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## **GIS AND RISK REDUCTION: THE CASE OF JAMAICA**

**Abstract:** Jamaica, based on its geographic location, topography and geology has experienced many natural hazards (e.g. earthquake, floods, storm surge, landslide) that oblige the government to generate new strategies to prevent those events from becoming major disasters. Following the June 1979 floods that devastated sections of the island, the government of Jamaica created a disaster relief organization called ODIPERC. In 1993, this agency became the Office of Disaster Preparedness and Emergency Management (ODPEM) and acquired a wider mandate covering the various areas of disaster management. The ODPEM in its mission statement states its commitment to taking pro-active and timely measures to prevent or reduce the impact of hazards on Jamaica, its people, natural resources and economy.

Recently, to better manage the physical and human environment at the local/national level before (planning, mitigation, preparedness), during (response) and after a (recovery) disaster event, the ODPEM has integrated the use of GIS technology in its operation. Within its GIS activities, GPS technology also plays a pivotal role of collecting data, especially in post-disaster tasks.

The paper highlights the role of the ODPEM in Jamaica, GIS implementation strategy, success, failures, challenges, current and future uses/applications.

## **INTRODUCTION**

Small Island Developing States (SIDS) are one of the countries of the world which vulnerabilities (e.g. medical and financial) and risks from natural/human disasters are the highest (SIDS, 2006). It is clear that in many reports in term of vulnerabilities, the governments of SIDS are facing big challenges (SIDS, 2006). Jamaica, as a SIDS, has experienced many natural disasters in the recent years. The hazards are majority geological and meteorologically related in nature and include hurricanes, floods landslides, earthquakes and droughts. An historic overview of the countries development would not be complete without mentioning the numerous disasters which have affected the country. Most notably the Port Royal Earthquake of 1692 which resulted in a significant change in island's land mass and the Great Kingston 1907 earthquake which resulted in the destruction and rebuilding of an entire city. In June 1979, a major flood event devastated sections of western Jamaica resulting in 40 deaths and economic losses of US \$27 Million (ODPEM National Disaster Catalogue, 2000).

This natural disaster signalled the need for the creation of an agency to coordinate, monitor and manage response to hazards and educate the public on all aspects of disasters. The call for the creation of this agency was strongly supported by the international donor community. The Office of Disaster Preparedness and Emergency Relief Coordination (ODIPERC) was created in 1980 to undertake this mandate. In 1993, the organisation was renamed the Office of Disaster Preparedness and Emergency Management (ODPEM) a statutory body under the provisions of the Disaster Preparedness and Emergency Management Act of the same year. This development occurred during the International Decade of Natural Disaster Reduction (IDNDR), a time when national policy for hazard mitigation was, as it is now, not in place and vulnerability reduction was limited (Jackson, 2005).

The ODPEM in its mission statement states its commitment to taking pro-active and timely measures to prevent or reduce the impact of hazards on Jamaica, its people, natural resources and economy. Appropriately the use of technology would only enhance the organisations ability to carry out its mission. As a result the organisation in the 90's, prior to GIS technology, invested in an Emergency Information System (EIS). This EIS was however not fully utilized by the organisation and subsequently had to be discontinued as a result of Y2K compliance. ODPEM non the less confident of the role of Information and Communication Technology in Disaster Management decided to investment in new technology.

To better manage the physical and human environment at the local/national level before (planning, mitigation, preparedness), during (response) and after (recovery and rehabilitation) disaster events, the ODPEM develop a plan to integrate the use of GIS technology in its operation (Figure 1).

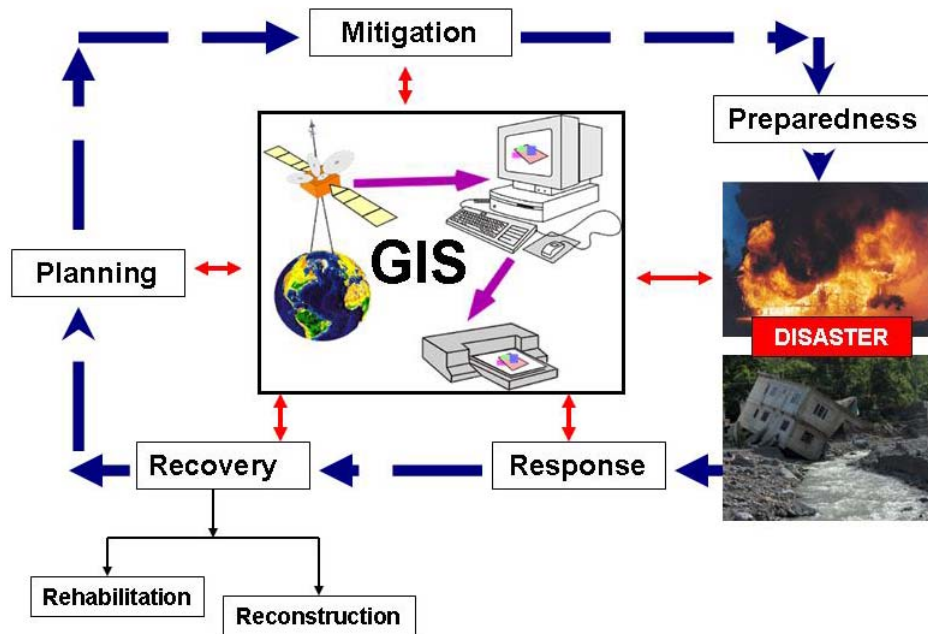


Figure 1. Incorporating GIS in the Disaster Management Cycle.

In 2000, ODPEM made a major shift to GIS technology, which included hardware and software in the form of the complete version of ESRI GIS software, notably ArcGIS (ArcView, ArcInfo), ArcSDE for MS SQL Server 2000, ArcIMS, and ERDAS Imagine (Image processing), 2 GPS Trimble Units, a scanner, a plotter and a computer. This investment was funded by the Inter American Development Bank (IADB), through an Institutional Capacity Strengthening project.

The mandate of developing GIS to support decision-making within ODPEM was given to the Mitigation, Planning and Research Division (MPRD) which consisted of three technical officers with earth science/planning background and no training in GIS. Subsequently officers including representatives from the Information Systems Department were trained (introductory) on how to apply the use of the technology. Consultants were also hired to initiate the development of a Geodatabase whilst undertaking the training of officers. This proved to be unsuccessful for varying reasons including;

1. Officers already had a job description and a core function which did not include GIS.
2. Training did not suit the immediate needs of officers and at times was too advanced.

The organisation was not reaping from its investment and the technology was being underutilized. The management team was cognisant of this and was adamant in integrating the use of the technology in its operations. Recognising that the lack of human resources in the form of trained and dedicated personnel in house and staff attrition was contributing to this underutilisation, the office sought the assistance of CUSO (Canadian Volunteer Agency) through a project.

This project would provide trained personnel in the form of a volunteer for a period of two years. This would have been advantageous to the organisation as the volunteer as part of the requirements required an understudy for training during his/her tenure.

In January 2005, a vacancy in the division created an opportunity for the organisation to solicit an earth scientist/planner with GIS skills and experience. This equipped the organisation with a volunteer acting in the capacity of a GIS Development Officer and an understudy. The organisation then began laying the foundation for implementing the use of GIS in its operations thereby applying the technology's application to Disaster Management. A database model was also created to structure the data in categories to improve the effectiveness and the simplicity of the Geodatabase. The state of GIS technology in the country facilitated the development of this database as relevant datasets were available from different agencies. Coordinating bodies such as the Land Information Council of Jamaica (LICJ) provided a focal point for networking with other professionals and organisations monthly along with satellite images (IKONOS), aerial photography and a Digital Elevation Model (DEM) of the island. As it relates to hazard related data, data exchange agreements were established with technical agencies such as the:

1. Water Resources Authority who were utilising the technology to create floodplain maps and flood inventory maps
2. Mines and Geology Division who were also utilising the technology for creating Landslide Susceptibility Maps and;
3. Earthquake Unit who were utilising the technology for locating epicentres and creating ground acceleration and intensity maps;
4. Unit for Disaster Studies (UWI Mona Campus) who are using GIS and geology knowledge to locate and analyze geohazard and study their impact on the environment.

By acquiring the relevant data sets the ODPEM began to shape the development of a central hazard database for the island, this was complemented with a critical facilities database. The Geodatabase now included various datasets with additional elements such as topography, geology, population etc. which provided the basis for analysis. Though most of the data was already created and acquired through exchange and sharing agreements the ODPEM had to create data sets pertinent to their operations. Such data sets included hazard inventory data which was digitised from existing paper maps and most importantly a shelter database which would enable the organisation and general public to spatially view the distribution of shelters island wide. When ODPEM have obtained all the basic GIS data from other agencies and started his own plan of data collection, the central database has been integrated in a fully ESRI Enterprise GIS.

## **APPLICATION**

The ODPEM has adapted geospatial technology for their specific needs, such as research (e.g. vulnerability ranking system), planning and mitigation programs (e.g. processing of subdivision applications, Public Participation GIS), emergency mapping (e.g. location of incidents, shelters, evacuation routes etc.), and damage assessment (e.g. mapping of damaged areas using GPS). For the purposes of this paper the organisations application in planning and emergency response and recovery will be detailed.

### **Planning**

The Mitigation Planning and Research Division as the name suggests is mandated with carrying out the goals of the Planning and Mitigation element of the Disaster Management Cycle. An element of the activities the division undertakes includes supporting the integration of Disaster Management in the Development Planning Process which would consist of activities such as conducting Hazard Vulnerability Assessments for Subdivision applications and Environmental Impact Assessments. These activities are of course geospatially related and require detailed analysis of various elements which may influence the vulnerability of a particular site usually contained in maps. Prior to 2005 this analysis process was being undertaken using paper maps. The advent of GIS technology allowed for the easy viewing of these maps in the form of layers (raster and vector files) at different scales. It also allowed for more meticulous analysis (query, buffering, spatial interpolation, hydrology) where important features such as fault lines existed, and provided for more detailed analysis from the various datasets which were available such as geology (vector), topography (1:12,500 raster map, 1:50,000 raster map, DEM/Hillshade and Slope (6m), drainage network, satellite images, aerial photography, high risk areas, landslide susceptibility (vector), floodplain maps (vector/raster), flood inventory maps (vector). Visualisations from utilising the technology and the different available layers were also helpful where areas were too large or not humanly accessible.

### **Emergency Response and Recovery**

In July of 2005 the technology underwent its first test since integration into the organisation with the passage of Hurricane Dennis. The NEOC was already fitted with a Lotus based Message Handling application which provided a database for documenting messages received in the NEOC. A free software application known as HURREVAC2000 was introduced along with GIS technology to the NEOC. HURREVAC is a restricted-use computer program used by official government emergency managers since 1988 to track hurricanes and assist in decision-making for their communities (Hurricane, 2006). HURREVAC basically displays the projected and actual path of a tropical storm or hurricane on computer plot maps using real-time information from the National Hurricane Centre (Hurricane, 2006, (see fig. 2). Advisories contain information on present and forecast position, intensity, size, and movement that is displayed by HURREVAC (Hurricane, 2006). The application allows for GIS integration as it

allows you to measure the distance between points, export storm path, wind speed and forecast data in shapefile format.

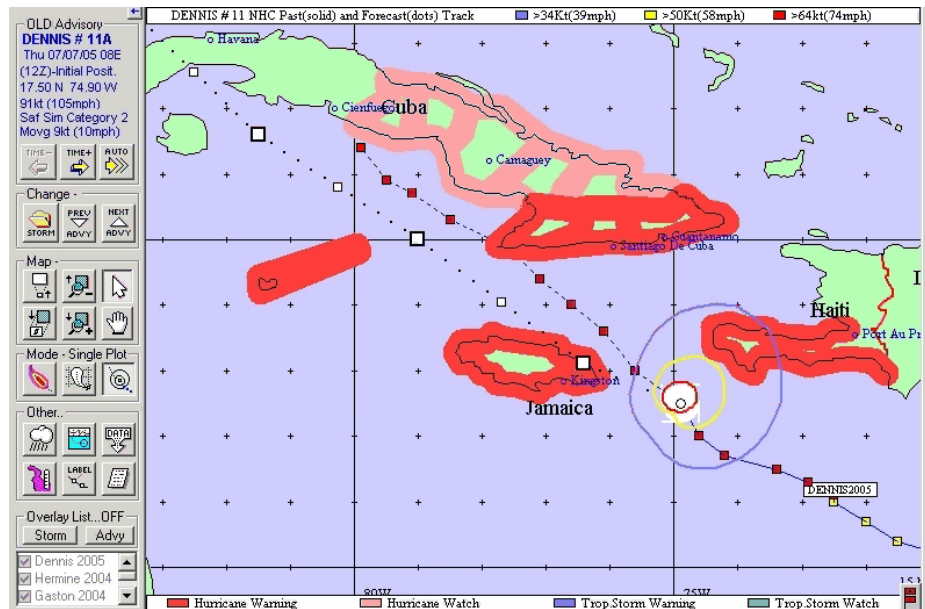


FIGURE 2. HURREVAC interface with hurricane Dennis path in July 2005.

Prior to the event, data extracted from HURREVAC showing the projected path and the hurricane's intensity (Category 1, 2, 3, 4) was used to compare previous hurricane/tropical storm information (e.g. Storm Surge map of Hurricane Allen in 1980). This data along with the Digital Elevation Model (DEM), high risk areas and population dataset, allowed for the simulation of areas likely to be affected by storm surge and estimate the possible number of persons (e.g. vulnerable persons: under 15 years old, over 65 years old) that would be displaced and areas which warrant evacuation.

During the event, ArcMap (customized interface) was used to provide an updated database and spatial representation of reported events from communities that were affected across the island whether by flooding or landslide (figure 3). A customized interface was developed in ArcMap 8.3 to improve automatic tasks and integrate information using forms and simple functions. The functions included are: creating a new incident file (e.g. for Hurricane Dennis 2005), re-projecting vector data, zooming to a community/road, saving incident information and producing a summary of communities affected by Parish.

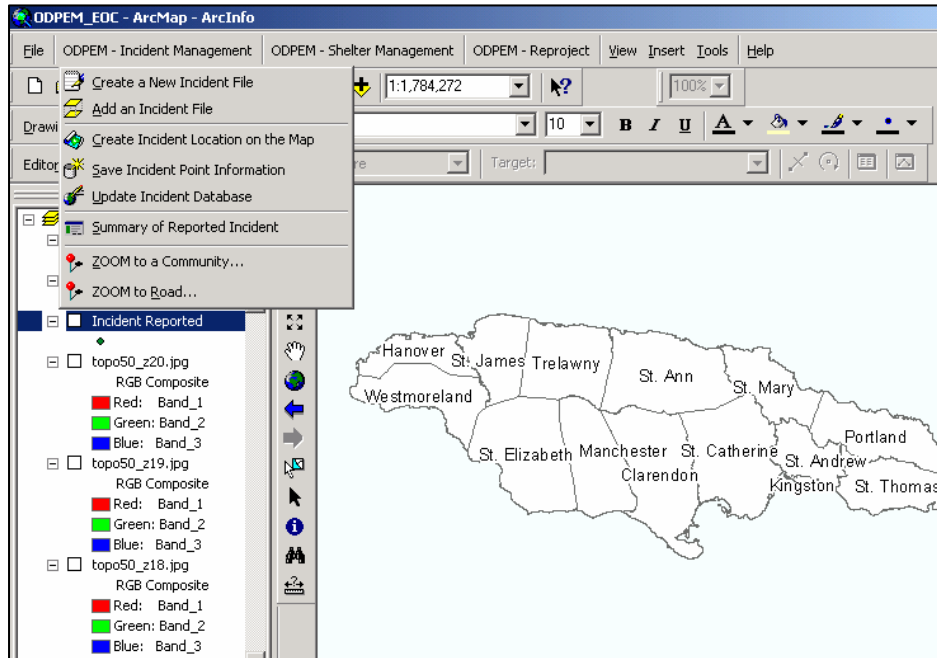


FIGURE 3. Customized interface in ArcMap 8.3 for the NEOC.

The Shelter database was updated to show the number of persons in shelters across the island and their status (close, open) over the period of the NEOC's activation (see fig 4). Maps showing the location of communities that were affected by the passage of Hurricane Dennis and Shelters that were occupied during the hurricane (see fig 5) were constantly updated and appended to situation reports that were issued on a timely basis to media key personnel and agencies.

NAME	PARISH	COMMENTS	OCCUPANTS
Mitchell Town Primary	Clarendon		1 person
Seaforth Primary	St Thomas		24 persons
Seaforth High	St Thomas		230 persons
Trinityville Primary	St Thomas		7 persons
Paul Bogle Junior Hight	St Thomas		60 persons
Hillside Primary	St Thomas		70 persons
Morant Bay Primary	St Thomas		50 persons
Cedar Valley Primary	St Thomas		54 persons
Breadnut Hill Primary	St Ann		10 persons
Tower Hill Primary	St Andrew		12 persons
Golden Valley All Age	St Andrew		12 persons
Bog Walk High	St Catherine	no problem reported to date	22 persons
Old Harbour Bay SDA Church	St Catherine	location not accurate	4 persons
Point Hill Community Centre	St Catherine	location not accurate	7 persons
Happy Grove High School	Portland		35 persons
11 Mile Community Centre	St Thomas	location not accurate	20 persons
Portland Cottage Community Centre	Clarendon	location not accurate	57 persons
Yallahs Primary	St Thomas	Close 8 July 15h07	61 persons
Yallahs High School	St Thomas	Close 8 July 15h07	5 persons
Barkers Lodge Primary	St Thomas		5 persons
Nain Primary and Junior High	St Elizabeth		2 persons
Black River Primary	St Elizabeth		7 persons

FIGURE 4. Database associated shelter's occupied during Hurricane Dennis.

After the passage of Hurricane/Tropical Storm, this database will serve as a basis for providing historical information on the event. It will also be useful for further analysis in terms of providing spatial representation of damage caused, planning the field assessment work and also providing baseline data, which will be useful in the processing of subdivision applications and vulnerability assessments. Finally, the geospatial database will be used to transmit information to the public, disaster coordinator and partner agencies by integrating them in situation reports (figure 5), the final damage assessment report and in the future, into a Web Mapping application which will be linked to the ODPEM's web site.

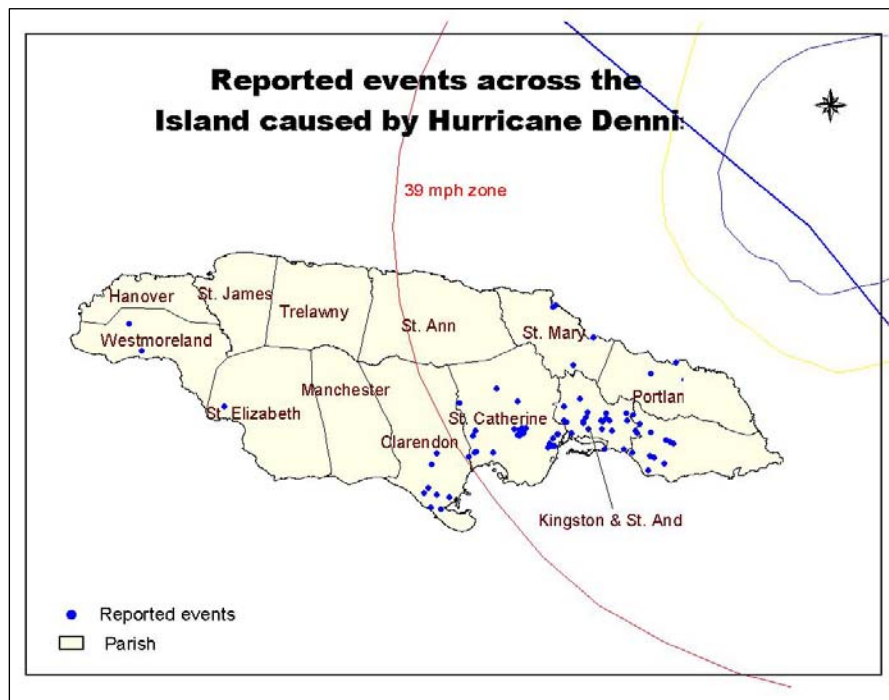


FIGURE 5. Map in a situation report showing communities affected by Hurricane Dennis and integrating the output from Hurrevac.

In 2006, the organisation through project funding invested further in hardware in the form of four (4) computers, two (2) GPS units, and a central server unit for housing data. This investment formed the basis for the training of staff and sustained use and development of GIS in the organisation. Training was undertaken by the GIS Development Officer and in some cases was assisted by the Planning Analyst (GIS experience). As such training was done to suit three different personnel based on their GIS background and technical expertise and function in the organisation. Training sessions targeted a selection of staff members from Information Systems Department, Corporate Services and the Management Team geared at introducing these members to Basic GIS. MPRD Officers (earth scientists/planners), who were more familiar with the technology

and software and finally the Planning Analyst who was understudy to the GIS Development Officer. Manual guides, tutorials and exercises which cover topics such as Introduction to GIS in Disaster Management, using ArcMap in Disaster Management, creating/editing data/metadata in ArcSDE, utilizing GPS device.

After realising the capabilities of GIS Technology in just two years the ODPEM is seeking to further utilise the application of the technology in its Disaster Management operations. The organisation recognises the importance of dedicated human resource personnel for the sustenance of its GIS Program. The organisation is therefore committed to developing a formal GIS unit to support its risk reduction efforts in Jamaica. In 2005, the government approved a Hazard Risk Reduction Policy. This policy explicitly stated the importance and support of GIS as a tool for achieving the goal of Risk Reduction. The ODPEM also recognises the need for a multi-agency approach towards achieving this goal. This multi-agency approach will see the specialisation of GIS activities in agencies already undertaking work related to specific hazards. The ODPEM will then undertake the role of a coordinating agency thereby merging all hazard related data with a view to establishing a multihazard database for planning and mitigation purposes. The ODPEM recognises that as part of fulfilling its mandate the transfer of knowledge to the public is integral. As such in the future the organisation hopes to implement web mapping by publishing maps on the web through the organisations website. Finally, the ODPEM hopes to improve its damage assessment capabilities through the use of remote sensing. The International Charter "Space and Major Disasters" aims at providing a unified system of space data acquisition and delivery to those affected by natural or man-made disasters through authorized users (International Charter "Space and Major Disasters", 2006). For example, in 2004, during the Hurricane Ivan in Grenada and Hurricane Jeanne in Haiti, the International Charter combined with the United Nations Office for Outer Space Affairs (UN/OOSA) and provided assistance in disaster management and produce maps of the most affected areas (UNOSAT, 2006; United Nations Office for Outer Space Affairs, 2006). As for Jamaica, an agreement with United Nations Development Programme (UNDP-Jamaica) and United Nations Office for Outer Space Affair (UN/OOSA) on the International Charter "Space and Major Disasters", has been created with the assistance of ODPEM to provide updated satellite imagery to support recovery and rehabilitation after a major event.

## **CHALLENGES**

Since 2005, ODPEM has been able to improve its functions through the use of GIS in its operations, but it has not been done without any challenges. In a nutshell the challenges being faced by the organisation can be summarized in the categories of human/technical (including training) and financial resources. Since the inception of GIS in its application to risk reduction in Jamaica (dates as far back as the 1990's) the lack of trained and qualified individuals has hampered the development and use of the application in Jamaica. Staff attrition and the lack

of specialised user training to facilitate knowledge transfer has resulted in the initiation and use of GIS in hazard related applications and limited and discontinued use of the technology. The lack of a dedicated division/unit towards performing these activities in the case of ODPEM could be identified as one of the main hindrances towards its development.

Though use of the technology in Jamaica may be viewed arguably as being quite popular, the discipline is none the less technical in nature and the demand for these professionals outweighs available supply. Jamaica as it is a third world developing country competing in a global and regional economy is faced with the challenge of limited financial resources. As such the budgetary allocations for development of GIS Departments and remuneration for GIS professionals act as a limitation for the growth and success of GIS in Risk Reduction. Maintenance costs associated with software packages has also been a proven hindrance and will continue to fester in the future, placing organisations in debt and limiting their access to current versions of the software. Migration to other software packages will also require a comparable initial investment backed by training and evaluation of such packages.

## **CONCLUSIONS**

Successful implementation and maintenance of a GIS Program is dependent on the establishment of partnerships to facilitate knowledge transfer, data sharing and exchange. In the case of Jamaica the Land Information Council of Jamaica (LICJ) provided a platform for the development of these partnerships.

Trained/dedicated personnel is integral for sustenance of GIS development this was evident in the development timeline of ODPEM which saw inception in 2000 and success in 2005 (one year) after dedicated personnel was charged with the responsibility of applying the use of the technology in Risk Reduction.

International Aid in the form of Projects provided a source of funding for the initial investment in terms of software and hardware and also human resources (CUSO – GIS Development Officer) for implementation. This assistance may however be limited to developing countries. It should however note that this approach is only successful for inception of the GIS development projects. Maintenance of the program is dependent on the client's (organization's) investment in both human and financial resources for its sustenance. Investing in local well-trained human resource and in Free Open Source solutions in GIS are also other avenues which countries can look at for a long term development (Gignac, N., 2006).

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