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CyberGIS and Crowdsourcing – a new approach in E-Governance

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1. Introduction

Geospatial technology has evolved in three evolutionary phases— Computer Mapping (70s), Spatial Database Management (80s) and Map Analysis/Modeling (90s). At twenty first century it is at a threshold that is pushing well beyond mapping, management, modeling, and multimedia to spatial reasoning, from a research-dominated to a user-dominated field, from webmaster to the end user on accessing spatial information. Web based technology development in recent years draw a large amount of ordinary citizens/ users to build large datasets, reversing the traditional top-down flow of information. This opens up new world of opportunities, new applications and new ways of using geographic information in society providing a complete geospatial ecosystem for the users and facilitating study of the world along with its integral components – physical elements, people, connectivity and events. The emerging trends not only generated consciousness among participants in thinking spatially for social and economic interaction but they also emerged as separate identity along with strength of visualization, rigorously evolved hardware & data capturing mechanism.

2. 'Thinking geographically' – the seed of public participation

Thinking Geographically ('Spatial' thinking) adds the flavor of 'power of analysis' on top of the concept 'is it all about data?' In present days scenario Geo-visualization is "of the people, for the people, by the people". Seeing spatial patterns is exiting for many but the really important element is combining visualization with analysis. Geo-visaulisation makes it more geo-concerned, invoke people to ask about space, time and subject.

a. Space is represented by Scale (local, regional, global) and extent (community, village, city, state, country).
b. Time in terms of historical or future perspective.
c. Subject in terms of specific information requirement and focus.

Technology and data explosion has made it easier for user to acquire information, which is available in wide range of format, at multiple scales, with variable quality. People's participation emerges from –

1) *Exploration of geographic data* - Once the unstructured data is turned into structured format like maps, tables and charts, they depict powerful patterns. Integration of different kinds of data from different sources such as images, photos, and features emerges as a very strong pattern to define the things on space and how they are changing over a period of time.
2) *Analyze geographic information* - Focus on relationships between the information helps people to satisfy their need for particular information/ query by drawing conclusions and understanding the issue better than before. Some of the after-analysis decisions help in turning pieces of data into knowledge. Integrated understandings of the relationships between diverse forces need to be realised by the community to make informed decisions. Understanding the wide spread linkage and helping others to act locally thinking in a global form.

CyberGIS is the internet based systems and services which facilitates/ performs the task of visualizing, analyzing & disseminating space related data, functions of GIS and access to it via internet/ web. It is evolving as a distributed enterprise, service oriented architecture and fully interoperable which makes it easily accessible and collaborative, by functionally connecting GIS professionals/ decision makers with a broader web community

Evolution of CyberGis is based on participatory environment facilitating public participation and collaborative efforts in a common and sharable platform. The power of getting users to create the database enables new forms of intelligence to be added to the data in the form of derivative products, by capturing individual knowledge of users. It has emerged as separate identity along with strength of visualization high-resolution satellite imagery, open source software, rigorously evolved hardware and data capturing mechanism. Google earth, Bhuban, Virtual earth, Bing maps, Global mapper, Tagzania and Flicr etc named to be a few in this context. The power of GIS is the combination of two elements – geo-visualisation and analysis. Visualization is good, visualization along with analysis is infinitely better.

a) Geo-visualisation

- ***Google earth*** has changed the definition of GIS to the common man. All of the "GIS" is done on an Google Earth Enterprise Server back-end with a front end web browser thin-client with minimum functionality. In addition KMl and KMZ files provides instant support to participatory users. This world-exploration application explore the Earth as a flat 2-D image or as a 3-D experience along with minimum geovisualisation functions and utilities, which is further enhanced with time series imagery to understand the recent changes on ground.
  Supporting application **Google maps** allow user the opportunity of mix and mash. **Google street view** explore the earth in terms of network analysis between two places along with alternate paths supported by road view and roadmap in 360º (to easily identify the road and location names).

- **Microsoft Surface Globe** is a hands-on, world-exploration application based on Microsoft Bing Maps *(earlier Virtual Earth)* content and technology along with windows-7 and WorldView-2 imagery. The Multi-touch pack can interact with Microsoft Surface Globe by using the touch gestures (or mouse and keyboard actions)*. 'Zoom into 3-D locations'* (like the Grand Canyon or Niagara Falls) along with Microsoft Silverlight, '*Visualize location-based data'* (demographic or census)

are other add on functionality beyond globe visualisation. *'Connect with people/community'* is encouraging to build location based applications and public participation.

- **Bhuban (Indian earth observation visualization)** is an Indian initiation for geovisualisation with IRS and cartosat series imageries similar to Google earth. Public participation is encouraged with spatial emphasis to Indian region along with Natural resource database (NRDB) and DEMs. Supports provided for users to select and download data, products and derived maps (like landuse).

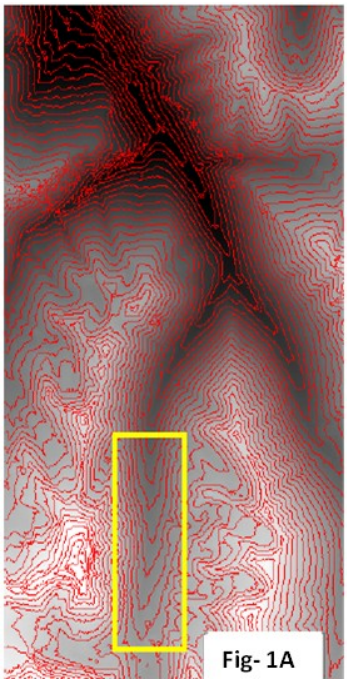

Fig- 1A

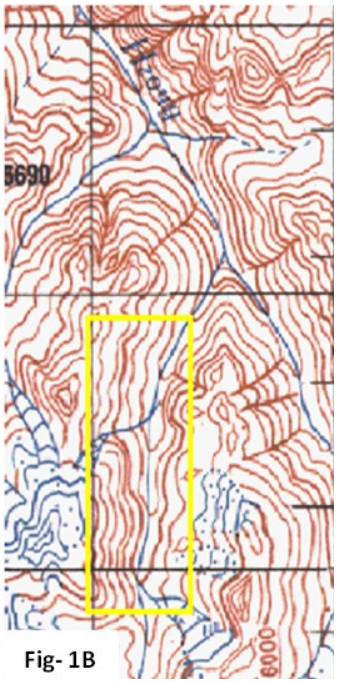

Fig- 1B

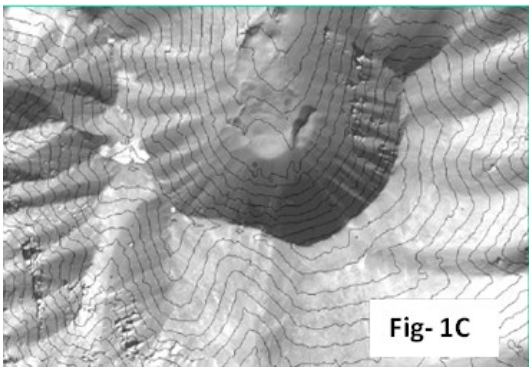

Fig- 1C

Cartosat DEM With better method and posting interval the first order stream and finer features are captured in the generated DEM. The quality of DEM is also evident from the contours which are generated without any filtering.

- **Tagzania** and **Flickr** are the online photo management and sharing applications with query in the time and spatial domain. It uses the geo-tagging concept to put a geographic coordinate tag in a photograph and relate it to the database and community.

Some applications/tools developed around above-mentioned 'flagship' applications to provide information beyond visualisation for navigational and community service.

- One such application developed around the Bing-maps is iPhone Navigation with MotionX . It allows to lookup businesses and visualize demographic information on and around a respective company. For example, an insurance company can use it as an agent locator application to visualize the locations of their respective agents by putting a particular icon and photo at a particular location on the map. This will support the quarry "Find Agents Near You" in a particular postal code. Listed results will have link of contact information and links for directions and emailing the agent.

b) Geo-visualisation with analysis and editing

These new systems are more of web mapping rather than GIS. Present day geo-visualisation systems are evolving themselves towards data creation, editing and maintenance environment for public participation. Some of the examples are:

i. *Walking papers* – 'OpenStreetMap' is a wiki-style map of the world that user can edit. In some places, participants are creating the first freely-available maps by GPS survey. Walking Papers is made to help user easily create printed maps, mark them with things they know, and then share that knowledge with OpenStreetMap.

ii. Google map maker supports overview, attribute and description of the user added features along with the history of edit.

iii. *Upcoming Mapzen* editor cloudmate -- POI Collector is the world's first iPhone OpenStreetMap *editor* which lets iPhone users to add and edit OpenStreetMap places of interest (POIs) on the iphone on the go.

iv. *Oakland Crimespotting geospatial analysis* -- Crimespotting enables user to do more than search for the things they already know. It addresses complex questions of patterns and trends, in a localised way on a block-by-block basis for crime analysis in space and time domain. Instead of simply knowing where a crime took place it investigates questions like: Is there more crime this week than last week? More this month than last? Do robberies tend to happen close to murders?

v. *GeoCommons* delivers visual analytics through maps. It helps to view massive amounts of data, make decisions and solve problems without prior training or experience using traditional mapping tools.

c) Public participations – some insights

Participatory environment has two main elements — consensus building and conflict resolution. Geospatial community is jointly developing the Geospatial Platform to promote improved coordination and more effective use of geospatial information by promoting sharing across multiple levels. It will function as the service and delivery mechanism for the geospatial data, services, applications and as the integration point for the discovery, access and joint use of state / non state geospatial data and services.

Use of GIS for public participation and collaborative efforts makes them enable for -

- Understanding the threats to our environment, such as global warming, species extinction and pollution.
- For conserving the earth's natural resources and wildlife (conservation projects) GIS is considered as an important tool. It is used in tracking wildlife, studying wildlife habitats, measuring resources and monitoring forests.
- Develop critical thinking skills by giving spatial perspective to what they have learned from theoretical perspectives.

Few examples of public interest and global environmental impact are mentioned here

1) International ocean clean up is an effort lead by Ocean Conservancy to collect trash from and along the waters of the world, and educate people about the need to be more responsible for our impact on the planet. Nearly 400,000 volunteers collected more than 6.8 million pounds of trash in 100 countries.

Website http://www.oceanconservancy.org/site/PageServer?pagename=icc_home

2) Algalita Marine Research Foundation has been doing analysis about the level of plastic debris in the ocean and reporting their findings through analytical maps.
   Website http://www.algalita.org/Maps_Home.html
3) The National Oceanic and Atmospheric Administration (NOAA) released a report on September 16, 2009 showing that global sea-surface temperatures for August and its comparison with other months.
   Website http://www.noaanews.noaa.gov/stories2009/20090916_globalstats.html

3. Components of Cyber-GIS -- the game changers

Distributed cloud computing, web-services, mash-ups and mobile GIS are a few that have captured geotechnology's imagination and acted as the game changers.

a) Cloud Architecture -

"Cloud computing" is the latest in this trajectory of terminology of computing advances. Cloud computing is not a technology—it is a concept of distributed computing. There are three distinguishing characteristics defining it—

- It involves ***virtualized*** resources - means workloads are allocated among a multitude of interconnected computers acting as a single device.
- It is dynamically ***scalable*** - indicates that the system can be readily enlarged.
- It acts as a ***service*** - translates that the software and data components are shared over the Internet.

Cloud computing is basically the movement of applications, services, and data from local storage to a dispersed set of servers and datacenters, resulting a "hosted elsewhere" environment for data and services. It is an advantageous environment for many data heavy and computationally demanding applications

There are two broad types of clouds depending on their application:
i) "*Software as a Service*" (SaaS) - delivering a single application through the browser to a multitude of users/ customers. On the customer side, it means minimal upfront investment in servers or software licensing and on the provider side, with just one application to maintain, costs are low compared to conventional hosting

2) "*Utility Computing*" - offering storage and virtual servers that can be accessed on demand by stitching together memory, I/O, storage, and computational capacity as a virtualized resource pool available over the Internet— thus creating a development environment for new services and usage accounting.

b) Crowdsourcing

Conventionally crowdsourcing is the act of outsourcing tasks, traditionally performed by an employee to a large group of people or community (crowd), through an open call. Crowdsourcing is a phenoma of 21st century in GIS to generate user driven collective intelligence by received asserted information from individual action voluntarily or from authoritative sources with / without authoritative guarantee (bottom up approach). It is implied to conversion of potential user's response in structured data creation with little of a direct push factor from the owners / managers / designers of these sites and enabling users to generate their own content with an uncoordinated and voluntary group dynamics. Crowdsourced spatial data collection is facilitated by devices like handheld GPS devices, digital notebooks, mobiles (equipped with open source software, photos,

video, voice-recorders). This data get synchronized with central database with/without moderation and is accessible / sharable as a web-based databases, services and maps.

Crowdcasting is union of broadcasting and crowdsourcing with the potential crowd being 'pulled' in as a direct result of the 'push' in the form of incentive. In crowdcasting, the push factor is making potential users aware of authority's desire for them to participate, often through other web sites and related digital media like email. The incentives for developing systems in this way clearly depend on the value that the crowd sees in interacting in this way. Some crowdcasting systems actually introduce incentives for users to feed their collected or own data by offering rewards, often in monetary value.

crowdsourcing and crowdcasting as essential ways in which large groups of users come together to create data, serving as human sensors. Facebook and Flickr is a potencial example of crowdsourcing. Some of the market based product survey implies the very primitive form of crowdcasting with push of incentives. But all these implicitly says that creating data through crowdsourcing or crowdcasting, tagging data, deriving patterns and correlations such as social networks, takes place in different web environments which are linked to one another.

c) Web 2.0

Web 2.0 have changed the web from a passive to an active experience where user can participate. Some of its major attributes are Crowdsourcing, Collective intelligence (the web site / service gets better the more that people use it), web service (not an application), data supremacy and design for flexibility (users can mix and mash data).
Web environments are acting as data bases that can be provided as a central service or can be built from the bottom up in decentralised fashion with distinct role of designers and users. These are just one subset of applications and services that form the Cloud.

Web user can create content on the web both collaboratively and individually, allowing for a personalized web experience through wikis, blogs, photo sharing, and other technologies. Various applications are available for taking part in the new form of gis and cartography: geotags, geoblogs, geowikis, GeoRSS feeds, Google MyMaps, and Yahoo Pipes.

d) Mashup and API

A mashup is a song or composition created from the combination of the music from one song with the vocals from another. Map mashups are just the visible tip of the GeoWeb. On the web, a mashup is a web application that combines data from one or more sources into a new product that enhances the value of the source datasets. Often the new product was not originally envisaged by any of the source data providers. Mashup can combines a map source with authoritative data (including government databases), and crowdsource data for interactive map creation on the geoweb using an API (application programming interface) creation by people with little or no programming knowledge. The mashup creator is freed from having to host, maintain, and update the data because the source data is not hosted on the same machine as the mashup site. For example, flickrvision.com combines Google Maps with Flickr photos to show georeferenced photos on a world map. None of the photos or maps is maintained at this site, except just the code to combine them.

APIs provide a way for mash-up developer that interacts easily with other software through a well-defined interface without paying license fees or royalties ('open'). For example, the Live Earthquake Mashup (http://www.oefiles. de/gmaps/eqmashup.html) combines a US Geological Survey feed of earthquakes, with a Google Maps background.

e) Web Services-

Web access of normal user is primarily through graphical user interfaces (GUIs) in the form of a 'browser' which enables users to graphically control their operations in the web environment. Most of such websites are highly interactive on an individual basis but are largely passive (in terms of the data users have access to) with users being unable to change the data or to interact with other users. Many of them contains locational information to be searched on property, crime, education for neighborhood with tagged base maps but accessible only in a passive web environments like *Google Ride Finder* and *Google Transit* enable users to plan trip services using taxis, public transport etc.

Increased locational awareness with crowdsourcing has catalyzed the need to attach geo-component with every bit of information that is feeded into the web and in Web 2.0 three methods are mainly used fo georeferencing content –

- Geotag - links content such as photo, video, or website, to a set of spatial coordinates (Example - Flickr). The content can then be found when a user performs location-based queries. It is useful for mobile phones and car navigation systems. Main challenges are geospam and user dependant accuracy of content. Usage example is adding a Mapplet to Google MyMaps and search/view photos for a given area.
- Geowikis and Geoblog - A wiki is a web application that lets users create and edit content, (example - Wikipedia, online encyclopedia). A geowiki is a map based wiki that lets users identify and comment on features on a map. One example, http://wikimapia.org uses Google Maps as the background map and supports user creation and editing of places. Users annotate maps by adding links to local landmarks/ features/ shops.
  A blog is a web page similar to a diary, that lets a user post text, video, images, and links to others web sites. Users can read and comment on the blog entries. A geoblog let users annotate maps by adding links to local landmarks, shops, facilities and other places. As in a real blog, and unlike a geowiki, other users can rate and comment on map entries. Allowing other users interaction (rate and comment) geoblogs have been proved as a useful tool in tourism.

- GeoRSS feeds - A RSS Feed publishes information out to an application like current weather alerts and news articles. RSS Feeds are XML/HTML files with coordinate information, which can be viewed by adding to existing map sites or in a special viewer. A GeoRSS feed adds additional format specifications to support tagging content with location information. There are three different standards that work with RSS – a)GeoRSS Simple - basic format limited to WGS84 latitude/longitude b)GeoRSS GML- richer format supporting more features and coordinate systems c)W3C geo GeoRSS - partly deprecated format, still used widely.
  For example, US Geological Survey publishes a W3C geo GeoRSS feed of earthquakes at http://earthquake.usgs.gov/eqcenter/catalogs/eqs7day-M5.xml. Another example, free ACME GeoRSS Map Viewer site http://www.acme.com/ GeoRSS/ about.html takes any GeoRSS feed and maps it. For earthquakes, the

web page http://www.acme.com/GeoRSS/?xmlsrc=http://earthquake.usgs.gov/eqcenter/catalogs/eqs_7day-M5.xml shows the feed on Google Maps background.

f) Online mapping Services-

In addition, some sites allow users to create their own maps using online mapping Services. Google MyMaps is a an example of online Mapping Service. Users can easily combine maps with data from GeoRSS feeds or other source by Google Maps API. The final mashup can be hosted on the user's web site instead of the Google site. *Living Science* which is a Google Map mashup located at www.livingscience.ethz.ch enables user to search geographically a database of scientific papers, deposited on the open archive arxiv.org. It allows users identify how many papers of specific categories or in total have been written in different locations (countries, cities) over any period of time and subcategories are shown in cartographic forms.

Many of the map mashups mentioned earlier use Google Maps service, a free online mapping service by Google (http://maps.google.com/), to incorporate a Google Map into a web page as well as to direct queries of a data base that is locationally tagged. Other free map services are Yahoo Maps (http://maps.yahoo.com/), Microsoft Virtual Earth (http://maps.live.com/), MapQuest (http://www.mapquest.com/), OpenLayers (http://openlayers.org/) – an open source alternative. Most of these map services offers multiple services with their own JavaScript application programming interface (APIs). Some of them have "no coding" interface that lets users make maps by using XML files. Users can freely access most of these these APIs for non-commercial / personal use, but there are restrictions and sometimes costs for commercial use. The sites require users to register (exception-OpenLayers site).

g) Mobile based platform

This trend motivates GIS being deployed on new generic hardware/ software platform like 'mobile phones with integrated advanced navigation features' for a variety of geospatial information services. Possibility of adding 'location capabilities' to mobile Web browsers promotes active as well as passive crowdsourcing (example - twitter with geolocation). Crowdsourcing of data via mobile phones will generate data in real time and some mobile applications like Short Message Service (SMS) geotagging. Efforts are being given to create open standard for geoSMS, so that SMS messages can be geotagged. These have huge potential in emergency service and disaster management.

A lot of live data, refered as human sensor feeds, is going to be available in the future which is waiting to integrate into geospatial applications. Real/ Near real time data creating through crowdsourcing / crowdcasting, tagging data, deriving patterns and correlations in interlinked web environments with a good catalogue of web based services is going to be the most potential tool for decision and policy makers.

4. E governance in the context of recent developments

E-Govrnance is 'digital interaction between government and citizens, government and business/ commerce, government and employees & between government and other government/ agencies'. E governance is defined as the utilization of Information and communication Technology and other web based telecom technologies to improve and enhance the efficiency / effectiveness of service delivery to citizens and public sector. It leads to new, better services and reduction of costs with an ease to upscale and reach thousands easily. E governance facilitates collaboration with agency, people and various government departments for information collection/ exchanges. Crowdsourcing

does not substitute for paid work, rather it is additive. In e-governance along with people's collaboration it requires government in-house advanced communication and content-related skills, continuous evolving of system to reduce the cost of failure.

To create collaborative e-governance the main criteria is creating enabling conditions by removing the barriers with ensuring that knowledgeable people are in charge and multistage approach in funding ned to be adopted. Services can be categorized as i) infrastructure as a service ii) data as a service iii) software as a service iv) platform as a service. CyberGis can act and support anyone of these or all four in multiple combinations. It can be delivered on demand, often on a pay-per-use basis with speed, flexibility and scalability.

The benefits of CyberGIS in e-governance as –

- Easier manage to huge data volume - 70% of all government/ business data have a location component, and as organizations capture, store and archive more information, the need for location intelligence grows exponentially. Readily access all of the necessary data sources and frequent update is a much easier task.
- Lower Total Cost of Ownership - subscription to On Demand solutions under pay-as-you-go terms reduce lesser investments/ maintenance in hardware/ software. There is less data to manage /updates.
- Greater Resource Utilization – It provides a better flexibility. Change in policy/ development model can easily be adopted and scalability is more with reduced response time.
- Intelligent Collaboration – It assures the ability to support 24/7 community computing at any time at any place. It provides significant advantages and consistency across an agencies/ departments and facilitates data sharing.
- Growing number of users - location intelligence drives day-to-day decisions in virtually every facet of a business, governance operations and risk management. Geo-analytical tools in the hands of an increasing number of users help to take better decisions.
- Growing complexity of data - Speed, capacity with enormous computing power is required to support spatial analysis tools that can process an enormous amount of data from multiple sources and deliver user within a small time.
- Increase in mobile applications - Mobile GIS technologies including GPS, smartphones, mobile apps and wireless communications are creating many opportunities. Field-based GIS is becoming more and more relevant to collect, view, validate and update spatial data in real time, on location.

5. Towards the future

The future of decisionmakeing and egovernance is collaboration between government and people, authoritative data and user created data.

- Crowdsourcing is a paradigm shift of data creation and editing. Though the initiation for crowdsourcing is already started, it will take some more time to reach a mature stage with necessary standard, metadata and authorization process.
- Geospatial problems, systems, and services for citizens existed in india are too large to build the infrastructure for. Software/ service maintained at single place, with the ability to scale and overflow to the cloud as needs demand and shrink back down to baseline as they retreat, will become a sought after deployment model for citizens services and decision making
- A real-time multimedia view world is available now. A new dimension is location sensing along with the ease of availability of Wi-fi, UWB and GPS etc. Location

based services along with smart grid will become a reality for storage, demand response, intelligent device and control system etc.

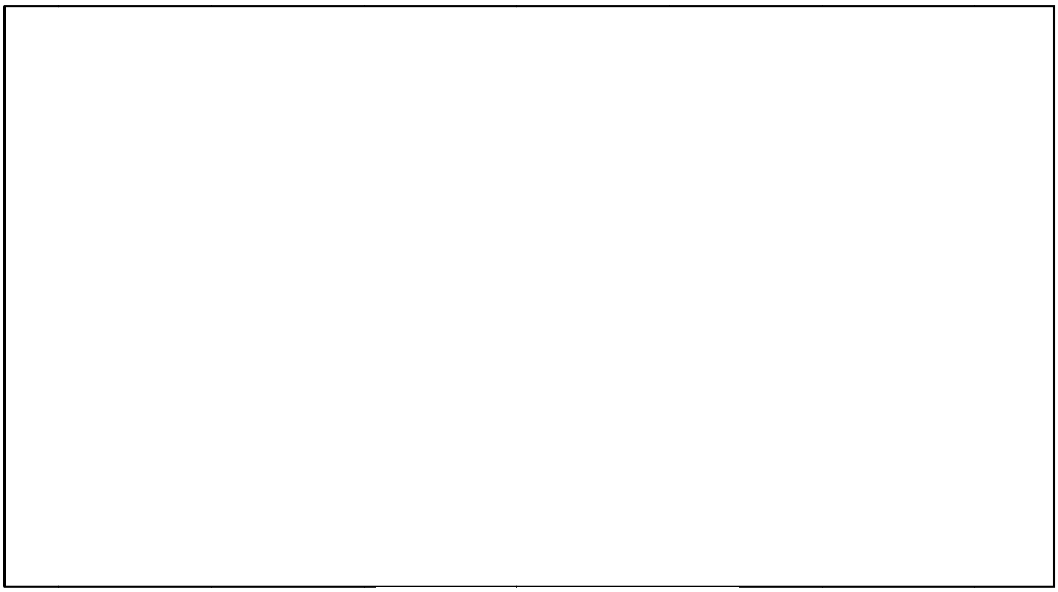

Fig - 2. E-Governance and crowdsourcing

Major challenges in implementation with Indian context are –

- How do we bring potential users for crowdsourcing / crowdcasting
- How to capitalize on the massive volumes of geospatial data that already exists within various agencies and better coordinate the technology platforms on which they reside.
- Standardize the properties of the data and make them accessable by those who need them across the Web.
- Make sure people can trust the data going out of government Web sites
- Accountability tools will become an important added dimension of the future of geospatial information
- Data ownership, sensitivity and privacy continues to be an issue.

Few examples of crowdsourcing and government efforts are mentioned here-

I. As part of the Obama Administration's Open Government Initiative, *a Geospatial platform* will provide user-friendly, integrated data collections and map-based tools from federal, state, regional and local governments, as well as non-governmental contributors. The platform is tied to Data.gov, the public portal of online Government data depository, a substantial portion of the data now available on the site comes from existing geographic data catalogues. The content of all datasets and services with the Data.gov have been verified by the agency to be consistent with Federal privacy, national security, and information quality policies. Data will reside with the agencies that created it, which is where it is most accurate, and shared via the platform.

II. Another example is by US Defense Department in project 'Pacific disaster center' by creating a Disaster Aware platform. It monitors continuously information feeds from meteorological and geological agencies and delivers information and alerts in real time to subscribers. Users can share analyses and situation reports and can query the underlying databases of DisasterAware, which has a presence on

Twitter. The system has been ported to iPhones and iPads. Backend components are based on ArcGIS server, and java applications

III. Geo- Wiki demonstrates the use of Crowdsourcing to validate data and improve database. Geo-Wiki Project is a global network of volunteers who wish to help to

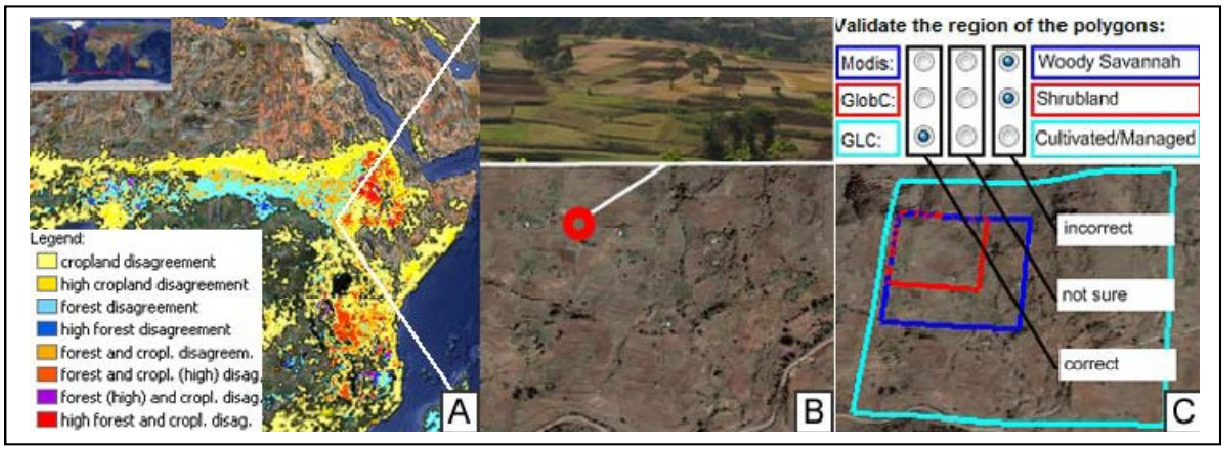

Fig-3. Snapshot of the GUI of geo-wiki validation project

improve the quality of global land cover maps. Since large differences occur between existing global land cover maps, current ecosystem and land-use there is a lack crucial accurate data. Volunteers are asked to review hotspot maps of global land cover disagreement and determine, based on what they actually see in Google Earth and their local knowledge, if the land cover maps are correct or incorrect. Land cover datasets are crowdsourced via a Web Map Service (WMS). Their input is recorded in a database, along with uploaded photos, to be used in the future for the creation of a new and improved hybrid global land cover map.

IV. The Gulf of Mexico Oil Spill was one of the worst environmental disasters in recent times. Mobile Crowdsourcing plays a crucial role for collecting geospatial data in the field to record the extent and severity of the Spill. People voluntarily record incidents, capture images and video, and blog on conditions in real time and it is used to prioritize sparse cleanup resources. The reports were submitted from cell phone, web form, SMS or MMS, e-mail, twitter. A central organization was responsible to create reports, mark oil damage locations, add comments, submit photos & video which are sharable in web. Mobile applications and website is free for access to the public.

V. In emergency response situations open and real-time spatial data can be collected involving crowd along with data fusion for integrating information from a wide variety of sources. Recently crowdsourcing is helping to map the infrastructure and devastation caused by natural disasters in Haiti and Pakistan.

6. Conclusions

The process initiated with geo-visualisation for integrating GIS and participatory mapping that addresses simultaneously the needs of all map-makers and map-viewers. There are multiple strategies for collecting participatory knowledge, integrating the information and generating additional location based catalogue of services based on the

elicited participatory information. The India is waiting for a paradigm shift — '*Crowdsourcing with spatial technology for decision making'*.

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