal and others. He also led ESRI distribution activities in India. He was also involved in a unique integrated project design by combined usage of GIS/GPS with direct satellite communication terminals.

For the past 5 years, he is in consulting domain of EO/GIS and Space and advises many entities in government, industry and academia. He has consulted for Indian Planning Commission as Expert on National GIS and was key person in conceptualization and definition of India's National GIS programme. He has steered the state-level enterprise of Karnataka-GIS. He also consults with geo-spatial industries on important technical and design aspects. He has vast experience in EO, GIS and Space Policy and regulatory aspects at national and international level. In 2012, he successfully led a DST project in NIAS for defining National GI Policy – a report has been published by NIAS.

Presently, at NIAS, he is working on definition of a renewed Space Policy for India. He has published key paper on renewing Indian Space Policy and also for privatization of Indian space. He is germinating a focused "UAS technology and policy" development study.

Dr Rao also serves as Member-Secretary of Karnataka Knolwedge Commission and steers various knowledge activities in education technology, biodiversity, arts management, sports policy, Karnataka-GIS and many other activities of relevance to state of Karnataka.

Dr Rao is well-recgnised in India and also in the world – he has contributed to many national and international initiatives – he was the founding and first President of the international Global Spatial Data Infrastructure Association (GSDI); Vice-President of the International Astronautical Federation (IAF); elected Member of International Academy of Astronautics (IAA) and International institute of Space Law (IISL); has been active in the international Committee on Earth Observations Satellites (CEOS) and other forum like International Society for Photogrammetry and Remote Sensing (ISPRS) and UN-Office for Outer Space Affairs and supported UN-ESCAP for GIS.

Dr Rao has been honored with many awards - GIS Professional of 2009 at the Map India, 2010 Conference; National Geospatial Award for Excellence of the Indian Society of Remote Sensing (ISRS) in 2009; Exemplary Service Medal from international Global Spatial Data Infrastructure (GSDI) association in 2009 and Hari Om Ashram's Vikram Sarabhai Young Scientist Award in the area of "Systems Analysis and Management" in 2002.

Contact: Mukund Kadursrinivas RAO (Email: mukund.k.rao@gmail.com)
Public profile: in.linkedin.com/pub/mukund-rao/0/448/25a/

Prof Ramamurthy is a well-known Indian nuclear scientist with a broad range of contributions from basic research to science administration. Prof Ramamurthy started his career in Bhabha Atomic Research Centre, Mumbai in the year 1963. He has made important research contributions, both experimental and theoretical, in many areas of nuclear fission and heavy ion reaction mechanisms, statistical and thermodynamic properties of nuclei, physics of atomic and molecular clusters and low energy accelerator applications. During the period 1995-2006, Prof Ramamurthy was fully involved in science promotion in India as Secretary to the Government of India, Department of Science & Technology (DST) New Delhi.

For more than a decade, Prof Ramamurthy has steered national level programmes of mapping and GIS and has been closely associated with the SOI mapping programmes, NRDMS programmes, NSDI conceptualization and also in National GIS and Karnataka-GIS framework. He continues to guide and support various GIS activiites in the countries – especially through NIAS research projects.

He was also the Chairman of the IAEA Standing Advisory Group on Nuclear Applications for nearly a decade. After retirement from government service, Prof Ramamurthy, in addition to continuing research in Nuclear Physics in the Inter-University Accelerator Centre, New Delhi has also been actively involved in human resource development in all aspects of nuclear research and applications. Prof Ramamurthy is also a Chairman, Recruitment and Assessment Board, Council of Scientific and Industrial Research and Member, National Security Advisory Board. In recognition of his services to the growth of Science and Technology in the country, Prof Ramamurthy was awarded one of the top civilian awards of the country, the Padma Bhushan, by the Government of India in 2005.

He was Director of NIAS from September 2009 - 31 August 2014 and now he is an Emeritus Professor of NIAS from September 2014.

Contact: Prof V S Ramamurthy (Email: vsramamurthy@nias.iisc.ernet.in)

Dr Baldev Raj has assumed responsibilities as the Director of the National Institute of Advanced Studies, Bangalore, one of India's leading multi-disciplinary institutions. A distinguished scientist and former Director of the Indira Gandhi Centre for Atomic Research in Kalapakkam, Dr Baldev Raj has helped advance several challenging technologies, especially those related to the Fast Breeder Test Reactor (FBTR) and the Prototype Fast Breeder Reactor (PFBR). He has also nurtured and grown excellent schools of global stature in nuclear materials and mechanics, non-destructive evaluation, nano science and technology, and robotics & automation. He is pursued his work in interdisciplinary domains of energy, cultural heritage, medical technologies, nano science and technology and education.

The author of more than 970 academic papers in peer reviewed journals along with 70 books and special journal volumes; Dr Baldev Raj has been recognized by way of more than 100 awards, 380 honors, keynote, invited lectures and assignments in more than 30 countries. A recipient of the Padma Shri; the other awards include Life Time Achievement Award of the Indian Nuclear Society, the Homi Bhabha Gold Medal, Distinguished Materials Science Award, Materials Research Society of India, etc. He is a distinguished alumni of Indian Institute of Science, Bangalore.

A member of the Circle of Advisors, Cambridge University, UK, and a member of the Search Group for the Queen Elizabeth prize in engineering, Dr Baldev Raj is also a Fellow of all the Science and Engineering academies in India, German Academy of Sciences and the World Academy of Sciences. He is the Chairman of the Board of Governors of IIT Gandhinagar, a member of the Court of Jawaharlal Nehru University, Delhi, and President-Elect of the International Council of Academies of Engineering and Technology Sources. He is Honorary Member, International Medical Sciences Academy.

Dr Baladev Raj brings his intense expertise and knowledge in standards, metrics, quality to the GIS domain through his active involvement in National GIS activities in NIAS and with state/central government agencies.

Dr Baldev Raj is known to have mentored hundreds of children, students, scientists and technologists, inspiring them to pursue high levels of professionalism in the pursuit of science and technology without losing sight of the need for exemplary ethical practices.

Contact: Dr. Baldev Raj, (Email: baldev.dr@gmail.com, baldev_dr@nias.iisc.ernet.in)

Ms. Shilpa Ramesh is member of staff at KSRSAC (Karnataka State Remote Sensing Application Center), Bangalore since last 7 years. As a Project Scientist at organisation she got involved in multiple GIS projects where she developed GIS skills. KSRSAC has undertaken state as well national wide project such as Land Suitability for Sericulture, Integrated Rural Development Program, Quality Analysis for Bangalore Municipal, Change Analysis for National Wasteland, Land Resource Information System and many more. She was part of data creation and customization team where she was also doing QA/QC for same.

While working on GIS technologies she has developed the knowledge theoretical parameter of project theme to develop the spatial & non spatial database. She was also a team member of GIS portal development at the organisation. She was actively involved in developing most of the modules of GIS portal from designing the database to testing the portal thoroughly.

Organisation has shown confidence in her by allowing her to present paper on relevant projects in various parts of countries. She attended the sessions at NESAC (Meghalaya) while working on land suitability for sericulture and understood the importance of developing GIS portal for same from user perspective.

Since November 2013 she is associated with Dr. Mukund Rao for National GIS project as Research Associate where she is leading team for defining Standards, Spatial Framework and Technologies for National GIS. She has researched worldwide GIS standards and GIS web portal in order to define GIS standards for India.

Contact: Shilpa Ramesh (Email: shilpa.r1585@gmail.com)

Mr. Vilas H. Chavan is working as Sr. GIS Analyst at KSRSAC (Karnataka State Remote Sensing Application Center), Bangalore. He has extensive experience in GIS Technology and Database technology and application. He has been working in IT industries over 15 years including 7 years in GIS technology.

He began his GIS profession at NGO where he was part of various projects. While working at socio-environmental NGO, where he gathered knowledge of ecological restoration, rural development, women empowerment and micro-finance etc. and there by developed linkage with GIS technology.

Also he had an opportunity to work in Industry where he acquired knowledge of commercialization of GIS. He had chance to be a part of different upcoming urban development GIS projects in India such as Property Tax, e-Governance for Municipality and so on. He did not only get involved into GIS technology but also learned designing the architecture of database.

Currently he is working with Government organisation and involved in a mixture of projects where he is designing database for MUDA and Asset Mapping which has helped him to get his good hands on GIS technology. Such multicultural work practice has led him to be team member of NIAS (National Institute of Advanced Studies) where he was part of defining the Standards, Spatial Framework and Technologies for National GIS.

Contact: Vilas H. Chavan (email: chavanvilash@gmail.com)

Ms. Diksha Bandil holds post graduate degree in Remote Sensing & GIS from Jiwaji University, Gwalior (MP). University recommended her to attend ISRO (Nagpur) to finish dissertation thesis as a part of course work where she got an opportunity to work on RS and GIS projects - Land Use/Land Cover Mapping Using Temporal IRS Resourcesat & AWiFS Data of Nagpur. She used satellite image and created larg-scale maps of urban landuse and also gained considerable experience with RS and GIS software processing.

She joined MPCST (Madhya Pradesh Council of Science & Technology), Bhopal as a GIS Assistant and worked on various projects - Space Based Information Support for Decentralized Planning (SISDP) where her role was in mapping and GIS data creation from satellite images. She adopted data accuracy parameters and this helped her to create and organise good quality GIS databases. Later, she worked for Birla Institute of Technology, Jaipur, as a Junior Research Fellow.

She joined NIAS (National Institute of Advance Studies) in end of November 2013 to October 2014 as a Junior Research Fellow. She worked as a team member for the project on Standards, Spatial Framework and Technologies for National GIS under guidance of Dr. Mukund Rao. Her role was mainly in assessing various standards, portals and technologies and helping the overall project. She has actively involved herself in the project and this has given her good end-to-end GIS standardisation definition and documentation experience.

She joined KSRSAC (Karnataka State Remote Sensing Center) in November 2014 as a Project Scientist. She is a team member of Slum Free City Mapping project and her role is in creating standardized large-scale GIS data for cities that will be used for slum-free data needs and also in defining and testing GIS applications.

Contact: Ms. Diksha Bandil (diksha.rsgis@gmail.com)

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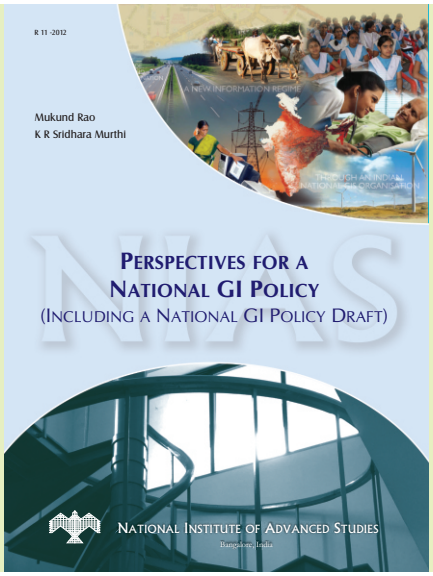

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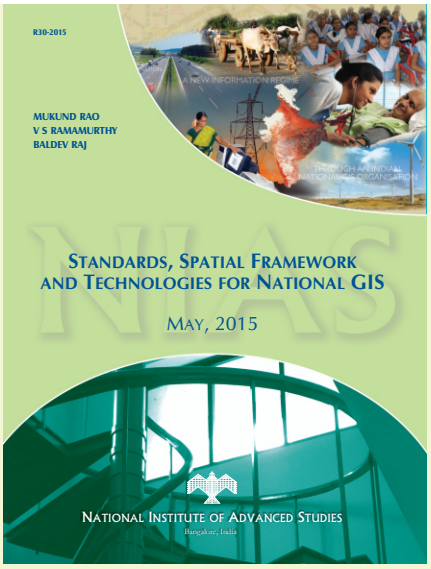

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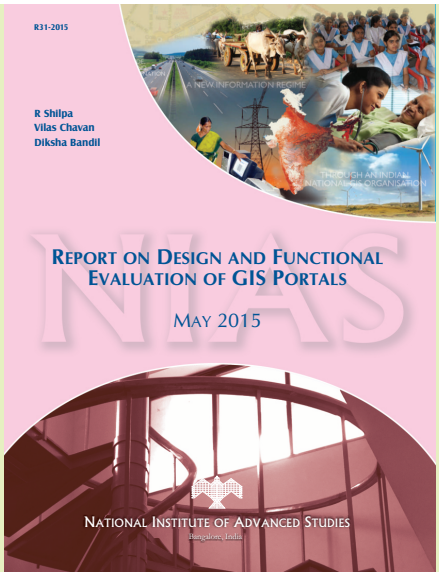

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