Belize National
Spatial Data Infrastructure

*Supporting Sustainable and Resilient National Development*

# e-Merging Technology Report

**Draft V1**

**15 February 2015**


GPC Group
A Global Network of Information Professionals

# Belize National Spatial Data Infrastructure

# e-MERGING TECHNOLOGY REPORT

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Prepared for

**Government of Belize**
**Social Investment Fund (SIF)**

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# 1 INTRODUCTION

## 1.1 Background

This BNSDI Requirements Analysis report provides a synthesis of requirements that need to be met by the Belize National Spatial Data Infrastructure (BNSDI) program. This report is one component of a structured work program for the planning, design, and implementation of the BNSDI. The position of this report relative to the entire work program is illustrated in the Figure below.

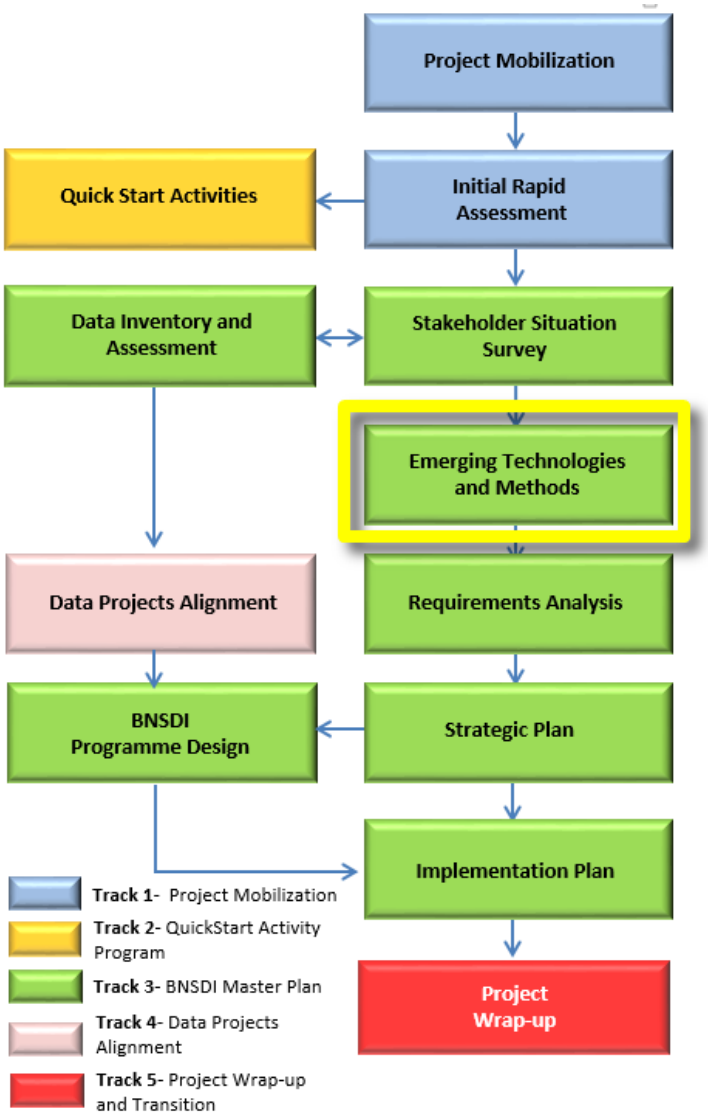



Figure 1 – Work Program Illustration

## 1.2 Purpose of this document

Technology development continues at a rapid pace across every field of human endeavor and new devices and capabilities are becoming more affordable and accessible every day worldwide. Many of these technologies are "spatially enabled" and "connected" meaning that knowing the location of a measurement or bit of information adds value that can be then visualized and analyzed across a network on a map. When lots of bits of information are spatially empowered across millions of social media users and the "internet of things" the implications for social and economic development and informed, wise use and preservation of environmental resources, cultural and natural heritage are vast.

The incorporation of emerging technologies to traditional spatial data infrastructure is in its infancy, but shows great promise as an invaluable component of SDI for Development ($SDI_4D$). This report has been prepared to explore how such technologies could contribute in the future to the development and benefits of the Belize National Spatial Data Infrastructure (BNSDI) initiative. This review has included mobile data collection, sensor networks, social media and crowd-sourcing, Big Data, Volunteered Geographic Information (VGI), new satellite remote sensing products, and many others. It also includes the growing field of Information and Communications Technology for Development ($ICT_4D$) and explores how basic technologies such as cell phones can be used to support and enhance information collection, management, dissemination and utilization. Also included is consideration to how these technologies and methods can be used to increase engagement, communication, collaboration and multilateral information exchange between government, information providers and users via multiple channels within or aligned with the framework of the BNSDI.

Belize has only recently focused some attention to high technology as an important component of its economic and social development. Internet users as of June, 2012 were 74,700, representing about 22.8% of the population. As of September the same year, there were 74,700 Facebook users, the same number of those using internet. At the end of 2012 there were approximately 318,000 mobile phone subscribers and by the end of 2013 one year later this number increased by nearly 4.3%, or 332,000.[1]

High technology and computer literacy in schools are mentioned within the Horizon 2030 Strategy, but not featured as a key driver. However other plans have been in the works the last few years that do pay more attention to this matter. The National ICT Strategy 2011-2015 laid out a vision to "accelerate development and improved quality of life for all Belizeans through universal access and widespread usage of information and communication technology".[2] The government has made plans to take actions to increase access to ICT across Belizean society, including expanding broadband connectivity and bridging the digital divide between the larger urban areas and remote villages. 30 public ICT centers have been

[1] http://www.fosigrid.org/central-america/belize
[2] http://www.belize.gov.bz/public/Data/1102716565571.pdf

set up in rural villages to provide internet access on a self-financing basis and programs targeting building awareness and ICT skills in schools have been established.

The 2014 draft of the e-Government Policy under development by the Central Information Technology Organization (CITO) is "designed to eliminate existing bureaucratic silos to build a collaborative working environment where Government, the private sector and people connect in productive partnerships enabled by the transformative power of ICT.[3] The strategic themes emphasized by the current draft include the following:

1. Public Sector Infrastructure Development: Building out a world-class Government Wide-Area Network (GWAN) for the Belize public sector using common and shared platforms that enable delivery of robust, seamless, user-friendly, end-to-end ICT services internally and to external clients.

2. Creative Regulatory Reform: Designing and implementing pioneering policy and regulatory approaches to ICT adoption and usage in the public service that allow e-Government to flourish in a secure environment.

3. Targeted Human Capacity Development: Shaping public sector frameworks for training, education and career-long learning that overcome significant existing deficiencies in individual and overall human capacity.

4. Improved Government Efficiency: Enhancing public sector responsiveness and the diffusion and use of ICT by upgrading existing delivery channels, creating new channels for delivery, designing compelling new content and services, changing the culture of bureaucracy and developing appropriate governance models.

5. Effective Cross-Functional Collaboration: Developing programs and initiatives to build capacity for e-Government related research and innovation, dissolve existing unproductive silos, improve collaboration, increase knowledge exchange, and support the sharing of experiences across Government.

The technology aspirations expressed in various plans in the last few years suggest an increased attention to this matter. The interest in the topic of emerging technology was expressed consistently by many of the stakeholders that were originally interviewed during the BNSDI consultancy. The point of the current exploration has been to anticipate how e-Merging technologies could be leveraged to advance the utility and societal benefits of the BNSDI. Many of the technologies and applications that were reviewed can also be beneficial for supporting the specific individual activities of each of the stakeholders. This report can provide a useful reference for individual stakeholders to consider their own needs, however

[3] National e-Government Strategy & Work Plan – Draft, 2014, Central Information Technology Organization, Ministry of Finance, Government of Belize

the main focus here is to identify and articulate those that have direct implications for BNSDI services and data capabilities that are needed in common across the community.

While all of these technologies are "e-lectronic", new and exciting each on their own merits, the even more interesting dimension of this investigation has been the interesting ways that organizations and people around the world are developing new combinations of technologies in ways that can serve multiple purposes towards truly disruptive and transformative impacts. This report uses case studies to illustrate where the merging of these technologies (e-Merging) is showing potential to extend the form and function of the BNSDI in new and compelling ways.

At its core, the BNSDI is about "geospatial" information and its dissemination and utilization across Belize society. However it should be emphasized that this is a means to an end, not an end in itself. The real underlying objective is the achievement of social, economic and physical development and the protection of natural and cultural heritage in a manner that promotes health, safety and welfare and is sustainable and resilient to climate change and other challenges. People live, work and play in "places", environmental and cultural resources are located "somewhere" and it has been noted internationally that over 85% of government activities relate to a location in one form or another. Likewise, geospatially-centric technologies like GIS, GPS and internet-based mapping portals do not exist in a technological or application vacuum and it is their application to real human need and their merging and configuration with other emerging technologies that has potential for positive, transformative and disruptive innovation towards solutions that matter.

The ideas and conclusions in this report will provide input to subsequent reports towards the development of the final program design and implementation strategy for moving the BNSDI forward to the next level of development.

## 1.3 Organization of this document

In researching this subject it became clear that the incorporation of e-Merging technology within the context of the BNSDI would require consideration and alignment of several important factors. These factors have been used to structure the main content of this report as indicated below. This document has been organized accordingly, as follows:

***Section 1 - Introduction.*** Provides as summary of the background, purpose and organization of the current report.

***Section 2 - e-Merging Technologies***. There are literally thousands of new location and NSDI relevant technologies being developed in every sector, every year. The field is very broad, diverse in its components, and this innovation and creation is happening all over the world. Those presented in this report were chosen as representative of the

many fields of e-Merging technology development that represent some area of potential benefit to the BNSDI.

***Section 3 - e-Merging Applications***. Almost all applications uncovered in this study represent the combination of multiple technologies that have been configured to respond to a particular need. The development and proliferation of standards enable the interoperability that makes these combinations possible. This section provides examples of solutions that have been configured to address issues that have some relevance to the BNSDI.

***Section 4 - e-Merging Policies and Programs***. Most of the applications explored here require the free flow of information across society, while not compromising national security and respecting certain privacy and intellectual property rights. Ensuring that the policies and programs are in place to empower the flow of information while balancing this against other critical concerns will be crucial to optimizing the advantages of e-Merging technology in the Belize context. This section provides a highlight of programs and associated policies that are optimizing the use of e-Merging technologies and applications.

***Section 5 - e-Merging Methods***. Technology solutions can be implemented singly, but international experience suggests that a more holistic and systemic treatment of technology and societal information infrastructure as an integral component of a community or national development approach is more likely to contribute most effectively to sustainable and resilient development. This section provides a highlight of example programs and associated policies that are, or could be optimizing the use of e-Merging technologies and applications.

***Section 6 – Implications for the BNSDI***. This section summarizes the implications of e-Merging technologies in the context of the BNSDI program as revealed through this investigation.

# 2 E-MERGING TECHNOLOGIES

This section provides an overview of various new and emerging technologies that have some potential application within the BNSDI. This covers information and communications technologies, as well as systems supporting the collection, management, distribution and analysis of geographic and geographic-related data.

## 2.1 Computing

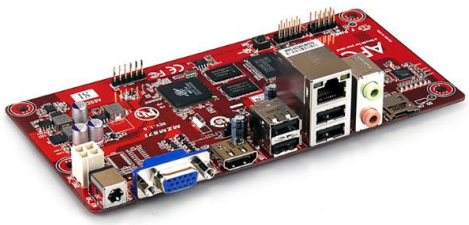
### 2.1.1 Small, Mobile, Cheap, Connected and Ubiquitous

Over the past twenty years computers have become smaller, more powerful, more mobile, less expensive, connected and increasing available to persons, companies and communities around the world. The following examples provide a sense of where this trend is today.

**Aakash**. At about $60 retail, the Aakash tablet is reputed to be the cheapest tablet available in the world. This tablet was promoted by the Government of India as part of a program to link 25,000 colleges and 400 universities across India. The tablet is produced by the British-Canadian company DataWind and is manufactured by Quad, and Indian company with a production center in Hyderabad. Government subsidies allowed these tablets to be purchased by students for $35.[4]

Aakash, at $60 the world's least expensive tablet. Image courtesy of DataWind

***VIA APC 8750***. At $49, the VIA Technologies' APC 8750 is a stripped down miniature PC that measure 17 X 8.5 CM. The computer comes as a naked motherboard that can be plugged into a TV or monitor. The devices runs Google Android 2.3 OS and is powered by an 800MHz processor with 512MB of RAM and 2GB of NAND Flash graphics. Ports include both VGA and HDMI display, HDTV, four USB 2.0 and a microSD slot for expandable storage.[5]



The VIA APC 8750 – world's cheapest computer. Courtesy APC

[4] http://en.wikipedia.org/wiki/Aakash_(tablet)
[5] http://apc.io/products/8750a/

### 2.1.2 Cloud Computing and Managed Services.


Cloud computing allows compute power to be centralized under controlled conditions, while services are offered to users over less expensive devices such as low cost desktops, laptops, tablets and internet enabled cell phones. This reduces the need for upfront capital investment as well as specialized capabilities and resources required to develop and manage a local computer center. Cloud computing service providers like Amazon Web Services and Google Cloud Platform are already being used by various private sector service offerings such as "Jobberman", Nigeria's largest jobs and careers website, M-Pesa, the mobile payments division of Safaricom, a mobile phone provider based in Kenya, 36Boutiques using Amazon's service for e-commerce, and in India, the provision of an online nationwide cab-booking service called Getmecab that uses Amazon servers. Both Amazon and Google are holding seminars internationally for startups to raise awareness and encourage development of new applications and services on the Cloud.

The use of cloud computing by governments in lesser developed countries has faced challenges. With centralization of computing also comes centralization of information, and this has raised concern regarding privacy and data security. Governments can choose to establish their own in-country cloud services, but doing so requires significant capital investment and they may lack the cloud computing related infrastructure such as data centers and affordable broadband networks.

### 2.1.3 Big Data

Big Data is a broadly defined term covering any one or combination of data and information sources so large that traditional data processing techniques are insufficient to handle them. The concept has evolved along with the applications and imaginative ways that people are looking to mash up, process and analyze available information to create new value and today can encompass structured as well as unstructured information, social media, sensor networks, cell phone movements and any combinations thereof. Many of these information sources include a geographic reference which may be a geographic coordinate, place name, address or landmark. Examples are provided elsewhere in this report include a wide range of "Big Data" related applications from the monitoring of multiple social media feeds and pharmacy sales to anticipate flu or other pandemic outbreaks, the use of cell phone position and movement information to identify

traffic issue, to the use of satellite imagery and marine navigation signals to identify potential illegal fishing.

## 2.2 Geographic Information Systems

Geographic Information System (GIS) technology is commonly described as a computerized system for the compilation, access, retrieval, analysis and display of geographic and geographic-related data. Modern GIS is much more than computerized mapping – with the right technical and institutional frameworks it can provide a multi-sector, interdisciplinary, society-wide information infrastructure for bringing all manner of data together geographically to support integrated and multi-sector decision-making, strengthen the ability of diverse interests to better understand complex natural and socioeconomic systems and the interactions among them. This infrastructure will ultimately help to develop more sustainable and resilient communities and economies, support wise management of resources and aid in the conservation of cultural and natural heritage. The following summarize some e-merging aspects of GIS that have implications for the development of the BNSDI.

### 2.1.1 Commercial and Open Source GIS software

Geographic information system (GIS) software has developed significantly over the past thirty years, and today there are a range of options in both commercial and open source software available. Many of these services can work on enterprise servers, desk or laptops or online. Determining the best platform for any particular organization or application is dependent upon the needs and capabilities required. Commercial software has the advantage of a company behind it to provide technical support and services when something breaks. Open source software consortia may also have a capability to respond to such issues, but accountability for doing so may be more diffuse. On the other hand, the cost of acquiring open source or public domain software may be low, but this needs to be considered against reliability and internal technical capabilities of the organization and community to effectively manage such a system.

The advent of open data standards has been important to keeping technology choices open. The Open Geospatial Consortium (OGC) is an international industry consortium of 511 companies, government agencies and universities participating in a consensus process to develop publicly available interface standards. OGC® Standards support interoperable solutions that "geo-enable" the Web, wireless and location-based services and mainstream IT. The standards empower technology developers to make complex spatial information and services accessible and useful with all kinds of applications.[6] Adoption of standards helps to ensure that data created in one system can be discovered, read or migrated to another, thus giving users more choice as to what system to use for what application.

### 2.1.2 Virtual Globes and GIS Portals

[6] http://www.opengeospatial.org/ogc

The premise of a virtual globe online three-dimensional environment that would allow everyone in the world to access and explore vast amounts of scientific and cultural information and that would be free to all over the internet was first envisioned in a speech by Al Gore in 1998. Today much of that vision has been realized, and a variety of commercial and government organizations are supporting just such an environment, such as Google Earth, Bing Maps, ArcGIS Online, and NASA's World Wind. Similar to virtual globes are a variety of geographic portals that can now be found online that provide access to local, regional and global information sources. There are literally thousands of geographic portals for cities, countries, international organizations, communities of practice and information federations at multiple levels. Some examples include:

- http://www.google.com/earth/
- http://www.bing.com/maps/
- http://www.esri.com/software/arcgis/arcgisonline/
- http://worldwind.arc.nasa.gov/java/

### 2.1.3 Geospatial Data Federations

Data federations are groups of people or organizations that decide that they should share their information to mutual benefit. Federations may be formally organized and governed or informal and they may be based around a common geographic area of interest or a topic of interest, or a combination of both. More formalized initiatives are often labeled as Spatial Data Infrastructure (SDI), with full policy, legal and institutional standing and governance. Less formal federations may simply be based on a common charter or memorandum of understanding (MOU) to share information among a select community of interested parties. Some examples include:

- http://www.earthobservations.org/index.php (Global – Data related to GEO identified Social Benefit Areas)
- http://inspire-geoportal.ec.europa.eu/ (European Union – multiple sectors)
- http://www.fgdc.gov/nsdi/nsdi.html (U.S. – Federal GIS data from all sectors);
- http://www.coloradowaterdata.org/ (Colorado – water management data);
- http://www.biodiversity.bz/ (Belize – biological data);

### 2.1.4 Volunteered Geographic Information

Volunteered geographic information (VGI) has multiple definitions by in principle includes the tools to capture, assemble and share geographic information provided voluntarily by individuals. Major international VGI initiatives include WikiMapia, OpenStreetMap and Google Map Maker. Today there is an ever expanding range of types and channels for volunteered and crowd-sourced information that are leveraging broad participation in information collection and sharing for a common purpose. VGI has been particularly useful for mapping of areas that have not been covered by traditional base mapping or that have not been kept up to date. VGI has also been useful in responding to natural disasters, allowing

remote contributors to outline damage areas through immediate access to the most recent satellite imagery, combined with tracking of cell phone observations and conditions on the ground. Some examples of VGI include:

- http://wikimapia.org/ (WikiMapia)
- http://www.openstreetmap.org/ (OpenStreetMap)
- http://www.google.com/mapmaker (Google Map Maker)
- http://www.onemap.sg/index.html (Singapore OneMap)

## 2.2 Internet, Mobile Telecommunications, Social Media and IoT

Telecommunications technologies and the internet have had a profound impact on modern society across the world, affecting nearly all aspects of our lives in one manner or another. The following summarizes those e-Merging technologies that are having the greatest impact and have significant implications for the future BNSDI.

### 2.2.1 Internet

Starting in the 1950's with the development of electronic computers, it was soon necessary to start developing methods for sharing information among these devices. Packet switching networks such as ARPANET were developed to address this challenge, and an evolutionary process was initiated that resulted in the development of the internet protocol suite (TCP/IP) as a standard in the early 1980's. Commercial Internet Service Providers (ISP's) started appearing in the late 1980's and by mid-1990's restrictions on commercial use of the internet were removed and the rest is history. In 1995 it was estimated that there were approximately 16 million users of internet services, representing about 0.4% of the world's population. By mid-2014 it was estimated that there were over 3.035 billion users, over 42% of people in the world last year[7]. Today the internet is a foundation for electronic commerce, entertainment, communications and cultural exchange for much of the world, and the rate of adoption in the developing world is increasing yearly.

### 2.2.2 Mobile Telephony

As of 2012 there were nearly as many cell phone subscriptions (6.8 billion) as there were people on the planet (about seven billion). The vast majority of this adoption took less than 20 years to happen.[8] Between 2013 and 2017, mobile phone penetration is predicted to rise from 61.1% to 69.4% of the global population, according to an eMarketer report, "Worldwide Mobile Phone Users: H1 2014 Forecast and Comparative Estimates."

Originally used for simple voice communications, the cell phones of yesterday have evolved to "smartphones" that have become an absolute necessity for many people around the world.

[7] http://www.internetworldstats.com/emarketing.htm
[8] http://qz.com/179897/more-people-around-the-world-have-cell-phones-than-ever-had-land-lines/

Today smartphones have an operating system and can act as a voice-activated personal digital assistant, receive and respond to SMS messages and emails, provide GPS location information and give navigation instructions as well as run any number of the 1000's of applications that are available online. The global smartphone audience of 1 billion in 2012 totaled more than 1.75 billion by 2014. Experts expect that smartphone adoption will continue to grow rapidly and by the end of 2017 should include about half of all cell phone users worldwide.[9] By all indications, smartphones will continue to evolve and with internet connectivity becoming ever more accessible and ubiquitous, these will provide a primary channel for connecting people with other people, information and services worldwide.

Of special note, the Open Geospatial Consortium (OGC) has developed GeoSMS, a standard that allows geospatial location information to be communicated through a short messaging service (SMS) between different mobile devices or applications. Open GeoSMS is compatible with standards such as the OASIS Common Alerting Protocol (CAP) standard (enabling information exchange to advance incident preparedness and response to emergency situations) and the IETF RFC Presence Information Data Format Location Object (PIDF-LO) (provides a flexible means to represent location information suited for routing applications).

### 2.2.3 Social Media

Social media are computer and internet supported tools that allow virtual communities of people to create, share or exchange information, ideas and all manner of digital media. Social media leverages rapidly increasing mobile technology and global connectivity to support a broad range of internet-based applications to create highly interactive platforms that allow personal and professional networks of people and organizations to form and grow. By 2014 it was estimated that there were over 1.79 billion social media users in the world and that number is expected to rise to about 2.44 billion people by 2017.[10] Social media platforms are increasingly utilizing location based information and services to add value. The millions of feeds provide unstructured information that can be used to interpret traffic or weather conditions, early warning for impending pandemics, characterize the "happiness" of a community and many other creative and innovative applications as described elsewhere in this report.

### 2.2.4 Internet of Things

The Internet of Things (IoT) refers to a wide range of uniquely identifiable devices and embedded computers and otherwise "smart" objects interconnected and interoperable across the Internet. This is a rapidly evolving field and today includes a wide range of devices and applications, from heart monitoring implants, biochip transponders for tracking domestic or wild animals, built in sensors in automobiles, networks of hobbyist weather monitoring

[9] http://www.emarketer.com/Article/Smartphone-Users-Worldwide-Will-Total-175-Billion-2014/1010536#sthash.HIVEUfkB.dpuf
[10] http://www.statista.com/statistics/278414/number-of-worldwide-social-network-users/

stations to the monitoring and automated control of home-based security, lighting, washing machines, coffeemakers and other home appliances. These devices are normally connected to a network via wire or Wi-Fi and either self-control or transmit and receive instructions from a central "brain". The number and type of devices is increasing exponentially and are generating massive volumes of information that require new and innovative ways to manage and use this information (e.g. Big Data).

## 2.3 Remote Sensing

Remote sensing is the measurement of an environment from a distance. Most remote sensing that is relevant for the BNSDI is carried out from either a satellite or airborne platform.

### 2.3.1 Satellite Remote Sensing

Satellite based remote sensing for civilian purposes has been in common use since the launch of LANDSAT in the early 1970's. The field has grown tremendously over the years, and today there is a wide variety of both government and privately owned satellites utilizing a wide variety of sensors that are collecting information at different temporal, spectral and spatial resolutions covering the entire planet.

The following provides a summary of those satellite borne remote sensing platforms that have the most promise for the BNSDI. This is not a comprehensive inventory of the field, which is very broad, but focusses specifically on those that relate most directly to the needs of the BNSDI community.

The last several years has seen the advent and rapid growth of high resolution data and imagery sourced from satellite-borne platforms. This field has thus far been dominated by private companies from the United States, and these until recently were restricted by the U.S. government in providing imagery above a certain level of resolution and accuracy. This restriction has recently been eased and companies are now looking to distribute their most detailed imagery products. The following summarizes those companies and products that are most relevant to the BNSDI.

***Digital Globe - WorldView-3***. The WorldView-3 satellite successfully launched August 14, 2014. WorldView-3 provides 31 cm panchromatic resolution, 1.24 m multispectral resolution, 3.7 m short wave infrared resolution and 30 m CAVIS resolution. WorldView-3 is the world's first super-spectral, high-resolution commercial satellite; SWIR bands penetrate haze, fog, smog, dust and smoke and the spectral diversity enables new imagery applications. WorldView-3 has an average revisit time of <1 day and is

WorldView-3 multiband analysis of crop and land cover. Courtesy Digital Globe.

capable of collecting up to 680,000 km2 per day[11]. With both high spatial, spectral and temporal resolution, this data shows significant promise for agricultural mapping, land use and conservation planning, watershed management, emergency management and many other applications in Belize.

***Digital Globe - QuickBird***. Digital Globe's QuickBird satellite continues to offer sub-meter resolution imagery with high geo-locational accuracy. With global collection of panchromatic and multispectral imagery, QuickBird is designed to support a wide range of geospatial applications. QuickBird is currently operating at an altitude of 400 km and will continue in a gradual descent until its end of mission life at an altitude of 300 km[12].

QuickBird high resolution (~60 cm) satellite imagery. Courtesy Digital Globe.

***Digital Globe - GeoEye-1***. On September 6, 2008 GeoEye launched the first of their second-generation high-resolution satellites, GeoEye-1. This satellite collects 41-centimeter (cm) panchromatic and 1.65-meter (m) 4-band multispectral (i.e. blue, green, red and NIR) imagery. GeoEye-1 circles 681 kilometers (km) above the Earth, reducing the satellite's revisit time to less than 3 days. The imagery reliably geo-locates features within 5m providing significant advantages for establishing a reasonable level of spatial accuracy in remote areas.

GeoEye-1 high resolution (~40 cm) satellite imagery. Courtesy Digital Globe.

***Digital Globe - IKONOS***. The IKONOS satellite is the world's first commercial satellite to collect panchromatic (black-and-white) images with .80 m resolution and multispectral (color) imagery with 3.2-meter resolution. Imagery from the panchromatic and multispectral sensors can be merged to create .80 m color imagery (pan-sharpened). From a 423-mile-high orbit, IKONOS has a revisit time of once every three days and downlinks directly to more than a dozen ground stations around the globe.[13] IKONOS imagery can be used within the BNSDI to support land use and land cover mapping, change detection, conservation planning and many other applications requiring the lower resolution end of the high resolution satellite data available.

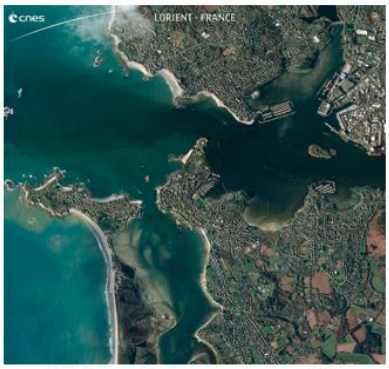
IKONOS moderate resolution (~2m). Courtesy Digital Globe.

[11] http://www.landinfo.com/WorldView3.htm?utm_source=bing&utm_medium=cpc&utm_campaign=Campaign%20%233&utm_term=WorldView-3

[12] https://www.digitalglobe.com/sites/default/files/QuickBird-DS-QB-Prod.pdf

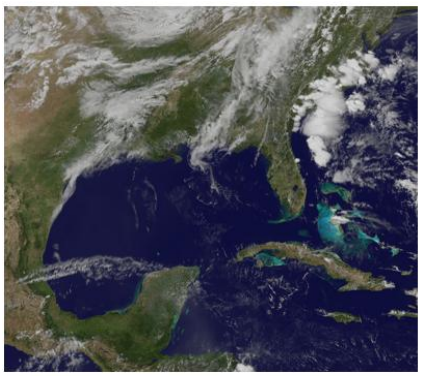
[13] http://en.wikipedia.org/wiki/Ikonos

***Pleiades-1B Satellite Sensor***. Pleiades-1B (0.5m) satellite sensor was successfully launched on December 2, 2012. Built by AIRBUS Defense & Space, the launch of Pleiades-1B satellite sensor marks the third step in the formation of a constellation of four satellites combining a double daily revisit capability and a specific range of resolutions. Pleiades-1A and 1B satellites will be phased 180° apart in the same near-polar sun-synchronous orbit at an altitude of 694 km, enabling daily revisits to any location on the planet which makes it ideal for mapping large scale areas including engineering and construction projects, monitoring of mining, industrial and military complexes, conflict zones and crisis/disaster areas, natural hazards, evacuation and rescue operations.[14]



Pleiades-1B high resolution satellite imagery. Courtesy AIRBUS.

***Geostationary Satellite System (GOES)***. The Geostationary Satellite system (GOES), operated by the United States National Environmental Satellite, Data, and Information Office (NESDIS), supports weather forecasting, severe storm tracking, and meteorology research. Spacecraft and ground-based elements of the system work together to provide a continuous stream of environmental data. The National Weather Office (NWS) uses the GOES system for its United States weather monitoring and forecasting operations, and scientific researchers use the data to better understand land, atmosphere, ocean, and climate interactions. Designed to operate to geostationary orbit, 35,790 km (22,240 statute miles) above the earth, thereby remaining stationary with respect to a point on the ground, the advanced GOES I–M spacecraft continuously view the continental United States, neighboring environs of the Pacific and Atlantic Oceans, and Central, South America and southern Canada. The three-axis, body-stabilized spacecraft design enables the sensors to "stare" at the earth and thus more frequently image clouds, monitor earth's surface temperature and water vapor fields, and sound the atmosphere for its vertical thermal and vapor structures. Thus the evolution of atmospheric phenomena can be followed, ensuring real-time coverage of short-lived dynamic events, especially severe local storms and tropical cyclones—two meteorological events that directly affect public safety, protection of property, and ultimately, economic health and development.[15] The Belize National Meteorological Office utilizes data products from the GOES/NESDIS.


GOES weather satellite imagery. Courtesy NOAA

U.S. National Aeronautics and Space Administration (NASA) is the United States government agency responsible for the civilian space program as well as aeronautics and aerospace research. NASA shares data with various national and international organizations

[14] http://www.satimagingcorp.com/gallery/pleiades-1b/
[15] http://en.wikipedia.org/wiki/Geostationary_Operational_Environmental_Satellite

***NASA – MODIS***. The Moderate Resolution Imaging Spectroradiometer (MODIS) is a key instrument aboard the NASA Terra (EOS AM) and Aqua (EOS PM) satellites. Terra's orbit around the Earth is timed so that it passes from north to south across the equator in the morning, while Aqua passes south to north over the equator in the afternoon. Terra MODIS and Aqua MODIS are viewing the entire Earth's surface every 1 to 2 days, acquiring data in 36 spectral bands, or groups of wavelengths (see MODIS Technical Specifications). These data will improve our understanding of global dynamics and processes occurring on the land, in the oceans, and in the lower atmosphere. MODIS is playing a vital role in the development of validated, global, interactive Earth system models able to predict global change accurately enough to assist policy makers in making sound decisions concerning the protection of our environment.[16]

MODIS data being used to track fires in Central America. Courtesy NASA

***Google/Skybox Imaging - SkySat-2***. SkySat-2 is a commercial Earth observation satellite by Skybox Imaging and licensed to collect high resolution panchromatic and multispectral images of the earth. The satellites operate in a polar inclined, circular orbit at approximately 450 km above the earth. SkySat-2 satellite is a high performance satellite producing sub-meter resolution imagery and high-definition video and is the smallest satellite ever flown that is capable of capturing imagery at better than 1 meter resolution. SkySat-2 satellite captures up to 90-second video clips at 30 frames per second. The resolution is high enough to view objects like shipping containers[17]. Note: In June of 2014, Google Inc. announced that it has entered into an agreement to buy Skybox Imaging. The stated intention is to use Skybox's satellites to help keep Google Maps accurate with up-to-date imagery. Press release also indicates that there is a hope that Skybox's team and technology will be able to help improve Internet access and disaster relief — areas Google has long been interested in.[18]

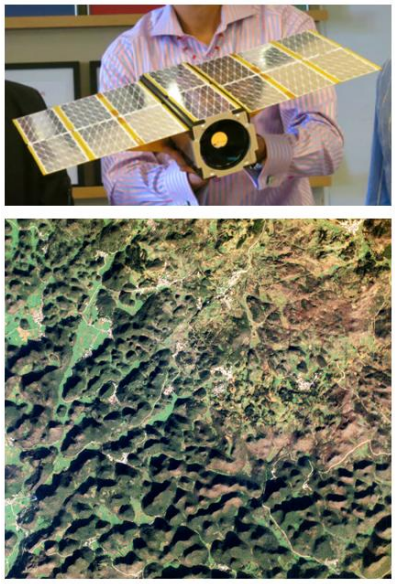
SkySat-2 high resolution, small satellite imagery. Courtesy SkyLabs.

***Planet Labs***. Planet Labs, Inc. is an American private company that aims to create an Earth-imaging satellite network with open data access to support environmental, humanitarian, and business applications. These orbit at a height of about 249 miles (400 km) and provide imagery with a resolution of 3–5 m (9–15 feet). In June 2013 the company announced plans for Flock-1, a constellation of 28 Earth-observing satellites. There were successfully deployed in mid-February 2014 and the company plans to launch a total of 131 satellites by mid-2015, but lost 26 satellites in October, 2014 during the Antares rocket explosion. Planet

[16] http://modis.gsfc.nasa.gov/about/
[17] http://www.satimagingcorp.com/satellite-sensors/skysat-2/
[18] http://investor.google.com/releases/2014/0609.html

Labs was founded the idea of deploying many very small satellites, or "doves" into low orbit with a lifespan of only 3-4 years. The company believes this will create a more nimble and cost effective model for collecting imagery about the Earth's surface in a more frequent manner that will support a broad array of new applications.

The distribution and access to Planet Labs data does not appear to be fully commercialized yet, but is included here to give a sense of the rapid developments going on in the satellite remote sensing field today.



Planet Labs moderate resolution (~3m-5m), small satellite imagery. Courtesy Planet Labs.

### 2.3.2 Airborne Remote Sensing

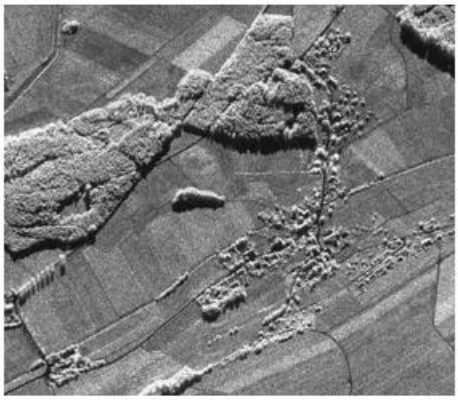
In airborne remote sensing, downward or sideward looking sensors are mounted on an aircraft to obtain images of the earth's surface. An advantage of airborne remote sensing, compared to satellite remote sensing, is the capability of offering very high spatial resolution images (20 cm or less). The disadvantages are low coverage area and high cost per unit area of ground coverage. It is not cost-effective to map a large area using an airborne remote sensing system. Airborne remote sensing missions are often carried out as one-time operations, whereas earth observation satellites offer the possibility of continuous monitoring of the earth[19]. While analog aerial photography is still common, the market is rapidly shifting to digital photography and other sensors that allow the real-time collection and transmission of data to a ground station for immediate analysis.

***Multi-spectral airborne data collection***. A variety of technologies are available today to conduct the collection of multispectral information from an airborne platform. These offer the advantage of mission-specific flexibility and the collection of very high spatial resolution that is not currently possible from spacecraft platforms. This is often used for detailed agricultural and urban environment surveys for detecting crop health, assessment of pest invasions, biomass calculation, heat islands in urban areas, post disaster damage assessment and other such applications.

[19] http://www.crisp.nus.edu.sg/~research/tutorial/airbrn.htm

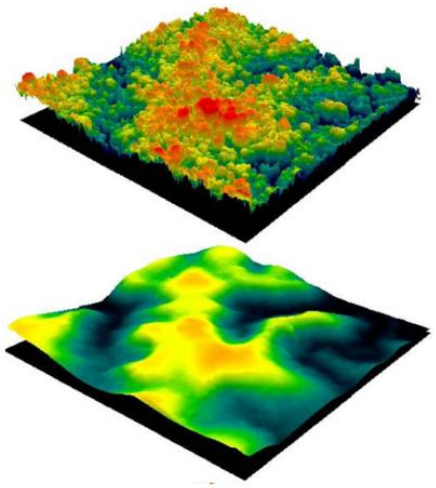
An overhead view of Villacañas, Spain, acquired in the short-wave infrared with the SASI-600 imager. Images in this band provide high-fidelity object classification, plant speciation and other vital data. Courtesy of ITRES.

***Synthetic Aperture Radar***. In synthetic aperture radar (SAR) imaging, microwave pulses are transmitted by an antenna mounted on an airplane or spacecraft and oriented towards the earth surface. The microwave energy scattered back to the spacecraft is measured and the SAR makes use of the radar signals to form an image based on the time delay of the backscattered signals. Due to the cloud penetrating property of microwave, SAR is able to acquire "cloud-free" images in all weather. This is especially useful in tropical regions such as Belize that are frequently under cloud covers throughout much of the year. Likewise, SAR is also capable of night-time operation.



Raw data courtesy of Daimler-Benz Aerospace, Dornier GmbH, Germany. Processed by RSL.

***LiDAR***. Light Detection and Ranging (LiDAR) is a proven method for creating fast and accurate terrain models for many different application areas. The technology is based on a scanning laser combined with both GPS and inertial technology to create a three dimensional set of points (point cloud). It can be mounted on an airplane, a vehicle or other platform depending on the subject to be surveyed. Airborne LiDAR is often used to create Digital Elevation Models (DEM's) and Digital Terrain Models (DTM's). Of special relevance in Belize, the specifications for LiDAR data collection to have enough "ground returns" in the signals to be able to distinguish terrain from forest cover. This is critical not only in creating an accurate terrain model that can be used for such



Canopy and ground elevation from LiDAR remote sensing. Kellner et al. Ecology 90:3274

applications as topographic slope and flooding analysis, but it also provides a basis for calculating the height and biomass of the forest cover which is significant for conservation, forestry, carbon accounting/REDD and other purposes. Bathymetric Lidar systems operate in a similar manner to land-based systems but transmit two different light waves to be able to detect two returns that indicate the water surface and seabed from which the bathymetry data is derived.

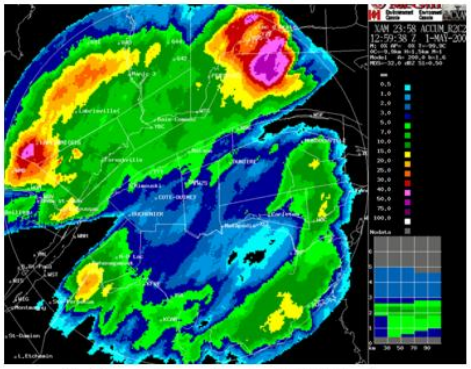
***Unmanned Aerial Vehicles (UAV)***. The use of Unmanned Aerial Vehicles (UAV's) for civilian survey and mapping purposes has grown exponentially over the last few years. UAV's can be deployed quickly and flexibly and today can be equipped with a variety of sensors. Because they can be flown at very low altitudes and low speed these platforms can capture very detailed information about specific sites and smaller geographic areas, and the information can be processed very quickly. UAV's may be driven interactively by a "pilot" on the ground, or can be pre-programmed along a predetermined flight path. A variety of sensors are now available for UAV's but most prevalent among these are natural color and near-infrared radiation (NIR).The main disadvantages of the current UAV technology is that they can be susceptible to damage from wind, rough landings and obstacles such as electric wires, buildings and trees. Also, because UAV's have much smaller individual scenes as compared to air and spacecraft, the time and effort required to create fully mosaicked and integrated imagery and data is significantly greater per unit of ground area.

UAV technology is advancing quickly, with many options for aircraft and sensor types

The regulatory context for use of UAV's is likewise evolving. In the United States and under pressure from UAV operators such as Facebook/Tital Aerospace and Amazon, the Federal Aviation Administration (FAA) is being pushed to devise new rulings for the commercial operation of UAV operations and services. According to industry experts there is a large and rapidly growing demand for UAV applications such as aerial mapping and monitoring for precision agriculture to optimize crop yields and fertilizer use, public security and safety for managing natural disasters, and monitoring infrastructure such as construction sites, power facilities, cargo ports and pipelines that will force governments to reconsider their current airspace policies and regulations.

### 2.3.3 Ground-Base Remote Sensing

***Weather Radar Systems***. Weather radar, also called weather surveillance radar (WSR) and Doppler weather radar, is a type of radar used to locate precipitation, calculate its motion, and estimate its type (rain, snow, hail etc.). Modern weather radars are mostly pulse-Doppler radars, capable of detecting the motion of rain droplets in addition to the intensity of the precipitation. Both types of data can be analyzed to determine the structure of storms and their potential to cause severe weather[20]. The Belize National Meteorological Office maintains a single weather radar station, located at the Philip Goldson International Airport. The Rainbow 5 system by Gematronik Weather Radar Systems is a comprehensive, state-of-the-art sensor management system for multi-radar network management, data analysis and display. It fulfills needs in the fields of radar management, weather monitoring/nowcasting, hydrology, aviation and research.



Weather radar imagery. Courtesy McGill University

## 2.4 Geographic Positioning Systems

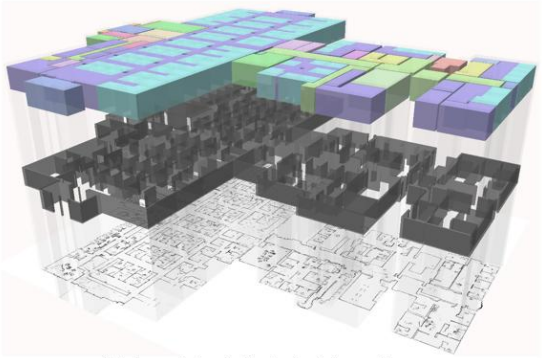
Geographic positioning technologies provide a method to determine one's location relative to the face of the Earth. Where once the position of the stars, sun and moon were used for celestial navigation for ships or explorers to know where they were within a few miles, today there are laser supported total station survey equipment and geo-positioning satellites that can provide accuracy down to sub-centimeter accuracy. Today geographic positioning capabilities are being built into all manner of consumer appliances such as phones, tablets, watches and vehicles. The following summarizes a few of the e-Merging technologies that have implications for the BNSDI.

### 2.4.1 Global Positioning System (GPS).

GPS is a satellite based technology for determining ones location on the face of the Earth. The original GPS was developed and maintained by the U.S. government in the early 1970's, originally for military purposes. The full network of satellites became fully operational in 1995 and selective availability was removed in 2000 thus allowing high accuracy information for public civilian uses. Today GPS is being used to support a wide variety of location based purposes all over the world. In addition to the U.S. controlled GPS other countries are also using or developing other similar systems such as the Russian Global Navigation Satellite System (GLONASS), the planned European Union Galileo positioning system, the Indian Regional Navigation Satellite System, and the Chinese Beidou Navigation Satellite System.

### 2.4.2 Augmented Geolocation

[20] http://en.wikipedia.org/wiki/Weather_radar



Robot mounted nagivation technologies used to geolocate indoor spaces. Courtesy PenBay Solutions

GPS signals cannot deliver location information in certain circumstances, such as inside man-made structures or natural situations that may block line of sight to the satellites, such as within caves or steep canyons. In such cases it is necessary to employ other techniques to augment the GPS signal. These can include the use of signals from cell towers, Wi-Fi, TV signals RFID tags and other such existing infrastructure. Accuracy can differ significantly depending on the methods used. Cell tower signal strength can be triangulated to achieve a maximum accuracy of around 50 meters. A similar technique can be applied to known Wi-Fi access points and their signal strength. In such cases the accuracy that can be achieved depends on a number of variables such as the number of points involved and obstructions such as buildings or walls.

Inside structures such as buildings, factories and hospitals the geolocation applications often use the Wi-Fi technique and/or RFID and other tagged asset solutions that rely on a network of fixed scanners throughout the building. Accuracy of these techniques will depend on the number, density and placement of scanners, and indoor obstructions. Alternatively, a variety of navigation sensors can be incorporated to the tracking system including compass, ranging radios or LiDAR, gyroscopes, accelerometers and altimeters. These may be used in combination thus requiring intelligent algorithms that can analyze the various streams of information collected to interpret the most accurate geolocation possible.

# 3 E-MERGING APPLICATIONS

This section provides an overview of various applications to which the e-Merging technologies covered in the previous section are being put. These have been formulated loosely around the key application groupings that were identified for the BNSDI Requirements Analysis.

## 3.1 Community Planning, Management and Public Engagement

### 3.1.1 Smart Santander

The City of Santander in northern Spain has been working diligently since 2009 to become the showcase for "smart city" in Europe. The underlying goal is to improve the daily life of Santander citizens and boosting the efficient and sustainable management of all the services of the city using new technologies. This has included the installation of over 1300 sensors and 20,000 wireless devices including cameras and mobile devices that are controlled from a


Santander Smart City combines technologies to improve city services. Courtesy Santander City Council

centralized Cloud City Center where the collection, management and analysis of the data will be carried out to monitor activities and services throughout the city. Services include monitoring of parking spaces to determine when a space becomes available, traffic monitoring and redirection for maximum efficiency. The city environment is monitored for temperature, humidity, emissions and air quality. A free application SmartSantanderRA uses Augmented Reality technology which allows residents and visitors to use their Smartphone to identify points of interest, touristic sites, shopping, beaches and museum information, as well as stops and schedules for transit. Over 2000 RFID and QR tags are being installed to map these areas. Irrigation of the urban landscaped areas is optimized through 50 moisture monitoring sensors that are distributed around the city and light sensors detect the amount of sunlight and are able to adjust street lighting to accommodate changes.

### 3.1.2 City Sourced

CitySourced is an enterprise civic engagement platform. CitySourced provides a mobile app in order for citizens to identify and report non-emergency civic issues, such as public works, quality of life, and environmental issues. It also incorporates a Civic Crowdfunding Platform for organizations to raise funds for civic projects. The service is part of the e-Government or gov 2.0 movement, which aims to connect government and citizens through the use of technology. The application is compatible with any iOS devices, including iPhone and iPad, Android devices, Blackberry devices, Windows Phone devices, and Windows computers, Windows computers.


City Sourced software uses the public to report potholes, trash dumping and more. Courtesy City Sourced Inc.

### 3.1.3 Ushahidi – Watertracker.

Watertracker is a community-centric reporting tool developed for the Sustainable Water Supply and Sanitation project (SWSS) by New York based company Arc Finance utilizing Ushahidi.[21] A system simple enough for even rural communities while able to support a multi-year, USAID-supported initiative that has, to date, constructed over 3,000 new water points throughout Afghanistan. Six digit codes are associated by SWSS to each new well as it becomes available to the public. If the well should break, anyone in the community can call that number. The IVR service asks them to enter the number, confirm that the well is broken, and then leave a short voice message about the problem.[22]


Watertracker used to support remote communities in Afghanistan. Courtesy Ushaihid

### 3.1.4 Putting Favela Businesses on the Map

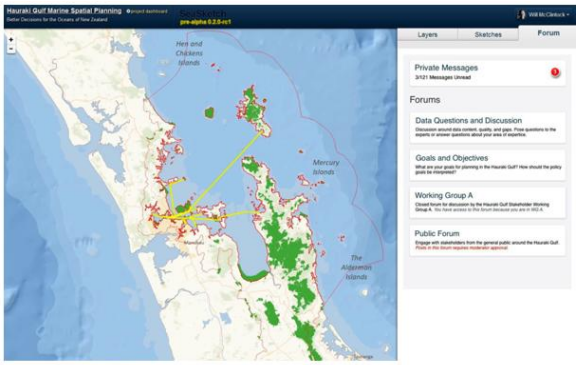
[21] http://www.ushahidi.com/2012/06/25/watertracker/
[22] http://www.ushahidi.com/product/ushahidi/

Informally developed slum areas of Brazil have in the past been largely excluded from the formal economy. However, in recognition that nearly 1.3 million of the favelas' 1.5 million residents today have mobile phones and nearly half of them have internet access, Microsoft and Google have partnered with local community groups and volunteers to map the locations of local businesses and institutions using their smartphones. Most areas of the favelas do not have street addresses, so adding this information to online maps is bringing much needed awareness and visibility to local businesses.

### 3.1.5 Ushahidi.

Ushahidi, Inc. is a non-profit software company that develops free and open-source software for information collection, visualization, and interactive mapping. Ushahidi (Swahili for "testimony" or "witness") created a website in the aftermath of Kenya's disputed 2007 presidential election that collected eyewitness reports of violence reported by email and text message and placed them on a Google Maps map. The organization uses the concept of crowdsourcing for social activism and public accountability, serving as an initial model for what has been coined as "activist mapping"—the combination of social activism, citizen journalism and geospatial information. Ushahidi offers products that enable local observers to submit reports using their mobile phones or the internet, while simultaneously creating a temporal and geospatial archive of events[23].

### 3.1.6 SeaSketch




SeaSketch used to engage multiple stakeholders in the marine spatial planning process. Image by McClintock Lab at the Marine Science Institute at the University of California Santa Barbara

SeaSketch is a software application that provides GIS-based tools for marine spatial planning. The system is designed for information access and multi-stakeholder engagement to bring together the perspectives of ocean planner, other stakeholder and the public into the planning process. Using the software, groups of stakeholders can work together to generate multiple alternative proposals for use of marine and coastal areas representing the interests and priorities of the participants. The software provides incorporates scientific and regulatory information regarding sensitive resources, protected areas, potential social or economic costs and benefits and can give the participants immediate feedback based on their proposed scenarios. It can also include input from advanced analysis modeling packages such as Marxan and

[23] http://en.wikipedia.org/wiki/Ushahidi

Cumulative Impacts. All stakeholder input is managed on the system providing the marine spatial planners with a flexible and organized recording of stakeholder ideas and input that can be folded into the planning process. The software is usable online over the web, thus users do not need to buy, install or manage expensive equipment to use the tools. SeaSketch is developed by the McClintock Lab at the Marine Science Institute at the University of California Santa Barbara. Initial funding and support for SeaSketch has been provided by Esri, the New Zealand Department of Conservation, and The Tindall Foundation.[24]

## 3.2 Climate and Weather Sensing

There are a variety of technologies being used today to monitor and forecast climatic and weather conditions from space, airborne platforms and in situ on the ground or ocean. Meteorological satellites are used to observe cloud cover and visible weather patterns, but beyond this are utilizing a variety of sensors to capture city lights at night, pollution in the land, sea and air, dust storms, ocean currents, fires and sea ice at the polar icecaps. On the ground, both highly sophisticated, complex and highly costly technologies requiring teams of scientists to use and maintain as well as simple and inexpensive technologies that can be locally managed without highly specialized expertise are adding new dimensions and value to weather monitoring globally. In between space and the ground, weather balloons, UAV drones and oceanic buoys are collecting information as they move through the air and ocean currents. This field is very broad and rapidly evolving. Many of the standard products of these technologies have been around for some time and are used to derive the television, radio newspaper and internet based weather broadcasts and predictions that everyone is familiar with, but with very little understanding of where that information comes from. The following highlights several existing and e-Merging climate and weather sensing technologies that have specific relevance to the BNSDI.

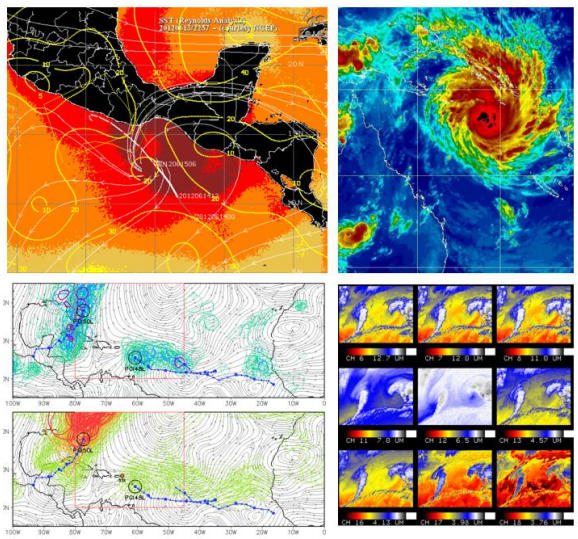
The U.S. National Oceanic and Atmospheric Administration (NOAA) is a premier provider of weather monitoring data globally. The organization develops and maintains an integrated observing systems that includes satellites (inclusive of both geostationary and polar orbiting), radars, surface automated weather stations, weather balloons, sounders, buoys, instrumented aircraft and other sensors, along with the data management infrastructure needed for this system. Many of these systems have global reach and information is shared with partners internationally. Belize and other countries utilize this data directly and/or collaborate with other regional centers who have the infrastructure and expertise to operate sophisticated weather forecasting models. Key satellite-based weather monitoring technologies that are particularly relevant to Belize include:

### 3.2.1 Weather Info for All (WIFA) Initiative

[24] http://www.seasketch.org/about/

The Weather Info for All (WIFA) Initiative is a public-private partnership that works to reinforce the capacities and the capabilities of national meteorological services with the goal of supporting local communities worst impacted by climate change through the improvement of weather monitoring. "By bringing together the expertise and resources of different public and private actors, this project may help to save lives and improve the livelihoods of communities in Africa living on the frontlines of climate change." Kofi Annan, President of the Global Humanitarian Forum. The Forum, together with Ericsson, the World Meteorological Organization, National Meteorological Services (NMSs), the Earth Institute at Columbia University, as well as Zain and other mobile phone operators aim to deploy up to 5,000 automatic weather stations (AWSs) at wireless network sites across Africa, where less than 300 are reporting today. http://en.wikipedia.org/wiki/Weather_Info_for_All_Initiative

### 3.2.2 CIMSS Weather Data Products.



The CIMMS utilizes a variety of satellite data to produce useful weather data and products. Courtesy CIMMS

The Cooperative Institute for Meteorological Satellite Studies (CIMSS) is a Cooperative Institute formed through a Memorandum of Understanding between the University of Wisconsin-Madison (UW-Madison), the National Oceanic and Atmospheric Administration (NOAA), and the National Aeronautics and Space Administration (NASA) in 1980. CIMSS operates as an institute within the Space Science and Engineering Center (SSEC) at the University of Wisconsin-Madison. CIMSS scientists conduct research using remote sensing systems for meteorological and surface-based applications and provide a variety of products and online services for general use by the public and other meteorological organizations worldwide. The Belize National Meteorological Office utilizes many of the real-time, near real-time, historical and predictive CIMSS products that are made available online[25].

### 3.2.3 Earth Networks.

Earth Networks and their WeatherBug brand leverage access to thousands of sensor networks around the world to monitor weather, lightning and greenhouse gases. According to their website, "Big data" from our networks make it possible for consumers, enterprises and governments to Know Before™ with Early Warning Systems that provide the most detailed information and the fastest alerts to severe weather when minutes matter.[26] The company collaborates with public and private entities around the world to advance severe weather

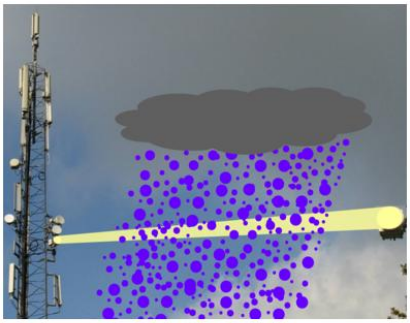
[25] http://cimss.ssec.wisc.edu/
[26] http://www.earthnetworks.com/AboutUs.aspx

detection and alerting, atmospheric research, and public education. Weather and related products are delivered through a variety of channels to governments, schools, research institutions, broadcast companies, industries and others who need up to date and accurate weather monitoring and forecasting.


Earth Networks – example of private sector tapping into available government information to develop new and creative ways to deliver value added information to the public . Courtesy Earth Networks

### 3.2.4 Cell Tower Rainfall Monitoring.

Around 2006, scientists realized that the disruption of certain frequencies in radio signals caused by rainfall could be used to reconstruct rain patterns near cell towers. Since then techniques have been developed to successfully apply this technique in several developed countries, and others are looking to apply this approach to other countries that may lack a complete weather monitoring infrastructure. This is particularly important in the face of climate change and variability that can exacerbate rain-related hazards such as floods and droughts[27].



Cell tower transmissions used to calculate rainfall. Courtesy Wageningen UR

### 3.2.5 NETATMO – Weather Station for Smart Phone.

Netatmo weather station is a consumer product that senses weather and other factors inside or outside of the home, and transmits this information to the owner's smart phone and/or to the web. The device tracks temperature, humidity, barometric pressure, noise levels, and carbon dioxide (CO2) levels. It delivers all this data in a smart phone app that provides a snapshot of indoor and outdoor conditions as well as timeline charts and an extended weather forecast. The user can also choose to make their outdoor weather data available on the Netatmo World Map and share it with friends on Facebook and Twitter.[28]


Netatmo citizen weather reporting in Central America. Courtesy Netatmo

### 3.2.6 StormTag and WeatherSignal.

[27] https://www.sciencenews.org/article/cell-phone-towers-monitor-african-rains
[28] https://www.netatmo.com/en-US/product/weather-station

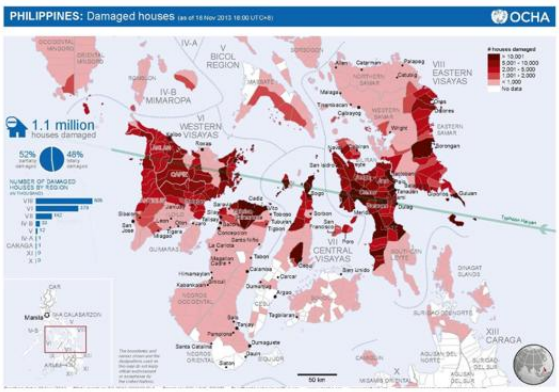

WeatherSignal has built an application that turn smart phones into weather stations. This application uses readings from a device's sensors such as light, pressure, temperature and humidity and this information is then fed to a central server to create crowd-sourced weather maps. In the past this information was limited to existing sensors on the device. To overcome this, WeatherSignal is now teaming up with another entity, StormTag who have built a low cost, low power demand, waterproof temperature and pressure sensor that communicates via Bluetooth LE. With these combined technologies and eventual porting to major smart phone operating systems, anyone with such a device will be able to monitor temperature and pressure, which are key weather variables in predicting and monitoring weather and major storm events.

## 3.3 Disaster Reduction and Emergency Response

The identification of hazards, assessment of vulnerable populations and critical resources and infrastructure at risk are important for understanding vulnerabilities. Once understood, planning to avoid risks can be carried out and contingency plans can be laid for planning an effective response and recovery program when disasters do strike. The following are example where emerging technologies are being used to support disaster planning and response.

### 3.3.1 Typhoon Haiyan

After typhoon Haiyan devastated portions of the Philippines in November 2013, 100's of volunteers around the world joined forces to analyze satellite imagery, conduct damage assessment and bring together a variety of data sources to supply relief agencies with the information needed to mount an effective response. This army of remote volunteers joined with international agencies and local responders to use online mapping tools, social networks and cell phone information to help understand the extent of damage and to prioritize and mobilize response resources where they were needed most. The UN Office for the Coordination of Humanitarian Affairs (OCHA) for the first time developed a team that was charged specifically with coordinating crowdsourced mapping with volunteer groups, to help organize, filter and channel the information to support response efforts. Following the




Damage assessment supported with information from over 1000 remote volunteers. Courtesy UN OCHA

typhoon many local and international organizations continued using updated maps of the stricken areas generated by more than 1,000 OpenStreetMap volunteers from 82 countries.

### 3.3.2 Humanitarian OpenStreetMap Team.

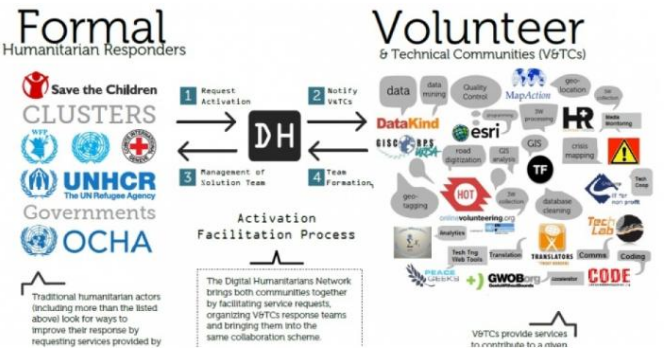
The Humanitarian OpenStreetMap Team (HOT) is a US-based non-governmental organization, launched in 2009 and incorporated as a 501c(3) not for profit organization in 2013. HOT first gained significant attention from international relief organizations in 2010 when a massive earthquake struck with widespread damage. HOT was able to generate some of the best damage assessment maps within days, providing responders on the ground with critical information.

Map data generated by HOT supporting response efforts in Haiti. Courtesy Humanitarian OpenStreetMap Team

According to the HOT website "Free, collaborative maps are uniquely valuable to humanitarian work, especially in places where base map data is often scarce, out of date, or rapidly changing. OpenStreetMap is a project to create a free and open map of the entire world, built entirely by volunteers surveying with GPS, digitizing aerial imagery, and collecting and liberating existing public sources of geographic data. The information in OpenStreetMap can fill in the gaps in base map data to assist in responses to disasters and crisis. In the same way that the OpenStreetMap data bridges the missing information, the Humanitarian OpenStreetMap Team [HOT] acts as a bridge between the traditional Humanitarian Responders and the OpenStreetMap Community. HOT works both remotely and physically in countries to assist the collection of geographic data, usage of that information and training others in OpenStreetMap."[29]

### 3.3.3 Digital Humanitarian Network (DHN).

The Digital Humanitarian Network (DHN) is an umbrella group of 16 volunteer technology organizations created in 2012 to provide a liaison between those groups and conventional humanitarian organizations. The DHN brings together expertise in geographical information systems, online mapping, data analysis and statistics. It also develops user-friendly tools that enable untrained volunteers to contribute to responses. In this way, the DHN looks to leverage the formal, professional humanitarian organizations with the informal but skilled and agile volunteer and technical networks. DHN




[29] http://hot.openstreetmap.org/about

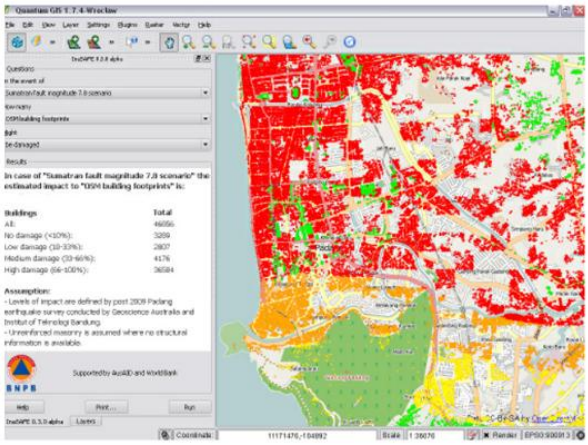
coordinators review activation request and then work with the appropriated volunteer and technical teams to formulate the skills and resources needed to respond to a particular situation. These teams conduct a variety of activities including real-time monitoring of mainstream and social media, rapid geo-location of event and infrastructure data, creation of live crisis maps, data development and data cleaning, GIS and Big Data analysis, satellite imagery tagging and tracing, and rapid time-sensitive web-based research.

### 3.3.4 Standby Task Force.

Locations of SBTF members around the world. Courtesy SBTF

The Standby Task Force (SBTF) organizes digital volunteers into a flexible, trained and prepared network ready to deploy in crises. The concept for the Task Force was launched at the 2010 International Conference on Crisis Mapping (ICCM 2010) to streamline online volunteer support for crisis mapping following lessons learned in Haiti, Chile and Pakistan, and to provide a dedicated interface for the humanitarian community. The main objective of SBTF is to effectively assist crisis affected communities through co-operation with local and international responders. The SBTF uses a variety of geospatial and social media tools to support crisis assessment and response support, including tapping into tweets, text messages and other social medial channels to monitor disasters as the develop, map damage and infrastructure and provide information to support local response teams. The SBTF uses a suite of applications specifically designed to support disaster response called MicroMappers. These applications support a range of capabilities including allowing users to tag tweets or photos showing damage to infrastructure or displaced populations or apply machine-learning techniques to filter social media feeds to mine for the most relevant information.

### 3.3.5 InaSAFE


InaSAFE allows emergency planners to assess risk and report damage. Courtesy GFDRR.

Communities often have an accurate and practical sense of their exposure to hazards, risks and impacts. When backed up with scientifically collected information and analysis it is possible to leverage community engagement to collect information and develop urban plans and disaster contingency response plans that are most closely responsive to unique local conditions. The Indonesian Disaster Management Agency (BNBP) has undertaken an effort in cooperation with the

Australian Agency for International Development (AusAID), the Humanitarian OpenStreetMap Team, the Civil Society Strengthening Scheme (ACCESS), the World Bank, the Global Facility for Disaster Reduction and Recovery, local students and the public to conduct community mapping of exposure and risk from natural disasters. A key component of this exercise has been the collection of structural data for buildings in both rural and urban communities. This information led to the development of the Indonesia Scenario Assessment for Emergencies (InaSAFE) system, an open source risk modeling software that can be used for disaster planning, preparedness, and response and for government contingency planning. Community workshops were held to train participants on building construction and what data to collect. During this first phase the participants were able to map 163,912 buildings in 5 major cities. InaSAFE is a free software that anyone can use to produce realistic natural hazard impact scenarios for better planning, preparedness and response activities.

## 3.4 Health, Safety and Welfare

Social media, cell phones, and other communication modes are opening up new two-way channels in health research, monitoring and response that is transforming the ways that health officials are responding to health issues, disasters and pandemics. The following summarizes several examples that illustrate case examples that have implications for the BNSDI.

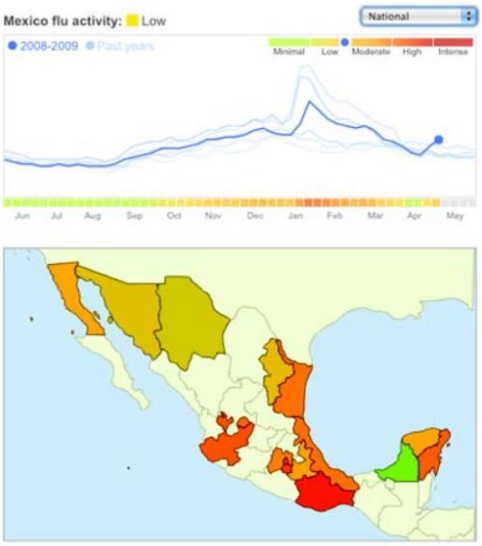
### 3.4.1 HealthMap.

HealthMap (http://healthmap.org/) mines news websites, government alerts, eyewitness accounts, and other data sources for various illnesses and outbreaks that are reported around the world. These are aggregates on a global map, thereby displaying outbreaks in real time. The team behind HealthMap has launched an iPhone application, Outbreaks Near Me, to deliver HealthMap information directly to the user's cell phone. The team is also developing a Flu Near You (https://flunearyou.org/), a website developed in cooperation with the American Public Health Association and the Skoll Global Threats Fund of San Francisco, California. This website allows individuals to act as potential disease sentinels by reporting their health status on a weekly basis.

HealthMap uses multiple media feeds to determine disease reporting and possible outbreaks. Courtesy HealthMap

### 3.4.2 Google Flu Trends.

Google has teamed up with the U.S. Centers for Disease Control and Prevention (CDC) to develop Google Flu Trends, a website that allows people to compare volumes of flu-related search activity against reported incidence rates for the illness displayed graphically on a map. Where traditionally relying upon outpatient reporting and virological test results supplied by laboratories in the U.S., which identifies outbreaks about 2 weeks after they begin, the social media based approach can flag potential issues in near real-time. The CDC now monitors Google Flu Trends as an additional source of information for determining when and where outbreaks may happen as an early warning for earlier action[30].




Healthmap flu activity monitoring in Mexico. Courtesy Google.org

### 3.4.3 Digital Disease Surveillance

When people don't feel well they often use an internet search engine to research the symptoms they are experiencing. Monitoring these queries and other social media feeds can provide early warning of an infectious disease outbreak according to recent studies. In a new study published in *Lancet Infectious Diseases,* internet-based surveillance has been found to detect infectious diseases such Dengue Fever and Influenza up to two weeks earlier than traditional surveillance methods. The paper titled *Internet-based surveillance systems for monitoring emerging infectious diseases*, QUT, contends that when investigating the occurrence of epidemics, spikes in searches for information about infectious diseases could accurately predict outbreaks of that disease. It goes on to indicate that digital surveillance through search engine algorithms such as Google Trends and Google Insights, detecting the 2005-06 avian influenza outbreak "Bird Flu" would have been possible between one and two weeks earlier than official surveillance reports. Another example indicates that a digital data collection network could detect a SARS outbreak more than two weeks earlier than traditional methods.

### 3.4.4 Illegal Fishing Surveillance

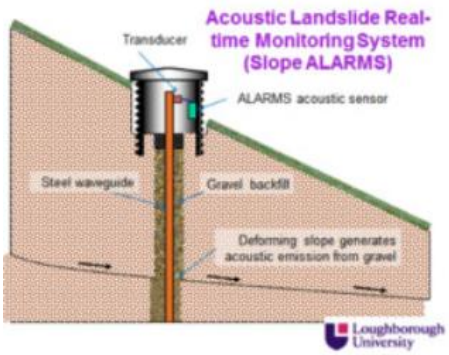
Fishing is an important source of food and income for coastal areas around the world, however overfishing in unsustainable ways can cripple a local economy and seriously impact food insecurity. Of special concern is illegal commercial fishing in the coastal waters of small island developing states (SIDS) and coastal areas in developing countries that may not have the resources to adequately patrol and enforce fishing regulations. To combat this, Google, SkyTruth and Oceana have teamed up to monitor and report such activity. This is accomplished by monitoring Automatic Identification System (AIS) transmissions that boats

[30] (http://www.google.org/flutrends/)

are required to transmit for safety reasons. Using this information, geospatial visualization and analysis the monitoring is able to detect when ships that are registered as fishing vessels or are exhibiting fishing-like movements and enter a prohibited area.

While any vessel can illegally disable their AIS, others are investigating the use of high resolution satellite imagery to locate vessels that are not transmitting and are therefore suspicious and may require more focused attention or interrogation.

### 3.4.5 ALARMS – Landslide Early Warning




Landslides around the world each year result in thousands of deaths and damage to major infrastructure and breakdown of vital services such as water supply, electricity, transportation and emergency response. The British Geological Survey (BGS) is using a prototype acoustic emission device developed at Loughborough University, UK to detect and provide early warning regarding potential landslides. The Assessment of Landslides using Acoustic Real-time Monitoring Systems (ALARMS) system utilize a state-of-the-art, low cost, miniaturized acoustic sensors integrated with GSM networking capability to detect and transmit an SMS text message early warning of potential slope instability. The device has been performance tested and demonstrated at an active landslide site, in Yorkshire, UK. The wireless telemetry and re-engineering required for ALARMS drew heavily on BGS's expertise in developing an Automated time-Lapse Electrical Resistivity (ALERT) system for monitoring the stability of both natural landslides and engineered structures like dams, embankments and hydraulic barriers.[31]

## 3.5 Environmental Monitoring and Biodiversity Management

Monitoring environmental conditions and trends and understanding the causative factors of these trends is important to the development of effective policies, plans and actions. The following provides a summary of innovative ways that countries and organizations are using social media, low cost devices and a variety of ingenious new ways of collecting and using environmental monitoring information.

### 3.5.1 Citizen Observatory Web (COBWEB).

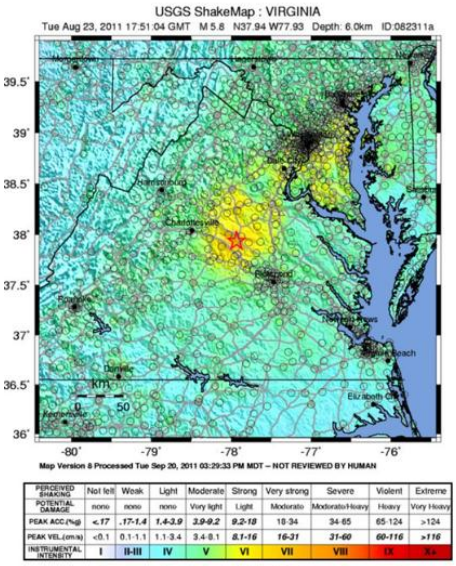
COBWEB brings together expertise from 13 partners and 5 countries. The main context for the project is the Global Earth Observation System of Systems (GEOSS) and the UNESCO World Network of Biosphere Reserves (WNBR). Concentrating on Biosphere Reserves in

[31] http://www.bgs.ac.uk/research/tomography/alarms.html

Wales, Germany and Greece, the main aim is to create a test bed environment which will enable citizens living within Biosphere Reserves to collect environmental data using mobile devices. Information of use for policy formation and delivery will be generated by quality controlling the crowdsourced data and aggregating with Spatial Data Infrastructure (SDI) type reference data from authoritative sources. In the process the project aims to build up shared expertise in these new and developing technologies and understand how crowdsourcing/citizen science techniques combined with SDI-like initiatives can deliver both societal and commercial benefits. COBWEB - Citizen OBservatory WEB – is funded under the European Union's Seventh Framework Programme (FP-7) in the Environment "Developing community-based environmental systems using innovative and novel earth observations applications" theme.[32]

### 3.5.2 Did You Feel It?

"The US Geological Survey's Community Internet Intensity Map ('Did you feel it?') website automatically maps reports from citizens about their perception of recent seismic activity in their areas. If a citizen feels a tremor of an earthquake these people can visit the DYFI website and report their location and their estimate of the intensity of the tremors they have just felt. In combination to a large network of sensors which are placed all over the world these additional citizen reports allow USGS to develop a more detailed map of the intensity of an earthquake's activity. Over 360,000 earthquake events have been submitted to DYFI and are available to browse online on the archive section of the website. There is an option citizens to give first-person descriptions of how the earthquake affected them. However it is made clear on the form that if the USGS use this qualitative information the citizen will only be referred to as "the observer". Contributors can watch the DYFI webpage for the display of their report. Maps and graphics are generated automatically by the DYFI system and made available to the public".[33]



Crowd sourced sensing of shaking intensity used to refine USGS earthquake information. Courtesy USGS

### 3.5.3 GROUND Lab Open Source Tracking Platform

GROUND Lab is a Research and Development company specialized in prototyping, field testing and implementing accessible technological solutions for research groups, Universities, Governments, large organizations, NGOs and their unique problem sets. The goal of the Open Source Tracking Project is to make an accessible tracking platform, to allow a greater range of people and organizations - from conservationist and small businesses to creative

[32] http://edina.ac.uk/about/annual_review2014/crowdsourcing-environmental-data.html
[33] https://crowdgov.wordpress.com/case-studies/usgs-did-you-feel-it/

people and hobbyists - the tools of real time GPS tracking and data visualization. The project aims to create an Open Source Toolchain of tracking devices, databases and data visualization tools that will be available through open documentation, code bases and DIY kits. The tracking modules which represent the physical hardware that sends GPS data as well as other environmental data to a network using GSM or GPRS. Once in the network, a MYSQL database stores and organizes the data, which can then be output in any desired format. The formatted data can then be displayed using the developed Web based visualization software and Google Earth.[34]


Tracking of lions helping to avoid conflicts with Maasai herders. Courtesy GROUND Lab

GROUND Lab, in collaboration with Living With Lions and Lion Guardians has applied the Tracking Platform to help conservationists protect the last 2000 lions living in the wild in Southern Kenya, and safeguard the Maasai herders cattle, restoring Maasai land to a working ecosystem and employing the Maasai to be actively involved in preserving the lion population rather than killing them to protect their livestock. A tracking collar that uses the GPS/GSM module is used to locate and track the lion locations and transmit this to researchers and Maasai herders. The device uses an Atmel low-power Microcontroller, SIM card, GSM and GPS antennas, rechargeable lithium-ion batteries, and GSM/GPRS/GPS module.[35]

## 3.6 Forest Management

### 3.6.1 Florida Agroforestry Decision Support System.

Agroforestry is being promoted in the United States as an alternative resource management system that can bring landowners economic benefits and provide environmental services such as reduced soil erosion, improved water quality, and wildlife habitat. Landowners, farmers, and extension agents need to be better informed about different agroforestry opportunities and potential tree species. Computers offer an effective means of delivering information as well as providing decision support for agroforestry planning and species selection. The Florida Agroforestry Decision Support System (FADSS) was designed to aid in the dissemination of such information and provide decision support for tree selection. FADSS utilizes a geographical information system (GIS) enabling the user to select a location of interest which is linked to spatial data on climate and soils characteristics for the state of Florida. The application also incorporates a plant database of over 1000 trees, shrubs, and grasses with over 50 attributes for each species. Together, the climate, soils, and plant databases form a relational database.

[34] http://home.groundlab.cc/opensourcetracking.html
[35] http://home.groundlab.cc/opensourcetracking.html

The application structure of FADSS consists primarily of building database queries using Standard Query Language (SQL). SQL queries are constructed during run-time based on spatial parameters of a selected location, the type of agroforestry system desired, and production and management criteria provided by the user. Experts were interviewed and literature consulted to help develop the queries and rules used to build the queries used to select trees and other agroforestry species (e.g. shrubs and forages). Being a prototype, the application is built with a modular and flexible framework in which spatial data of different scales and/or regions as well as plant data may be easily incorporated. Among the major limitations encountered during the development of FADSS with major implications on future agroforestry decision support systems was the current lack of tree information relevant to agroforestry and the lack of research involving the assessment of suitable agroforestry trees and their characteristics.[36]

### 3.6.2 Invisible Track

Invisible Track allows an illegally harvested log to send an alert and location once it passes within 20 miles of a cellular network. Courtesy Gemalto

Invisible Track is a technology that is being used to alert officials to illegally cut trees that are not caught by remote sensing or rangers. Using this technology, selected trees in protected areas or areas that are vulnerable to illegal logging are outfitted with a device smaller than a pack of cards that includes advanced localization algorithms and new Radiation Exchange Data (RED) technology that extends the range of wireless communications in low signal areas. As soon as one of the illegally cut logs is transported within 20 miles of a cellular network it sends an alarm notification and location information to officials, allowing them to react in real time, trace the loggers to sawmills and prevent the processing, sale and profit from the illegally harvested lumber. The device has been developed by the Dutch digital security company Gemalto, has a battery life of up to a year and is ruggedized to handle tropical climates.[37]

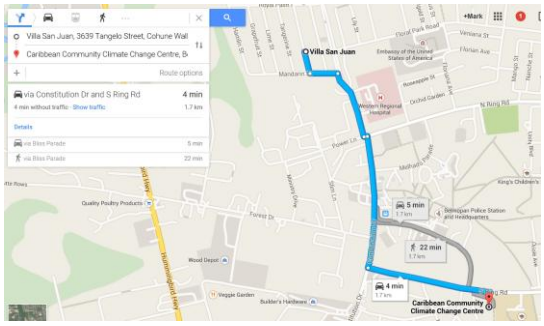
## 3.7 Wayfinding, Traffic, Transit and Road Incident Monitoring

Once more accurate GPS signals were made available for civilian uses in 1996, it opened the flood gates for location based services of all types. Car navigation systems were some of the first to explore this capability. Since then the technology has been incorporated into literally thousands of different applications including smart phones, making every smart phone user both a spatially enabled user and producer of useful information. The following provides an overview of how GPS and mobile telephony are being applied to wayfinding, traffic and other

[36] http://ufdcimages.uflib.ufl.edu/UF/E0/00/07/09/00001/jeswani_s.pdf
[37] http://www.gemalto.com/press/Pages/news_1482.aspx

issues affecting how we find places, navigate our way, and report roadway issues that affect others.

### 3.7.1 Google Maps.

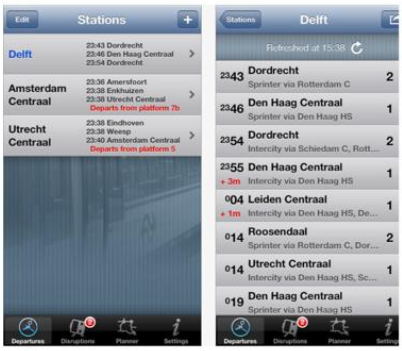


Google Maps is a desktop and mobile web mapping service application and technology provided by Google, offering satellite imagery, street maps, and Street View perspectives, as well as functions such as a route planner for traveling by foot, car, bicycle (beta test), or with public transportation. Also supported are maps embedded on third-party websites via the Google Maps API, and a locator for urban businesses and other organizations in numerous countries around the world. Google Maps satellite images are not updated in real time; however, Google adds data to their Primary Database on a regular basis. Google Earth support states that most of the images are no more than 3 years old. Google maps now include real-time crowdsourced traffic and road hazard notifications from Waze.

### 3.7.2 Waze


Waze is a Google-owned application that provides real-time crowd-based navigation, traffic monitoring, weather conditions and incident reporting for smart phones. The app is free of charge and allows the user to leave it running with GPS-enabled to provide real-time traffic and road data to the Waze community which as of this writing had more than 60 million users. In addition to the navigation information, the application will notify the user of traffic jams, road closures or bad information conditions that may affect your trip. When such hindrances are identified, the application can automatically generate an alternate route. You can also use the application to send a meeting point message to a friend and allows them to track your progress to the location on a map, as well as locate find the cheapest place to buy gas.

### 3.7.3 Trein



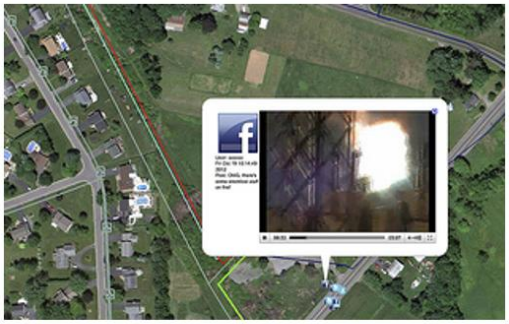

Trein tracks train arrivals and departures in the Netherlands. Courtesy Dennis Stevense.

Trein is an iPhone application developed by a student in the Netherlands that brings real-time train tracking information to mobile devices. The application taps into timetables and train numbers from Somda.nl, a website for "trainspotters" that reports locations of trains, delays, accidents and other

such information along with other information that is gleaned from the Dutch Railways website. This application is combining crowd-sourced information from trainspotter hobbyists along with official government information to provide a value-add service to the public, without official affiliation with either organization.

## 3.8 Infrastructure Management

### 3.8.1 GridIQ

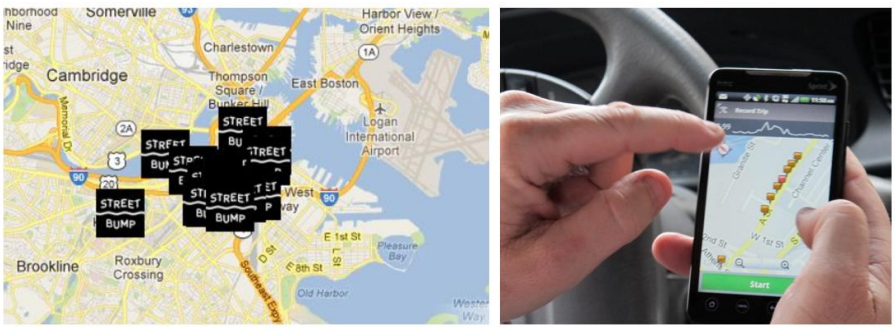


GridIQ will mine social media to identify locations of power outages. Courtesy GreenMonk blog.

General Electric (GE) has developed new technology that could provide an effective early warning system to detect when parts of the electric grid are not meeting demand. GridIQ makes use of multiple social media channels to provide advance notification of impending or current power outages and their locations. Social media posts are "mined" to isolate those that refer to issues with power service, and these are interpreted topically and geographically to identify service problems and patterns. The technology could potentially fulfil a significant need for utility companies to better monitor customer services, without having to invest resources in updating infrastructure to enable smart monitoring.[38]

### 3.8.2 StreetBump

StreetBump is a mobile phone application deployed by the City of Boston to detect rough spots in roadways. The StreetBump application is run on the client smartphone which is left in a fixed position in a moving vehicle. When the jolt of a bump or pothole is detected by the application the geographical coordinates and other data are uploaded to the City of Boston StreetBump web service. The Roads and Public Infrastructure Division monitor these reports, and if enough users detect road roughness in the same location suggesting a bump or pothole problem, an engineer will physically examine that street location.[39]




StreetBump uses smartphones to detect potholes and bumps in city streets. Courtesy City of Boston.

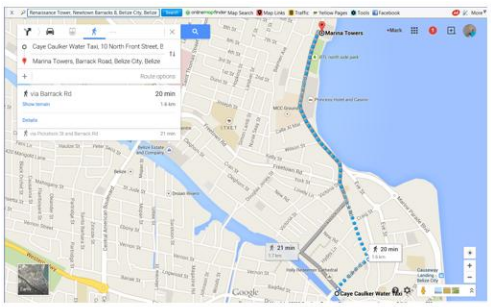
[38] https://www.gedigitalenergy.com/DemandOpt/catalog/GridIQ.htm
[39] http://www.streetbump.org/

### 3.8.3 FixMyStreet

FixMyStreet is a web-based application that enables citizens to report local problems. The problem reporting uses Ordnance Survey maps as a backdrop for users to spot the exact location of the problem. The issues reported are propagated to the relevant councils by email. Users reporting a problem are contacted by FixMyStreet after four weeks to report the status of the resolution. This is being used to report a variety of issues such as abandoned vehicles, dog fouling, fly posting, graffiti, fly tipping, unlit lampposts, potholes, litter and street cleaning. This application was developed and is administered by mySociety, a non-profit registered charity. The central website is free to us, but there is a paid version that is adapted to meet the needs of specific Councils.

### 3.8.4 Transportation and Wayfinding

***Google Maps***. Google Maps is a desktop and mobile web mapping service application and technology provided by Google, offering satellite imagery, street maps, and Street View perspectives, as well as functions such as a route planner for traveling by foot, car, bicycle (beta test), or with public transportation. Also supported are maps embedded on third-party websites via the Google Maps API, and a locator for urban businesses and other organizations in numerous countries around the world. Google Maps satellite images are not updated in real time; however, Google adds data to their Primary Database on a regular basis. Google Earth support states that most of the images are no more than 3 years old. Google Maps for mobile is the world's most popular app for smartphones, with over 54% of global smartphone owners using it at least once during the month of August 2013.[40] Google Traffic is a feature on Google Maps which displays traffic conditions in real-time on major roads and highways in over 50 countries. Google Traffic can be viewed at the Google Maps website, or by using the Google Maps application on a handheld device. Google Traffic works by analyzing the GPS-determined locations transmitted to them by a large number of cellphone users. By calculating the speed of users along a stretch of road, Google is able to generate a live traffic map.[41]



Google Maps for mobile wayfinding. Courtesy Google

### 3.8.5 Zipcar.

Zipcar, a subsidiary of the US car rental company Avis Budget Group, provides access to car rentals by the hour or day. Zipcar

Zipcar vehicles can be located and unlocked with the users smartphone. Courtesy Zipcar

[40] http://en.wikipedia.org/wiki/Google_Maps
[41] http://en.wikipedia.org/wiki/Google_Traffic

members can reserve Zipcars online or by phone at any time night or day and can use an iPhone or Android application that allows a member to honk the horn to locate the car and unlock the door. Zipcar charges a one-time application fee and annual fee in addition to the reservation charge. As of mid-2013 there were more than 810,000 members and 10,000 vehicles with services provided throughout the United States, Canada, United Kingdom, Spain and Austria.

## 3.9 Survey and Mapping

### 3.9.1 Volunteered geographic information (VGI).

VGI is a term for the capture of geographic information voluntarily by individuals, first coined in 2007 by Dr. Michael Goodchild of the University of California, Santa Barbara. Organized contemporary examples of this include WikiMapia, OpenStreetMap and Google Map Maker. These sites provide general interest base map information and allow users to create their own content for use by others. This process is very useful for creating up to date information for areas that may not have been previously mapped or have not been updated for a period of time. Formal mapping organizations such as the UK's Ordnance Survey are collaborating with VGI data producers as a way to more quickly identify areas that have changed and require updating.

### 3.9.2 Open Street Map

OpenStreetMap (OSM) is a collaborative platform for the creation of fee and editable maps of the world by volunteers. Created by Steve Coast in the UK in 2004, OSM was inspired by the success of Wikipedia and driving by the restrictions on use, prohibitive costs or lack of availability of map data in much of the world. The OSM approach also benefited from the increasing availability of inexpensive portable GPS devices and high resolution satellite imagery. OSM today includes over 1.6 million registered users in many countries around the world who are collecting information through a variety of means and posting that data under the Open Database License.[42]

### 3.9.3 National Mapping

National mapping organizations (NMO's) have traditionally provided topographic maps and spatial products for use by government and the public. The Mapping Information Branch (MIB) at Natural Resources Canada has been responsible for updating information at 1:50,000 scale for an area of over 10 million Km2 divided into 13,200 map sheets. Given the rising

[42] http://en.wikipedia.org/wiki/OpenStreetMap

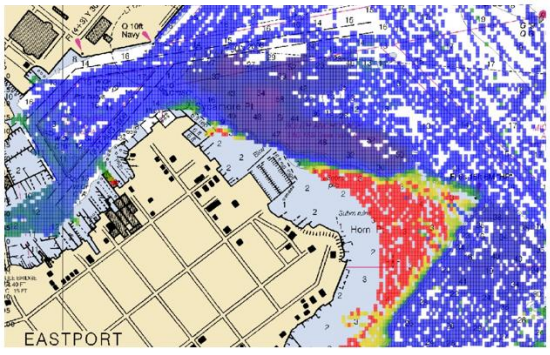
costs of maintaining this information, the government evaluated options including volunteered geographic information (VGI) to see if this could be used to keep up with map updating more efficiently. The MIB subsequently decided to work with the OpenStreetMap community, which started with the government providing all of their existing data to the community in the .osm format. The community has undertaken the verification, correction and addition of base map features and these are monitored by the MIB to identify areas of change that can then be updated to the official maps maintaining national map accuracy standards.

### 3.9.4 FINTAN

Common local names are important for emergency response and other issues. Courtesy UK Ordnance Survey

Recording both official and vernacular place names used locally for common reference is important for understanding references to place, be it for an emergency response situation or to associate information about a news item or incident with its geographic location on the ground. The UK HM Coastguard of the Maritime and Coastguard Agency (MCA) and the Ordnance Survey (OS), teamed up to develop a comprehensive record of vernacular names to complement the official names already maintained in the national gazetteer. This was accomplished by crowd sourcing local names through both regular coastguard and local coastguard volunteers. A software application, FINTAN was developed to support the crowd sourcing initiative. The system was equipped with the standard OS topographic base map products at multiple scales. It also includes the entire place names gazetteers and the use of different referencing systems used by other emergency services was also considered, thus providing a comprehensive repository of both official and common names for rapid, efficient and flexible location referencing.

### 3.9.5 Sea ID



Crowd sourced bathymetry data can be used to check and refined traditional maritime charts. Courtesy GeoGarage Marine

Sea ID Ltd. has partnered with the International Hydrographics Organization (IHO) and the Google Ocean Program, to explore the potential for every yacht to become a survey vessel providing bathymetric data that can be used to map and study underwater depth in oceans, seas, lakes and rivers. Sea ID Ltd. is working with the IHO to determine the best ways to capture and process "crowd sourced bathymetry" (CSB) information at a level that will allow this data to be contributed to maritime charts, and with Google who will make this information available to the public through Google Earth and Google Maps. The company has created and is testing a data logging box that collects

accurate and reliable data that can be assembled and processed before sending it to a central repository for distribution.

## 3.10 Geospatial Enabled $ICT_4D$

Advances in recent years in mobile telecommunications, low-cost computing, internet, cloud computing and other technologies has resulted in the evolution of the concept of Information and Communications Technology for Development ($ICT_4D$), whereby these technologies are being used particularly in developing countries for economic and social advancement. There are many examples from around the world of $ICT_4D$ being applied to real-world challenges and opportunities, from SMS-based financial transactions and banking via mobile phones, to access to current market prices of agricultural products for farmers, to access to micro-finance markets for would-be 3rd world entrepreneurs. In parallel, there has also been a recognition of the application of geographic information systems (GIS) technology in support of development issues (poverty mapping, emergency planning and response, economic development, delivery of humanitarian relief and many other areas) and Spatial Data Infrastructure (SDI) as a valid platform for sharing information across government organizations for increased efficiency, transparency, more effective coordination of foreign aid, amongst other advantages. This section provides a summary of several areas of $ICT_4D$ that have some relevance to the BNSDI but were not covered in previous sections.

### 3.10.1 Mobile Banking

Mobile banking and electronic payment services have seen a significant global upsurge in usage over the past several years in developing countries. Previously, the vast majority of poor people in developing countries have had to rely on the physical delivery of cash or other goods to make transactions. With the introduction of electronic payment services accessible via mobile phones and the internet, users are able to make transactions in a much quicker, safer, and more reliable manner. Establishing a geographic coordinate for a banking customer (e.g. using a geographic coordinate from a map or GeoSMS) can help a bank understand the pattern of banking customers in an area and could be used for promoting further community engagement.

### 3.10.2 Microfinance

Microfinance is a general term to describe financial services made available to low-income individuals as well as those who simply do not have access to financial services. Microfinance is founded on the idea that when provided with the proper financial support and opportunity, these individuals are able to lift themselves and their family out of poverty. Today there are many thousands of sources of microfinance all over the world. The internet is making it easier for a broad range of borrowers to tap into those networks, but there is no central catalog or registry that ties them all together, and many beneficiaries do not have the internet

connectivity to access those that are available. Adding a confirmable geolocator to the home and/or project location of a beneficiary, established through a map interface, gps or GeoSMS place name translator as described later, would provide perspective into a borrower's location and need and could be incorporated into the procedures for authenticating requests. The ability to also see the location and distribution of microfinanced projects can also help lenders to understand patterns in borrowing activities that could be used to strengthen these programs.

### 3.10.3 Agriculture Extension

Remote agriculture extension services refers to the idea that ICTs can be applied to agriculture in hopes of increasing productivity, bettering the lives of farmers, increasing the access to information, etc. This can be accomplished by adapting technologies such as computers/internet, mobile phones, etc. to existing extension services to improve the agrarian situation as a whole. Currently, there is a severe lack of agriculture extension workers in developing countries relative to population and required output. Traditional models of agricultural extension work stand to gain enormously by adopting ICTs to improve the overall process. Similar to many other areas, the adoption of ICT in agricultural extension work will lead to increased productivity via access to better information, increased sharing of information, and more efficient procedures in general. This service area can be greatly strengthened geospatial capabilities to track the location of farms, monitor crop productivity relative to other data such as soils and climatic factors, diagnose and track crop diseases spatially and many other uses.

### 3.10.4 Agriculture e-Market

Local markets are a major component of a developing economy and the day-to-day lives of local communities. Prices paid for various agricultural products can vary between local markets and farmers and fishers need to decide to transport their crop for the best return and consumers need to know where to go for the best price. Formalized or informal services can be established to track prices in local markets and to broadcast this information for access by producers and consumers alike. In addition, these same services could be set up to accommodate "virtual markets" for more convenient access to locally available products and services. By recording the location of a market or product for sale, geographic proximity can be included in the buying or selling decision-making process.

### 3.10.5 Tele-Health and Tele-Medicine

"The delivery of health care services, where distance is a critical factor, by all health care professionals using information and communication technologies for the exchange of valid information for diagnosis, treatment and prevention of disease and injuries, research and evaluation, and for the continuing education of health care providers, all in the interests of advancing the health of individuals and their communities." (World Health Organization, 2010). The many definitions available internationally for Tele-Health and Tele-Medicine make it clear that telemedicine is an open and constantly changing science. It incorporates

new advancements in technology and responds and adapts to the changing health needs and contexts of communities. Despite the many definitions and evolving nature of telemedicine, the World Health Organization has made it clear that there are 4 essential aspects:

- Its purpose is to provide clinical support.
- It is intended to overcome geographical barriers, connecting users who are not in the same physical location.
- It involves the use of various types of ICT.
- Its goal is to improve health outcomes.

While the provision of an initial tele-health service is not encumbered by distance, it is useful to understand the location and context of a service requestor. Patterns of service requests may suggest environmental issues or epidemic outbreak. Diagnosis of a severe problem may require transportation to a hospital or clinic, thus finding the location of the person and identifying the nearest capable medical facility are both important geographic matters.

### 3.10.6 Remote Learning

E-Learning is a broad term that encompasses many different teaching technologies as they are applied to teaching, learning, and other administrative actions related to education. Remote educational services is an area that is developing rapidly and constantly evolving to include new technologies, methods of delivery, etc. E-Learning is a concept that has taken root in many developed nations already and has the potential to transform education at all levels in the developing world as well. Understanding the locations of eLearners can help educators visualize the distribution and characterization of an entire class as well as the unique context of individuals. This location information could also be used to connect eLearners to each other, or to tutor or other supplementary services available within a geographic area.

### 3.10.7 Online employment

The use of the internet for both finding employment and finding workers of any type is common around the world. The use of this capability for both permanent jobs and temporary technical or labor work could also be used at the level of local communities, where a sufficient percentage of the population is connected or has access to internet services. The internet can also be used a source of crowd-sourced marketplace for services, such as is the case with Amazon Mechanical Turk[43] and SamaSource[44].

### 3.10.8 Community eCenters

The government of Belize has started establishing ICT Centers in selected villages to make internet services available to more remote locations. These fee based services are important

[43] http://en.wikipedia.org/wiki/Amazon_Mechanical_Turk
[44] http://www.samasource.org/

for providing access to ICT4D resources that might not otherwise be available, such as those listed previously in this section.

# 4 E-MERGING POLICIES AND FRAMEWORKS

The examples provided in the previous section of this report make clear that there are many countries and organizations around the world that are taking advantage of new technologies to create all manner of value add service and useful applications that can benefit society. Optimizing the use of e-Merging technology requires that government policies and programs reflect a philosophy to encourage, enable and support such developments. Progressive governments in Kenya, Singapore, Korea and other countries are proving that embracing technology and establishing incentive programs and open data policies is critical to catalyzing new invention, new professions and businesses and a growing and diversified economy. This section showcases several programs around the world that are making a difference and embody principles that are worth considering for enabling the BNSDI and further providing a fertile environment for the development and application of e-Merging technologies.

## 4.1 Open Data Policies

### 4.1.1 World Bank Open Data Programs

In mid-2010 the World Bank issued a new policy on access to information in its possession. This policy recognized that "transparency and accountability are of fundamental importance to the development process and to achieving its mission to alleviate poverty", and that the free flow of information is important to those principles. The policy furthermore recognizes "It is also critical for enhancing good governance, accountability, and development effectiveness. Openness promotes engagement with stakeholders, which, in turn, improves the design and implementation of projects and policies, and strengthens development outcomes. It facilitates public oversight of Bank-supported operations during their preparation and implementation, which not only assists in exposing potential wrongdoing and corruption, but also enhances the possibility that problems will be identified and addressed early on."[45]

While the policy favors and open approach and maximum access to information by stakeholders and the public, it also recognizes the need to protect the confidentiality of certain information, and thus the need for a proper balance according to clear and accepted exceptions and request process. Exceptions relate mostly to privacy of personal information, intellectual property rights and information that could compromise security or confidentiality agreements with a member country or third party.

Within the general parameters of the World Bank Policy on Information there have been several GIS-specific programs that have relevance to the BNSDI. The Bank's use of GIS has spread considerably in recent years and today there are several World Bank sectors and

[45] The World Bank Policy On Access to Information, July 1, 2010.

networks that are using and developing GIS tools for a wide range of applications. Specific programs of interest include:

***Mapping for Results***. The Bank worked with AidData[46] to geocode over 30,000 project locations that are linked to data about each project that can be used to visualize and understand where development investment is going. "All new World Bank projects are now geo-referenced to ensure that development planners can track and deliver resources more efficiently and effectively and avoid work duplication. Since the data is publicly accessible, it also empowers citizens to follow the progress of projects and service delivery in their countries."[47]

***Development Research Group***. The World Bank Research Department is using GIS methods extensively to carry out policy research, and provide support to Bank operations, and has developed its own GIS lab to support its activities;

***Global Facility for Disaster Reduction and Recovery (GFDRR)***. The World Bank has established the GFDRR with a specialist GIS team to assist in conducting geospatial risk assessments which are central to the Bank's disaster reduction strategy. The GFDRR has identified 31 "priority" countries deemed most at risk of disasters, such as climate change-related events. The GFDRR lab has been able to greatly magnify its impact by inviting specialists in GIS and related fields to help map risk profiles in countries such as Haiti, under the Open Data for Resilience program.

***World Bank Climate Change Knowledge Portal***. The Bank's Climate Change Knowledge Portal provides convenient access to climate and climate-related data as well as a GIS-based tool for visualizing key climate variables and a tool for assessing development projects for their sensitivities to climate change factors.

***World Bank Open Data Toolkit***. The Bank has also established an online website that provides a toolkit of resources to support open government data approaches. This includes links to open data portals around the world, lists of benefits, open data policies and applications, learning resources and access to technical assistance. It also includes tools for governments to self-assess readiness for an open data approach and other resources.

***World Bank – Open Aid Partnership***. "The Open Aid Partnership (OAP) brings together development partners, governments, civil society organizations, foundations, and the private sector to improve aid transparency and effectiveness. The OAP's goal is to collect and open up local development data to engage citizens and other stakeholders in evidence-based conversations on development."[48] The Partnership seeks to strengthen the capacity of partner

[46] http://aiddata.org/geocoding

[47] http://web.worldbank.org/external/default/main?menuPK=6454478&theSitePK=5929282&piPK=64911825&pagePK=7278674&contentMDK=23035843

[48] www.openaidmap.org

countries to manage and use information about aid projects within their boundaries, to build an aid map that provides a visualization of where project investments are being made and to build the capacity of citizens and civil society to understand and be able to provide feedback in regard to these investments.


The Open Aid Partnership supports the mapping and visualization of aid project data at multiple levels. Courtesy Open Aid Partnership, World Bank Group

The OAP is a collaboration between 14 countries, several multilateral and bilateral develop donors and foundations and the World Bank Group. The OAP works closely with International Aid Transparency Initiative (IATI) and its partner institutions to ensure harmonization and interoperable sub-national aid data and supports partners in collecting and publishing data under IATI.

### 4.1.2 Open Aid Data Initiatives

Most developing countries suffer from a lack of up-to-date information about their natural resources, populations, and infrastructure. Furthermore they often also lack information about the international aid, development and humanitarian activities that they need to plan, prioritize and manage those important resources in an effective and coordinated manner. Citizens in developing and donor countries also lack the information that is needed to understand where government resources are being invested and what outcomes are being achieved. Several open aid data initiatives have been launched to address this issue, including the following:

***International Aid Transparency Initiative (IATI)***. "IATI is a voluntary, multi-stakeholder initiative that seeks to improve the transparency of aid, development, and humanitarian resources in order to increase their effectiveness in tackling poverty. IATI brings together donor and recipient countries, civil society organizations, and other experts in aid information who are committed to working together to increase the transparency and openness of aid. At the center of IATI is the IATI Standard, a format and framework for publishing data on development cooperation activities, intended to be used by all organizations in development, including government donors, private sector organizations, and national and international NGOs. It was designed in close consultation with key users of development cooperation data

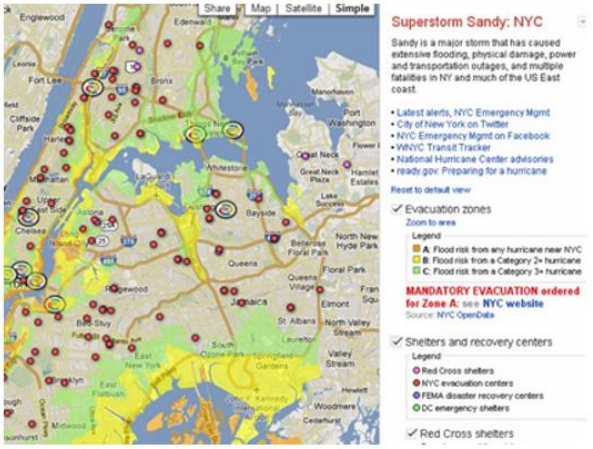
in developing countries, to ensure its relevance and utility for a variety of different data users. Organizations implement IATI by publishing their aid information in IATI's agreed electronic format (XML) – usually on their website – before linking it to the IATI Registry. The Registry acts as an online catalogue and index of links to all of the raw data published to the IATI Standard. [49]

### 4.1.3 DATA.GOV

The U.S. Government under the Obama administration developed DATA.GOV as a central site for accessing government data. The site currently has open data about 39 States, 46 U.S. cities and counties, 45 international countries and 163 international regions. The repository includes over 138,000 datasets covering a wide range of topics, nearly 96,000 of which are geospatial data. Many of the remaining non-geospatial datasets are referenced to zip codes and other geographic areas that can be used to link and visualize this information on maps. All datasets can be downloaded from the website in a variety of formats free of charge.

### 4.1.4 New York City Open Data Initiative

Developing and maintaining city data can be time consuming and expensive. Getting the most out of this investment can mean partnering with the public, civil society and the private sector to help collect information and then to use it for a variety of public good and private enterprise purposes. In September 2013, New Your City released over 200 government datasets to the public as part of a broad open data initiative to "improve the accessibility, transparency, and accountability of City government. This is the implementation of an aggressive open data initiative law signed by Mayor Bloomberg in March, 2012. In partnership with the Department of Information Technology and Telecommunications (DoITT), the OpenStreetMap community and Mapbox have begun to import city building footprint and address point datasets into the OSM database. All work is coordinated on Github and OpenStreetMap mailing lists. To date, over 1100 datasets have been made available on the city's open data portal and numerous applications have been built that address



New York's open data initiative at work after Superstorm Sandy.
Courtesy City of New York.

### 4.1.5 Kenya Open Data

In 2011 the Government of Kenya launched the Kenya Open Data Initiative for the purpose of making government data freely available to the public through a single online portal. Initial

[49] http://www.aidtransparency.net/about#sthash.pkKMqfSB.dpuf

information included the national census, government expenditures and information regarding key public services. According to the website, "Kenya is the first developing country to have an open government data portal, the first in sub-Saharan Africa and second on the continent after Morocco. The initiative has been widely acclaimed globally as one of the most significant steps Kenya has made to improve governance and implement the new Constitution's provisions on access to information. As of November 2011, there are close to 390 datasets that have been uploaded to the site, with a plan currently in place to upload more data over the next year. There have been over 17,000 page views and over 2,500 dataset downloaded and embedded to various websites and portals. There are now over a hundred requests from the public for new datasets, and there is a clear demand for more data to be made available. Kenya's information is a national asset, and this site ensuring that this information is shared. The goal of opendata.go.ke is to make core government development, demographic, statistical and expenditure data available in a useful digital format for researchers, policymakers, ICT developers and the general public."[50]

### 4.1.6 Singapore OneMap Crowd Sourcing

Image credits: FutureGov/ Cat community on OneMap

The Singapore Land Authority (SLA) has launched "OneMap Crowd Sourcing Tools" a set of map-based tools and data services, to support NGO's and other civil society organizations to gather location-based information from the public through their websites. This has been developed in recognition of the value that can be gained in supporting these organizations and where appropriate tapping into their networks of members for supporting their efforts and collecting important information about communities across Singapore. Several organizations are already using the service. The Cat Welfare Society is using the tools to identify locations of concentrations of feral cats for feeding and sterilization. The Accounting and Corporate Regulatory Authority (ACRA) has deployed its "BizQuery service to allow users to find the locations of registered businesses across Singapore. In addition the SLA sponsored a competition to promote creative innovation in the use of OneMap for development of desktop and mobile applications that have included applications to encourage recycling and finding tutors for children, among others. Since its inception in 2013, OneMap has supported 28 agencies from the public sector who are providing 50 information themes and 29 service offerings to Singapore citizens and residents.[51]

[50] https://www.opendata.go.ke/page/about
[51] http://www.onemap.sg/home/

## 4.2 E-merging Frameworks

The fields of planning and development are continuously evolving to meet the demands for sustainable and resilient development in the face of continued population growth, scarcity of resources and the added complications of climate change impacts. This evolution has led to small incremental improvements over time although these improvements don't always extend equally to all segments of society in all countries.

There is currently a convergence of factors that could, if aligned correctly, result in a more accelerated transformation touching more lives across the planet than was ever possible in human history. A significant factor in this transformation is the revolution in technology, communications and data that is quickly connecting and informing even the most remote regions of the world. As pointed out in the previous chapter, governments and organizations need to adopt the policies and design the programs to leverage this connectedness and information flow to the benefit of people, countries and regions. Related to these policies are new ways of thinking about international development, how we set our goals, analyze the "ecosystem" of the issues we need to solve, surgically invest our resources and finances where they can have the most systemic impact, build the capacity of "communities" at all scales to best manage their own sustainable development process, and take advantage of the technology and data revolution to support the achievement of desired future states.

This chapter explores several areas of e-Merging principles and methods that are worth considering in how they may help to shape the BNSDI. This is not a deep analysis of each area but rather a summary and starting point for the conversation that will need to be had in considering the development of the BNSDI Strategic Plan in the next stage of the project.

### 4.2.1 Sustainable Development Goals

The Millennium Development Goals (MDG's) were officially established following the United Nations Millennium Summit in 2000. These were framed around eight globally agreed goas in regards to poverty alleviation, education, gender equality and empowerment of women, child and maternal health, environmental sustainability, reducing HIV/AIDS and communicable diseases, and building a global partnership for development. The target data of the MDG's is 2015, and in preparation for this 192 UN member states agreed at the Rio+2-summit in 2012 to undertake a process of designing Sustainable Development Goals (SDG's) that are "action-oriented, concise and easy to communicate, limited in number, aspirational, global in nature and universally applicable to all countries while taking into account different national realities, capacities and levels of development and respecting national policies and priorities".[52] In mid-July 2014 the UN General Assembly's Open Working Group on Sustainable Development Goals forwarded to the Assembly its proposal for a set of SDG's

[52] UN General Assembly Creates Key Group on Rio+20 Follow-up, Press Release United Nations Division for Sustainable Development, retrieved 26 February 2013

containing 17 goals with 169 targets covering a broad range of issues. Inspection of the SDG's suggests that they are even more comprehensive and data-driven than the MDG's, requiring over 22 proposed indicators that have a geospatial data dependency. Developing the in-country capacity to develop and maintain accurate and timely information regarding these indicators will be important for country development and monitoring of program effectiveness over time.

### 4.2.2 Data Revolution and Societal Information Infrastructure

In August 2014, the United Nations Secretary-General established an Independent Expert Advisory Group (IEAG) on a Data Revolution for Sustainable Development. In November 2014 the IEAG released their report which stresses the importance of high quality data to development decision making. The report recognizes that "New technologies are leading to an exponential increase in the volume and types of data available, creating unprecedented possibilities for informing and transforming society and protecting the environment" [53] Several key recommendations have been framed in the report, summarize here:

- Develop a global consensus on principles and standards. Organization need to cooperate to make their information more aligned and interoperable;
- Share technology and innovations for the common good. Stresses the need for a Network of Data Innovation Networks to bridge the gaps among disparate efforts globally;
- New resources for capacity development. Capacity building for better development, management and use of data needed through direct investment;
- Leadership for coordination and mobilization. Activate a UN-led "Global Partnership for Sustainable Development Data" to coordinate and channel actions and institutions, including the holding of a "World Forum on Sustainable Development Data", and establishment of a "Global Users Forum for Data for SDGs";
- Exploit some quick wins on SDG data. This suggests the establishment of a SDGs data lab" to support the development of a first wave of SDG indicators and developing an SDG analysis and visualization platform.

### 4.2.3 Whole Systems Thinking/ Systemic Action

Experience in addressing the world's development challenges over the past several decades suggests that achieving long-lasting, positive results requires understanding the whole context and addressing challenges at their roots rather than just the symptoms. It is equally clear that the capacity to assess and respond to these issues must ultimately be embedded in the local people, organizations and systems that will drive and sustain positive change over time.

[53] "A World That Counts – Mobilizing the Data Revolution for Sustainable Development, Independent Expert Advisory Group (IEAG) on a Data Revolution for Sustainable Development, November 2014.

The field of "Systems Dynamics" as applied to sustainable and resilient development involves an approach to understanding the behavior of "whole systems" and the complex interdependencies and interactions among the many economic, social and environmental factors systems that make up that "ecology". Armed with this knowledge it is possible to define and implement development interventions, projects and programs that can respond to driving issues while catalyzing systemic impacts across interrelated parts of the system. Development of local capacity as an integral part of each program and project provides local teams and organizations with the perspective, methods, tools and data that they need to manage adaptive change into the future.

***Clinton Climate Initiative (CCI)***. One entity at the forefront of the "Whole Systems" approach as applied to international development is the Clinton Climate Initiative (CCI), a major global program within the Bill, Hillary and Chelsea Clinton Foundation. CCI has recognized that "Climate change may be the most complex systems problem that humanity has ever confronted because the roots of the problem lie in the very structure of our civilization… Access to water, the price of food, agricultural systems, economic opportunity, public health, national security and a certain future are all placed in jeopardy by climate change."[54]

CCI is applying a "whole systems" approach to the development of its programs that seeks to understand the full ecosystem of the most important issues in a country or community, and then to address these issues synergistically at the root of the problems, not just the symptoms. CCI has also recognized the important contribution that emerging technologies can make to the development of new and innovative approaches to solving today's and tomorrow's problems. The organization is in the process of developing a "CCI GeoSmart" program that combines the whole systems approach with new and accessible technological solutions that are right-sized to meet community needs.

Crafting an approach in a way that address people's fundamental needs and desires involves finding solutions to problems while avoiding the patterns that have led to the current situation. "CCI's programs moving forward will be outcome-driven and based on the realization that outcomes are the results of the interactions between the elements of a system. A powerful way to influence the outcome(s) of a system is to identify and activate leverage points: points where intervention in a system can have the greatest impact."

### 4.2.4 SDI 3.0 for Development

The concept of "spatial data infrastructure (SDI)" has been around for nearly two decades now, and many of the underlying principles have been around for even longer. While the formal definitions have not changed substantially with time, there is growing number of

[54] "From Systemic Thinking to Systemic Action – Creating Resilient Communities 2015 and Onwards", Clinton Climate Initiative (CCI) Strategic Plan, October 2014

converging forces that suggest we are approaching a new era that could fundamentally reposition SDI from a framework for sharing information and applications services, to a new "GeoSmart" way of looking at governance and public engagement. These trends are happening worldwide in both developed and developing countries, and today there are more opportunities than ever to configure emerging technologies and respond to perspectives about democracy, societal sustainability and resilience in ways that matter most, if we have the institutional awareness, leadership, and foresight to do so.

A Spatial Data Infrastructure (SDI) incorporates GIS and further facilitates the development of a multi-scale, shared information environment that is analogous to other public-benefit infrastructure such as roads, utility networks and other physical infrastructure. While GIS is a technology and a science, an SDI adds the institutional and governance elements that are necessary for effective and reliable information sharing and coordination across traditional administrative and political boundaries.

Technology provides the technical framework for information sharing, but much of that is often already under development for other more generic purposes such as the computerization of government organizations and the expansion of telecommunications networks in support of economic development and security. SDI leverages those investments to eliminate redundancy, reduce costs of GIS adoption, leverage the investment in geospatial and related data sources, and build channels of coordination laterally across sectors in ways that might otherwise not exist. It also introduces policy and regulatory mechanisms to encourage transparency and community participation while also protecting sovereign prerogative, security, privacy, and intellectual property rights.

With the virtual explosion of mechanisms for the collection and proliferation of information from a wide and heterogeneous field of connected and potentially connected sources from location aware mobile phones, smart infrastructure and buildings, information collecting vehicles, fixed monitoring stations, security apparatus and all manner of "sense networks", many of which are not governed or controlled by any central authority, the field is wide open in terms of how these networks may impact governments and vice versus.

Those involved in the field have looked to leverage SDI international sound practices and shaping these to fit the special circumstances and developmental priorities of developing countries. Both in practice and more generally in the field, the scope and profile of programs has evolved significantly. Major drivers for this evolution include adaptation in response to new technology opportunities and trends and greater awareness among government leaders and managers of the potential application of SDI to substantively improving government services and effectiveness. In parallel there has been a maturing of institutional mechanisms for more effectively leveraging SDI to address major societal issues. This has coincided with a growing recognition that most if not all societal and environmental problems that we face are symptoms of underlying dynamics that cannot be isolated nor treated effectively as separate "sectors", and that more holistic and systemic policies and coordinated interventions

are required to achieve effective solutions. This latter issue is a very major challenge, given that most of our governments, educational, scientific, finance, professional and international finance institution systems are built around sector specializations and there are precious few mechanisms for interdisciplinary, cross-sector engagement and problem solving at the technical level in most governments. $SDI_4D$ 3.0 aspires to fill this gap.

# 5 IMPLICATIONS FOR BELIZE

The development of the BNSDI is in its infancy, but there is strong interest in the community to build and utilize an effective geospatial infrastructure. There is the opportunity to leverage e-Merging technologies and concepts to "leapfrog" the classical notions of an NSDI in a manner that is especially relevant to the Country's requirements and that establishes a regional and international showcase. This section provides some initial ideas of how e-Merging technology issue can support and extend the benefits of the BNSDI. This is not a comprehensive assessment of all implications that may be possible, but rather a starting point for discussions among the stakeholders that can lead to truly new ideas and transformative actions.

## 5.1 Technology Access and Utilization

The government is already taking steps to increase awareness and utilization of ICT both in the urban and more remote rural areas of the Country. Where ICT goes, so can geospatial and there is the potential to use the geospatial dimension to add significant value to the information and services that can be made to the public through this infrastructure. Ideas that could increase access and utilization of the BNSDI include, but are not limited to the following:

- Encourage local manufacturing of low-cost computers with internet connectivity. Low cost components are available internationally, and assembling these into integrated products that are specifically developed and branded for Belize and perhaps the Caribbean could be a viable future manufacturing sector in the Country;
- One laptop per family program. Remote villages and poorer neighborhoods have only have access to computing and the internet through internet cafes and ICT Centers. Providing poorer families with their own inexpensive laptop connected to local wireless internet to be used by the entire family could help to increase awareness and provide a channel to government and other services (see GeoVillage concept later in this document);
- Lobby for lower cost internet in Belize. In a 2014 study of internet costs across 19 countries in the Caribbean, Belize was revealed as most expensive at almost double the cost of the same level of service in other States.[55] Lower cost connectivity at a reasonable speed is an important prerequisite to the adoption and utilization of internet across the country and at the current level could seriously constrain the effectiveness of eGovernment, BNSDI and other e-Merging technologies.
- Encourage private sector services development by providing broad access to government data. Most government geospatial data made available to the public is limited and/or highly generalized. The data currently made available to the public is

[55] http://edition.channel5belize.com/archives/98646

not sufficient to catalyze private sector investment in new products and services. Policies in this area will need further evaluation as the BNSDI grows in the type and extent of geospatial data available that could be leveraged for private sector development.

- Sponsor local and regional hackathons to encourage youth to get involved in e-Merging technology research and development. The government has sponsored technology competitions in schools. These programs could be extended and others created that would include geospatial technology, combined with social media and other e-Merging technologies;
- Establish data sharing arrangements with virtual globe service providers. Providers of online virtual globes like Google, Bing and Esri rely upon data compiled from a variety of sources. The government of Belize could further leverage the benefits of investment in up to date and accurate geospatial datasets by making the appropriate information available to the virtual globe service providers as an ongoing relationship.
- Encourage and support volunteered geographic information (VGI) initiatives. VGI in Belize could tap into the ability and desire of various communities to generate data that is useful to their purpose. The government could gain benefit by encouraging such initiatives, including the provision of BNSDI data resources that are useful to these communities;
- Establish collaborative R&D relationships with imagery and technology providers. Most of the commercial satellite data providers are searching for new and creative ways to apply their imagery. Many of these have large archives of imagery that has never been used. The development of new business models for how imagery is provided could be pioneered in Belize;
- My Location Program. Provide a way for every household or business to receive a GeoSMS reference to their geographic location. That GeoSMS could then be used through both standard and smartphones or any other internet or telephony connected devices to declare a location. This would be especially useful in areas that do not yet have a regular street address, which is most of the Country.

## 5.2 Common Applications Support

The BNSDI will likely host several commonly needed traditional applications that can be incorporated into the business specific applications of any of the stakeholders with access to these services (e.g. Map Viewer or Mobile Mapping Module). In the case of e-Merging technologies and applications there are several areas that may be worth considering in a like manner for common development, including those listed below. This is not an exhaustive exploration of each area, but is rather intended to represent what is possible to act as a catalyst for further conversation, debate and new ideas as the BNSDI initiative moves forward.

***Multi-Channel Access to BNSDI Data and Services***. Optimizing the use of location based social media and applications can benefit greatly from access to useful information through

the BNSDI. Ideally this access would be provided through several channels for accessing data and services, including:

- eGovernment Portal. It would be beneficial for the CITO eGovernment portal to support access to BNSDI map data and geospatial application services. The BNSDI should also support the development of spatially enabled eGov services;
- Website. Information concerning the BNSDI and available map data and services should be provided. This should also support access to authorized data by different segments of users. The site should be programmed for compatibility with use on various mobile and fixed devices and screens;
- Live Chat. The BNSDI could consider the use of live chat capabilities for technical support, taking service requests and responding to request for information from stakeholder entities and the public;
- Mobile. The BNSDI could provide information to be consumed by both government and public mobile applications. This could include the provision of graphical map and location data services to smartphone apps as well as websites that can be accessed from mobile media. In addition to graphical map services, the BNSDI should consider how to support non-smartphone users through the use of GeoSMS, an Open Geospatial Consortium (OGC) developed standard that allows geospatial location information to be communicated through a short messaging service (SMS) between different mobile devices or applications. It may also be desirable to support the use of place names within an SMS as a means of determining a geographic location, and to use this information to support the provision of government services, collect information, and spatially aware location based services without use of a gps-enabled smartphone;
- Social Media. The BNSDI should be linked to all the major social media networks and provide information across those networks, both to build awareness about available data, applications and products, as well as support a channel for crowd-based technical advice and support to the user community;
- Village Kiosk. Over 30 villages in Belize have been equipped with ICT Centers where local persons can access the internet. BNSDI (or eGov) could consider the establishment of other local nodes where such access can be provided for an affordable per-use fee. Local persons could be trained to support such a function, perhaps set up as a microenterprise.

***Belize Locator.*** Many applications across the BNSDI community will require an effective means to identify the location of an asset, incident, request or delivery point without a GPS. A Belize Locator function would access the full range of addresses, place names (gazetteer), points of interest (urban gazetteer), business names, street names, or any other means used commonly by the public when referring to a specific location. Such a function could be supported with data from a variety of data sources within the BNSDI and used as the basis for providing a general geographic location reference without use of a map or GPS. A user of this function within any application would then be able to identify and zoom to that location after choosing from among similar names, if any.

BNSDI could also consider the development of a Belize Place to GeoSMS translator. This would allow a person with a cell phone note equipped with GPS to SMS the Belize Locator service with a place name and have the coordinates of a confirmed reference returned in GeoSMS for use in other SMS based applications.

A Belize Locator should include the ability to crowd-source location reference information. This could include collaboration with OpenStreetMap or other volunteered geographic information (VGI) networks and platforms, and accommodating inputs from GeoSMS, thus building over time a rich source of commonly used place references.

***VGI Belize Server***. The BNSDI could consider the development of a service specifically to support the capture and posting of volunteered geographic information by any community for any (legal) purpose. Service subscribers would be provided with link to a service and provide them with the computing and database services that will allow them to compile and manage information their information. Any subscriber community could opt in to make their information accessible to others, or to maintain that information in a secure environment where privacy is warranted.

***GeoDesign Server***. The engagement of local communities in the planning process is recognized as critical to success. The use of online applications with functions similar to "SeaSketch" can help spatial planners in any sector to carry out their community engagement and planning work more effectively, but has the extra added advantage that community groups can also access and utilize these tools on their own to develop and present additional considerations and ideas.

***Drone Imaging Service Center***. Drones equipped with the hardware and software for site imaging and data collection are especially useful for capturing information for small to medium sites, and for capturing this information as often as needed. A drone platform supports flying low and slow, thus giving the ability to capture very high resolution information. The BNSDI could consider operating a Drone Imaging Service Center to provide this service to government agencies, businesses, property owners and the general public for a fee.

***Geo-Tracker Service***. There are many organizations in Belize that could benefit from the use of low cost geographic tracking devices. These include environmental organizations tracking animals to understand their movements,

***BNSDI e-Merging Technology Innovations Lab***. All of the above e-Merging technology services could be managed through a Technology Innovations Lab. Such a lab could be operated as a service by government, through a public/private partnership, or encouraged as a private enterprise initiative.

## 5.3 Enabling Policies and Incentives for e-Merging Technologies

International experience suggests that government policies regarding information and related matters can have a profound impact on technology adoption and utilization within a country. In general, those countries that have established open data policies and have taken proactive steps to encourage technology R&D and a knowledge-based economy and society tend to be doing better in economic terms than those who have not. The following are ideas for policy and incentive frameworks that could influence the leveraging of e-Merging technologies.

***Open Belize***. Belize has not yet established a focused program around open data principles. The existing Freedom of Information Act and other such policies are well defined but open to interpretation. In many cases it appears that the interpretation by agency managers who control access to information from their organization tends towards a more restrictive stance. The adoption of a specific country-wide policy framework with persistent leadership commitment and follow-up would be needed to overcome this perspective.

***Belize Knowledge Economy***. The Government of Belize has in recent years established the Science and Technology Department within the Ministry of Energy, Science & Technology and Public Utilities (MoESTPU). One of the objectives of that Department is the encouragement of high technology education, research and development within the Country. This will be critical to raising technology awareness and capacity across Belize government and society, which is a critical prerequisite for building a knowledge based economy and leveraging technology to support more effective government operations and services to the public.

## 5.4 Leveraging e-Merging Technology and BNSDI for Government Transformation

More progressive governments around the world are leveraging new and emerging technologies and open data policies as a matter of national importance and priority. Those that are succeeding in moving their aspirations from philosophy to policy to reality are those who are proactively ensuring that the spirit of the philosophy is ingrained into every government agency, policy, program and investment activity and continuously communicated to all types and levels of stakeholders and the public.

BNSDI is one of those policy initiatives that has significant potential to contribute to the achievement of the Belize Horizon 2030 Plan, and beyond. Once fully implemented, it will provide the technical and institutional framework for sharing geospatial information across the entire stakeholder community that can increase efficiency and eliminate redundancy. Beyond this it will also provide the foundation for both executive decision support and crafting of new ways for government agencies and other sectors of society and the public to engage. This latter issue in modern times is not typically constrained by technology, but rather by institutional inertia against substantive change. Overcoming this inertia is the role of leadership.

The following program summaries are ideas and principles that could help to enable the optimization of the BNSDI and e-Merging technologies for meeting the sustainable development goals and aspirations in Belize

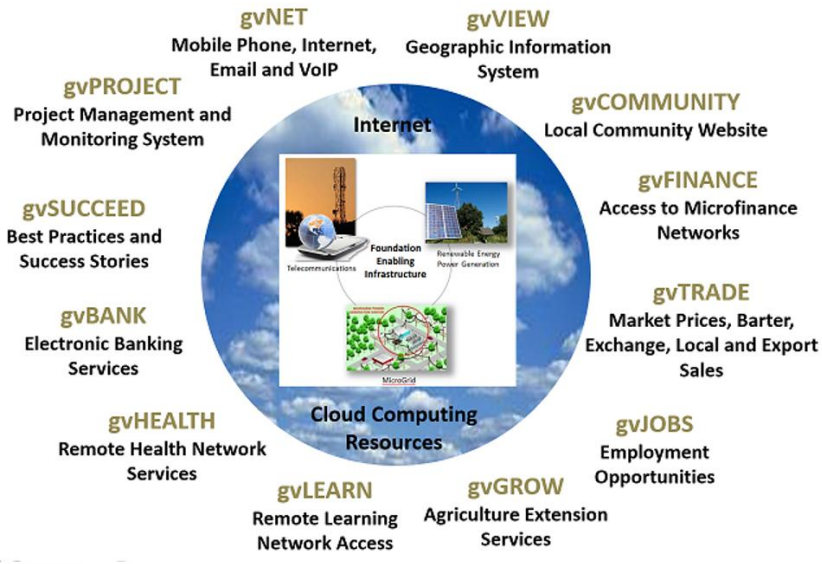
***BNSDI 3.0***. Belize has the opportunity to "leapfrog" the traditional definition of what a national spatial data infrastructure has been to create an updated vision that takes advantage of e-Merging technologies and concepts, thereby increasing the positive impacts and outcomes of the program.

***Belize Smart Government***. The Government of Belize has initiated the development of an eGovernment program and is currently in the policy and strategy development stage. The current draft does not incorporate the geospatial dimension of eGovernment. The BNSDI consultant has reviewed the draft strategy and provided input to MNRA and CITO as to those dimensions of the plan that could be improved with the incorporation of geospatial technology, data and services.

***GeoVillage – Geospatial-enabled eGovernment for the Bottom of the Pyramid***. In development economics, the "bottom of the pyramid" refers to the poorest socio-economic groups in any country who are living near or below the poverty line. In Belize, as in many other developing countries, a significant portion of this demographic lives most of its life in the "informal economy". Most governments are primarily structured to support the "formal" economy and thus often have difficulty in effectively providing the sort of services that are most relevant to and needed by poorer communities. Companies, institutions and a few governments are developing new models of business or social services that specifically target this demographic, and coming up with creative and innovative ways to do so, often using e-Merging technologies.

As addressed in much of this report, advances in recent years in mobile telecommunications, low-cost computing, internet, cloud computing and other technologies has resulted in the evolution of the concept of Information and Communications Technology for Development (ICT4D), whereby these technologies are being used in developing countries. There are many examples from around the world of ICT4D being applied to real-world challenges and opportunities, from SMS-based financial transactions and banking via mobile phones, to access to current market prices of agricultural products for farmers, to access to micro-finance markets for would-be entrepreneurs. However, these have never been treated as an interrelated suite of applications that could be leveraged by government to bring locally relevant services to local communities in a manner that is eminently useful and locally appreciated. In parallel there has also been a recognition of the application of geographic information systems (GIS) technology in support of development issues (poverty mapping, emergency planning and response, economic development, delivery of humanitarian relief and many other areas) and Spatial Data Infrastructure (SDI) as a valid platform for sharing information across government organizations for increased efficiency, transparency, more effective coordination of foreign aid, and other advantages.

While all of these technologies and examples are being applied successfully in many parts of the world, there is a need for the development of locally-based and focused infrastructure and content that can be configured in an integrated framework supporting sustainable and resilient local development at the village scale. GPC Group has developed a concept for such a framework under the name of GeoVillage. This is not a software or product but rather, like SDI, a framework that combines ICT4D, GIS, SDI and related technologies, applications and content in a form that can support many aspects of local community development that responds both to local needs as well as the needs of the international donor community to support better project formulation, management, monitoring and evaluation.




GeoVillage – spatially enabled eGovernment for the bottom of the pyramid.
Courtesy GPC Group

The GeoVillage concept can be developed in a step-wise, incremental manner that is focused around local issues and priorities, and grown over time. With this approach, it is possible to put ICT, GIS and SDI to work for local communities, while also building the local and national infrastructure that is needed for communities and the central government to maximize their natural and societal resources, build a strong economy, protect natural and social heritage, and support sustainable, resilient and equitable development in ways that can make a fundamental difference for the future.

# APPENDIX A - GLOSSARY OF TERMS AND ACRONYMS

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| *APAMO* | Association of Protected Areas Management Organizations |
| *BCC* | Belize City Council |
| *BCCI* | Belize Chamber of Commerce and Industry |
| *BEL* | Belize Electric Company Limited |
| *Bmp CITCO* | Belmopan City Council |
| *BERDS* | Biodiversity and Environmental Resource Data System of Belize |
| *BEST* | Belize Enterprise for Sustainable Technology |
| *BLPA* | Belize Livestock Producers Association |
| *BNCC* | Belize NSDI Coordination Center. Function or unit proposed to provide the facilitation, coordination, promotion and support that is needed to build and operate an NSDI |
| *BNE* | Belize Natural Energy Ltd. |
| *BNSDI* | Belize National Spatial Data Infrastructure |
| *BTB* | Belize Tourism Board |
| *BWSL* | Belize Water Service Limited |
| *CARDI* | The Caribbean Agricultural Research and Development Institute (CARDI) was established in 1975 to serve the agricultural research and development needs of the member states of the Caribbean Community (CARICOM). |
| *CATHALAC* | Water Center for the Humid Tropics of Latin America and the Caribbean (in Spanish ¨CATHALAC¨- Centro del Agua del Trópico Húmedo para America Latina y el Caribe) is an autonomous international organization dedicated to promote sustainable development through applied research and development, education, and technology transfer in the areas of integrated watershed management, climate change, environmental modeling and analysis, and risk management in Latin America and the Caribbean |
| *CBA* | Central Building Authority |
| *CEO* | Chief Executive Officer / Chief Environmental Officer |
| *CCCCC (5C's)* | Caribbean Community Climate Change Center |
| *CIMSS* | Cooperative Institute for Meteorological Satellite Studies |
| *CITES* | Convention on International Trade in Endangered Species of Wild Fauna and Flora |
| *CITO* | Central Information Technology Organization |
| *CRIP* | Climate Resilient Infrastructure Project. |
| *CZMAI* | Coastal Zone Management Authority and Institute |
| *EIA* | Environmental Impact Assessment |
| *ERI* | Environmental Research Institute of the University of Belize |
| *FAO* | The Food and Agriculture Organization of the United Nations leads international efforts to defeat hunger. Serving both developed and developing countries, FAO acts as a neutral forum where all nations meet as equals to negotiate agreements and debate policy. FAO is also a source of knowledge and information. We help developing countries and countries in transition modernize and improve agriculture, forestry and fisheries practices and ensure good nutrition for all. Since our founding in 1945, we have focused special attention on developing rural areas, home to 70 percent of the world's poor and hungry people. |
| *FCD* | Friends for Conservation and Development |
| *FGDS* | Fundamental Geospatial Data Set. This is any data theme or topic that is needed in common across a stakeholder community. |
| *GB* | Gigabyte |
| *GEF* | Global Environment Facility. |
| *GeoNode* | GeoNode is an open-source, web-based application and platform for developing geospatial information systems (GIS) and for deploying spatial data infrastructures (SDI) |
| *GeoSMS* | A standard that allows geospatial location information to be communicated through a short messaging service (SMS) between different mobile devices or applications |
| *GFDRR* | Global Facility for Disaster Reduction and Recovery |
| *GHG* | Green House Gas |
| *GIS* | Geographic Information System. A Geographic Information System is a computer system designed to allow users to collect, manage, and analyze large volumes of spatially |

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| | referenced and associated attribute data. The major components of a GIS are: a user interface system; data base management capabilities; data base creation/data entry capacity; spatial data manipulation and analysis packages; and display/product generation functions. |
| *GoB* | Government of Belize |
| *GPS* | Global Positioning System |
| *HOT* | Humanitarian OpenStreetMap |
| *Hydromet* | Belize National Meteorological Center |
| *ICT4D* | Information and Communications Technology for Development |
| *IICA* | The Inter-American Institute for Cooperation on Agriculture (IICA) is a specialized agency of the inter-American system, and its purposes are to encourage and support the efforts of its Member States to foster agricultural development and rural well-being in their territories. |
| *IoT* | Internet of Things |
| *IUCN* | International Union for Conservation of Nature |
| *LiDAR* | Light Detection and Ranging |
| *LLES* | Limited Level Environmental Study. |
| *Metadata* | Standardized catalog of information about each geospatial data set |
| *MFED* | Ministry of Finance and Economic Development |
| *MFFSD* | Ministry of Forestry, Fisheries and Sustainable Development |
| *MLGRD* | Ministry of Local Government and Rural Development |
| *MNRA* | Ministry of Natural Resources and Agriculture |
| *MoESTPU* | Min of Energy, Science & Technology, and Public Utilities |
| *MoFED* | Ministry of Finance and Economic Development |
| *MoH* | Ministry of Health |
| *MoWT* | Ministry of Works and Transport |
| *Multispectral* | Remote sensing device that records reflected light from the earth's surface in multiple bands of the spectrum |
| *NASA* | The National Aeronautics and Space Administration (NASA) is the agency of the United States government that is responsible for the nation's civilian space program and for aeronautics and aerospace research |
| *NAVCO* | National Association of Village Councils Organization |
| *NCCC* | National Climate Change Committee was established to advise government on issues regarding climate change |
| *NCRIP* | National Climate Resilient Investment Plan |
| *NEAC* | National Environmental Appraisal Committee. The Committee was established to review development projects in the context of the national environment. |
| *NEMO* | National Emergency Management Organization |
| *NFAB* | National Fisheries Advisory Board established to provide guidance on fisheries commodities extraction strategies and policies |
| *NGO* | Non-Governmental Organization |
| *NICH* | National Institute for Culture and History |
| *NMO* | National Mapping Organization |
| *NMS* | National Meteorological Service |
| *Node* | A facility that is connected to other facilities over the Internet for the purpose of publishing and sharing data |
| *NPAC* | National Protected Areas Committee. This Committee was established to advise the government of Belize on issues concerning the national protected area system |
| *NREPS* | Natural Resource and Environmental Sub- committee was established to increase the national understanding and acceptance of the linkages between natural resource and environmental protection and socio-economic development |
| *NSDI* | National Spatial Data Infrastructure. An institutional and technical framework for coordinating and sharing geospatial information across a stakeholder community. |
| *OAS* | Organization of American States |
| *OGC* | Open Geospatial Consortium |

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| *OIRSA* | The International Regional Organization for Plant and Animal Health (OIRSA) is a technical organization established to provide administrative and technical support to the Ministries or Secretariats of Agriculture from its member countries, to protect and develop their agricultural resources in order to achieve a healthy production to satisfy population's demands and provide well-being. OIRSA's assistance is focused on its member countries' projects and plans for plant and animal health, food safety and facilitation towards agricultural commerce |
| *OSM* | OpenStreetMap (OSM) is a collaborative platform for the creation of fee and editable maps of the world by volunteers |
| *QR Code* | Quick Response Code – a type of matrix barcode |
| *QuickStart* | An activity that is an accelerated portion of a longer term initiative, intended to result in near-term, visible and compelling results. |
| *RAM* | Random Access Memory |
| *RFID* | Radio Frequency Identification |
| *SAR* | Synthetic Aperture Radar |
| *SCADA* | System Control and Data Acquisition |
| *SDG* | Sustainable Development Goals |
| *SIB* | Statistics Institute of Belize |
| *SIF* | Social Investment Fund |
| *SISE* | San Ignacio/ Santa Elena Town Council |
| *SIG* | Special Interest Group. A permanent multi-stakeholder body that is established to provide communication, coordination and support around a particular common interest or practice. |
| *Spatial Data Clearinghouse* | Common repository of geospatial information, often composed of data provided by multiple custodians |
| *Stakeholder* | Any organization or person that will be involved in the development and/or use of the Belize NSDI |
| *TBSL* | Total Business Solutions Ltd. |
| *TOR* | Terms of Reference |
| *UAV* | Unmanned Aerial Vehicle (also called a "drone") |
| *UB* | University of Belize |
| *UNCCD* | United Nations Convention to Combat Desertification |
| *UNESCO* | United Nations Educational, Scientific and Cultural Organization |
| *UN OCHA* | UN Office for the Coordination of Humanitarian Affairs |
| *USGS* | United States Geological Survey |
| *VGI* | Volunteered Geographic Information |
| *WB* | World Bank |
| *Working Group* | A temporary body, normally consisting of representative members from multiple concerned organizations, assigned to address a particular subject over a certain period of time |