DESIGNING A GIS TO MEET REAL NEEDS IN THE MALDIVES

Mohamed Shafee
Head, Spatial Planning Section,
Department of National Planning
Ghazee Building, Ameer Ahmed Magu, Male', Maldives

Dr. Kevin Lim, President
Lim Geomatics Inc.
264 Catamount Court, Ottawa, Ontario, K2M 0A9, Canada

Dr. Robert Ryerson, CMS, FASPRS, President
Kim Geomatics Corporation
(Corresponding author)
Box 1125, Manotick, Ontario, K4M 1A9, Canada
bryerson@kimgeomatics.com

Mr. Ihsan Sadiq
Senior Planning Officer
Spatial Planning Section,
Department of National Planning
Ghazee Building, Ameer Ahmed Magu, Male', Maldives

Ahmed Rasheed
Senior Analyst Programmer
Spatial Planning Section,
Department of National Planning

ABSTRACT

The Government of the Republic of Maldives has received financing from the International Development Association (IDA) toward the cost of the Maldives Environmental Management Project, part of which was to develop a National Geographic Information System (NGIS) Strategic Framework and Implementation Plan. The development objective of the project is to strengthen the capacity for environmental management in the Maldives, by addressing some of the human resource constraints and informational impediments to improved environmental management.

This paper presents the approaches used to overcome the many hurdles that were faced to develop the Strategic Framework and Implementation Plan. While the many challenges of designing an enterprise GIS to meet the real needs of small-island nations have been reviewed in previous papers, this project faced additional issues. To the challenges of dealing with national as well as local issues and operating with limited budgets, the situation in the Maldives was further complicated by a general lack of expertise in GIS, limited education in the field, virtually no existing system capability in the field, and a user community that generally lacked practical experience. This paper describes how all of these countervailing forces were seamlessly managed by the team so that the solution was made by and for the citizens of the Maldives. The description of the approaches used to develop the solution forms a useful guide to the development of a Spatial Data Infrastructure in the development context.

Key Words: Islands, development, GIS, The Maldives

INTRODUCTION

The Government of the Republic of Maldives (hereafter referred to as the Maldives) has received financing from the International Development Association (IDA) toward the cost of the Maldives Environmental Management Project, part of which was to develop a National Geographic Information System (NGIS) Strategic Framework and

Implementation Plan. The development objective of the project is to strengthen the capacity for environmental management in the Maldives, by addressing some of the human resource constraints and informational impediments to improved environmental management. The result of this project was a detailed implementation plan and system specification for which requests for proposals have already been solicited.

The next section of this paper provides some background to the Maldives, while subsequent sections detail the challenges to implementing a national GIS and how they have been met by the project team. Taken together the challenges and solutions provide a useful road-map to the design of a spatial data infrastructure in the development context.

THE MALDIVES: AN OVERVIEW

The Maldives is an island nation consisting of a series of 26 atolls straddling the equator in the Indian Ocean south west of the tip of India. There are an estimated 1,192 islands, of which 193 are inhabited (Ministry of Planning and National Development, 2008). The area of the country is 859,000 sq. km., of which over 99% is the sea. The total land area is about 300 sq. km. While the total area of the atolls and reefs is open to some interpretation, the official estimate places it at approximately 21,300 sq. km. The largest island (Gan) is 5.16 sq. km.

The low-lying islands are on average one meter above sea level. Ring-shaped coral reef structures provide a natural defense against wind and wave action. However, with its low-lying islands, significant storm or other events, such as the December 2004 Indian Ocean Tsunami can be devastating. The Tsunami caused the loss of 100 lives and enormous damage to the country, rendering 14 islands uninhabitable and leaving 79 islands without safe drinking water. The spirit of the people is seen in how the nation has rebounded from the loss to rebuild a vibrant tourist industry and how it has prepared and is preparing for the future. Part of that future preparation is the development of a national GIS with the support of the government and industry.

The islands have been inhabited for over 3000 years and being on an important trade route, its people and their culture and religion reflect the nature of the many visitors from Asia, Africa and the Middle East. The population is 300,000, of which over 1/3 live on the capital island of Male. The challenges faced by the country include the usual island issues such as erosion, environmental protection, and the like. In the case of the Maldives, an even more pressing concern is climate change – especially global warming. Even a one or two meter rise in sea level will, in effect, inundate the entire country. The challenges facing the development of a national GIS are detailed in the following section.

COMPLICATING FACTORS IN IMPLEMENTING A NATIONAL GIS

Island nations and states face different needs and issues from larger countries. We have already mentioned the issue of climate change and rising sea levels. A number of other issues and problems have been listed by others (Atwood *et al*., 2009). In the case of the Maldives, these include the same myriad of national issues that geospatial data and technology address in developing and developed countries alike: housing provision, regulation of commercial development, encouragement of economic development, protection and enhancement of natural resources, census management, public safety, border/coastal security, hazard assessment and management, marine resource management (e.g. mangroves, coral and fisheries), transportation infrastructure development, and utilities/telecommunications infrastructure. Small island nations have further responsibility for monitoring, policing and managing extensive ocean resources (Atwood *et al*., 2009). It should come as no surprise that the only GIS routinely used by the Government in the Maldives is being used in the Coast Guard.

Small nations must also address and manage their national issues at a *local* level. Data must be collected to a local scale and efforts carried out on the ground – and in the water. This has implications for legislation, policy, and human resource management and provision, in addition to technology implementation and project management. The small population usually means that there is a limited talent pool and, in some jurisdictions, including the Maldives, to gain much needed skills in geospatial data management, overseas travel is required for training and professional development opportunities. Further complicating the human resource shortage in the Maldives is that post-graduate training often means promotion out of the technical area in which the professional has been trained.

As noted by Atwood *et al*. (2009), together these factors place a strain on financial budgets for geospatial work in small nations. Local government-sized budgets can be inappropriate for addressing national issues and often

development aid can leave the country's geospatial program in limbo if funding dries up or is redirected to other projects: achieving sustainability is essential.

While these institutional and what we would call geography- or environmentally-based factors are important, there can be a number of other issues or challenges that can be listed. These include:

- There is usually no information available on the type and range of information already available;
- Who owns what data and what systems is often unknown;
- Who knows what about GIS and what training has been taken is usually unknown;
- Who has what practical experience is unknown, as is the true level of that experience;
- There is usually a limited understanding of the value of the technology – from the working level in the user community to the most senior political level;
- At the same time as there is limited understanding, there are usually some unknown pockets of expertise;
- The importance of standards and consistency in data and metadata is not widely known;
- Knowledge about what systems are needed often comes from system vendors or from students who used a particular software at university;
- In some jurisdictions illegally obtained software may be used;
- What geospatial information that does exist is often found in silos and is inaccessible to those in other departments. This often leads to needless duplication;
- There are no standards (or no consistent standards) for the geospatial data that are collected;
- There has usually been no strategic planning on the uses of the data – what is important and what isn't;
- There is no one group with responsibility for geospatial data;
- There is often confusion about what responsibility for geospatial data means;
- There is usually no coherent geospatial data policy;
- The implications for the people involved and the need for change management is often overlooked;
- Where a consulting assignment is to be carried out to design a system, all too often the Terms of Reference fail to consider the many factors noted above. They tend to deal with hardware, software and training – largely ignoring the policy and strategic implications associated with attempting to build a sustainable system.

To address these challenges the consulting team and client country project team developed an approach to the creation of an implementation plan to build a national GIS to meet real needs. This approach is described in the next section.

AN APPROACH TO THE CREATION OF A NATIONAL GIS AND SPATIAL DATA INFRASTRUCTURE IN THE DEVELOPMENT CONTEXT

Introduction

The creation of a GIS that will be both sustainable and useful in the development context is not something that just happens. It requires a delicate blend of in-country expertise and commitment, a broad range of expertise on the part of the consulting team, and a commitment on the part of the funding or donor agency. This section provides some of the background experience brought to bear on the problem and then describes how the project was approached to eliminate or minimize the negative impacts of the various challenges that were faced. The limitation to the length of this paper prevents us from providing complete details of each facet of the approach.

Past Experience

We had the benefit of considerable experience on our team gained in work in over twenty developing countries. Previous research on what makes a remote sensing project work by Ryerson and Quiroga (2000) examined over 200 remote sensing projects in developing countries. As a sister discipline to GIS, the results of this study are germane here. They concluded that "successful projects seem to share the following operational and institutional characteristics:

- There was some previous experience with satellite or other remote sensing imagery;
- There was a clear focus;
- There was a combination of experienced researchers and bright innovative younger scientists involved in the project;

- There was great attention to detail – technical and financial;
- There was a basic understanding, either explicit or implicit, of the economics of the use of remote sensing for the specific application;
- There were close ties to real users with the interest, dedication, and ability to sustain the work;
- There were close personal ties to scientists in the developed-country sponsor;
- Training, personal ties, and the experience noted above resulted in the development of confidence and a lack of fear of failure on the part of the in-country project leaders;
- There was an entrepreneurial "can-do" spirit;
- Institutional reform/innovations are needed to ensure that the benefits of a new technology reach the target group. Specifically, institutional infrastructure is the key factor in successful technology transfer."

To the understanding provided by this analysis, we also had the benefit of the experience gained on the importance of data policy development in Thailand (Ryerson and Peanvijarnpong, 2007). Lessons learned and experience gained in Bermuda, another small island state, were also instructive. In Bermuda, the same consulting team used a needs-based approach for the development of the Spatial Data Infrastructure strategy. The consulting team worked with the Bermudians to determine their needs, and then the stakeholders in Bermuda carried out a strategic planning exercise facilitated by the consulting team. In summary, work involved pre-visit fact finding, an on-line questionnaire, a Strengths, Weaknesses, Opportunities and Threats (SWOT) Analysis, all of which were used to instruct on-site interviews, leading to a strategic planning workshop, and a report. (Atwood *et al*., 2009)

The following subsections introduce the approaches used to deal with the key issues and challenges.

Thorough and Well Written Terms of Reference for the Project

While having a thorough, well written and easily understood terms-of-reference (TOR) document would seem to be an obvious requirement for a successful project, like common sense, such a TOR is not that common. For the Maldives, the context of the work and background to the project was clearly explained, as was the need for information and what it would be used for, the challenges that would be faced, and the existing organizational structures. The eighteen anticipated tasks were listed under four headings: (1) review of lessons learned elsewhere; (2) review of existing assets and resources; (3) development of technical standards for implementation; (4) provide strategic advice and reporting. Of particular importance was the emphasis on the need for a strategic framework, the type of advice that was anticipated, and the long term goal of sustainability. That the TOR was written by people in the Government of the Maldives provides a useful lesson for others. Like the formation of a national strategy, such tasks are best left to those with a close and personal stake in the result.

With such a clear document it was then possible for the consulting team to develop a detailed work plan that was reviewed and modified by the in-country personnel. The Work Plan showed what would be done, by whom, and when. The clarity of the resulting contract led to a positive and continuing relationship between the contractors and those from the Maldives on the project team. This paper is a manifestation of that relationship.

A Willingness to Learn from Others

An oft-quoted comment from one of the consultants in this project was: "some-one somewhere has probably done it and you can learn from their successes, and especially from their mistakes." That the TOR began with the requirement that lessons learned elsewhere were to be reported on at the outset was an indication that the local members of the Project Team were willing to learn from others: there was to be no re-inventing of the wheel. At the same time, it was made very clear that the solution developed would have to meet the needs of the Maldives and could not be a simple adaptation of something that worked in a developed country with different needs and concerns.

Appropriate Mix of Managerial and Technical Experience in the Consulting Team

One of the recurring problems or issues encountered in other projects which have been reviewed by the team, and referenced above, is that of an inappropriate mix of managerial and technical experience. To work at the national level in development projects obviously requires experience in the developmental context. But it also requires an understanding of management in government and experience in dealing with the senior bureaucratic and political levels. This sort of experience, essential to obtain senior level "buy-in," is rarely found in technically oriented GIS experts. Furthermore, dealing with strategic planning, change management and broader issues of national policy, including security and the requirements of the military and police, is another set of skills rarely found in the technical GIS expert. At the same time, those with experience in the senior levels of government and

these other more strategic areas rarely have a completely up-to-date understanding of the finer nuances of the technology. In some cases, cross-cultural understanding is an added important issue, although in this case the international experience and education of everyone on the Maldives side eliminated this as an issue.

The consulting team was led by a senior consultant with expertise across management, development, strategy formulation and policy. The technical side was managed by a highly experienced technical consultant with some experience in dealing with senior levels. The team was rounded out by a management consultant in strategy formation and change management and, lastly, a data collection specialist. This balance resulted in the completion of the tasks in a seamless and consistent fashion in all of the important requirements of the activity.

Pre-visit Data Collection and Research

For many assessments of technology needs and uses in the development context, consultants arrive in a country and begin to collect information. This is often done through conducting on-site interviews. In the case of collection of technical information, this can be a labor intensive and difficult task. Many of the technical details being sought will be found in different parts of an organization or with different people within the organization. In effect, the consultant starts with little knowledge or understanding of the situation. This is especially troubling when, in most cases, the consulting team is expected to meet first with senior level people including the political level and have something coherent to say about the situation in their country.

In this project, this problem was overcome through a thorough pre-visit data collection and research activity in which the client was involved. We began with the study of published materials on the Maldives – both those provided by the client and those obtained independently. We also studied major issues being faced (to validate the TOR), and policy statements from the Government. Using experience gained in Bermuda, the Project Team then developed an on-line questionnaire to elicit information on technical capacity, gaps, education, use of data, data policies, strategic data sets, etc. The questionnaire contained a total of over 75 questions with as many as seven to ten sub-questions. It was administered to seventeen people using an on-line survey tool after it was approved in advance by the client to ensure that the wording and language was understandable. In some cases, several people from one organization completed the questionnaire that was sent to one individual.

With the responses (and in some cases lack of responses) and our analysis, we began to build an idea of what would constitute basic and required information (framework data) to meet the Maldives' needs, begin a SWOT analysis, and inform the site visit to make the most of the limited time "on the ground." And perhaps as importantly, it prepared the people in the Maldives to better understand what we were attempting to accomplish. An important component of the pre-visit work was the development of an understanding of the data management environment which in turn allowed the technical members of the consulting team to begin to provide an analysis of the technical limits of a GIS in the Maldives. This information played an important role in the eventual strategic plan. We estimate that to reach the same number of people in interviews with the same level of detail would have taken an additional fifteen days on site, including time to code the responses and do the analysis. The savings in hotel and consulting fees were used to broaden the team and provide more analysis and more in-depth workshops.

Senior Bureaucratic and Political Support

Senior bureaucratic and political understanding and support are obviously essential to the implementation and sustainability of a national GIS in the development context. Without such support across a number of ministries, the sharing of information (and costs of doing so) would not be possible. With the pre-visit preparation the Project Team had a clear idea of where there was already interest and activity, and where there was little or none. With a clear picture of the issues in each department and each department's knowledge and understanding of geospatial data, the consulting team was able to better prepare for each meeting. During that meeting, the senior consultant would outline the benefits to each department in terms that they would understand, while seeking support and further information. These discussions highlighted the benefits of involvement while reassuring Ministers and senior bureaucrats that they would maintain control of their information while at the same time gaining credit by having it used more widely, as well as gaining access to other information from others that they might need. Since the level of understanding of geospatial at senior levels ranged from almost nothing to an individual with a Ph.D. in remote sensing, such preparation and understanding was essential.

With senior level support assured, further meetings were held at the officials' level to seek clarifications and their interest and support for the workshops that were planned to develop both data policy and a "Made-in-the-Maldives" strategy.

A Clear Approach to Strategic Planning

Strategic planning was recognized to be a key element in the implementation of a national GIS, and was specified as such in the TOR and Work Plan. But before we could get to a common strategy it was decided that since there was no common data policy, a workshop on data policy should be held to develop a geospatial data policy that would naturally lead into a strategic planning workshop.

The data policy workshop was developed using the Data Policy Framework that has been reported on and used elsewhere (Ryerson, 2005; Atwood, *et al*., 2009; and Ryerson and Peanvijarnpong, 2007). The data policy workshop was used to both develop a data policy and to start to build a sense of a geospatial community both across government and the broader community. The workshop attendees included government, NGOs, and industry. Knowledge and experience in the field of GIS and geospatial ran from negligible to a Ph.D. (ABD) in GIS. A data policy was created and has subsequently been submitted for approval by Government.

With the beginning of a sense of community, the next step was to hold a data policy workshop. A commonly accepted approach to strategic planning was adopted and modified for the Maldives. With general support secured from the political and senior bureaucratic levels and the working levels, a one-day workshop was planned to develop a common language and understanding of what was needed and what the GIS would do for the Maldives. At the workshop the core values that provided some of the context for the strategy were modified and accepted, and the strategic drivers that had been developed were refined and these too were accepted. Participants came from virtually all of the ministries of Government including the Office of the President. In what was later characterised as a thoughtful and lively discussion, a strategy emerged. The following is taken directly from the resulting report.

The primary objective of the technical assistance (as taken from the contract for this work) is "to expand the knowledge base regarding critical natural resources on which the Maldives ecosystem and economy depend." The GIS development with which we are concerned will integrate the environmental information that is collected, and allow that information and other social and economic information to be overlaid. Then all of this can be used as overlays and in modelling to better support the decision making process.

The strategic/vision drivers that were developed in the strategic planning workshop tracked directly to the objective stated above. A GIS is needed to provide information that can be used to meet the end goals of:

- Sustainable economic development in both tourism and fishing;
- Ensuring safety and security for both tourists and the people of the Maldives;
- Provision of health and medical services; and
- Management of marine and terrestrial resources.

It was envisioned that resources, as outlined in the future state for many of the vision drivers, will be better managed if two major goals are achieved:

- Effective use of new GIS technologies and the fostering of a local knowledge-based approach to its use; and
- Development of the policies and procedures to acquire and share information across government and with other partners, both in the Maldives and internationally.

To achieve these major goals, a strategy framework was proposed with four focal points:

- Developing a new way of doing business which focuses on the expanded use of GIS in the Maldives;
- Building a sustainable, relevant, responsive institutional framework to support the use of GIS technologies;
- Developing a coordinated approach to data capture and integration; and
- Building a national geo-capability available to everyone.

A Dedicated Core Geospatial Group In-Country

A dedicated core group within the government, eager to implement an effective GIS within the country, is believed to be an essential ingredient in developing a successful national GIS Program. In the case of the Maldives, the Spatial Planning Section in the Department of National Planning was given this role. The limits to this role have been clearly specified – users and providers of geospatial data retain their responsibilities. In effect, the Spatial Planning Unit has the responsibility for the GIS system hardware and software and its maintenance, and has what may be considered to be the role of a maintainer of standards and gate-keeper for geospatial data within the country. With the way that the National GIS has been introduced, and the way in which it has been explained across government, the Spatial Planning Unit has not been seen as a threat to those making and using geospatial data. The fact is that the Spatial Planning Unit will be helping others do their jobs better, and this fact has been recognized by the players across government.

Desire to Work Together to Succeed

One of the secondary (and yet very important) outputs of the Strategic Planning Workshop was the beginnings of what has since become the GIS Technical Committee for the country. Over the development of the project the Spatial Planning Unit and the consulting team has focused on showing a genuine desire to work together with everyone across government to succeed. With support from the senior levels within government (from the offices of the President and virtually all of the Ministers and senior officials), and with the success of both the data policy workshop and strategic planning workshop, support within the data supplier and data user communities has grown. A community has developed with all that that implies. The challenge in the coming months will be to manage expectations and continue the dialogue within the growing geospatial community to ensure that support remains strong.

Awareness in the Community of the Value of Geospatial Information

Awareness of the value of geospatial information is seen as one of the keys to ensuring that support continues. With the advanced preparation and workshops, awareness of the value of geospatial information within the community of users has been developed. Similarly, there is a level of awareness within the political level and senior levels of the bureaucracy. One of the additional activities related to the GIS Project to foster such awareness was a workshop on Change Management conducted by the consulting team – to re-enforce the importance that the new GIS will bring. Awareness within the broader community has also been addressed. One of the first elements of that has been the release of the *Official Atlas of the Maldives* (Ministry of Planning and National Development, 2008). As momentum was building, during the period of the consultancy, a public lecture given by the senior consultant was attended by a broad range of the public – from school children to Cabinet Ministers. Over a period of weeks, several television interviews were also given by the consulting team leader in English as well as translated into the local language.

The challenge will be to continue building and maintaining awareness. To that end events are being planned to mark significant milestones in the development of the program, as well as the idea of a GIS Day as has been featured in Bermuda.

A Broad Pool of In-country Knowledge and Commitment to Training

The Maldives is a small country in population and it is a developing country. Beginning with these two statements, one might wrongly surmise that there is a dearth of trained people in geospatial. This is not completely the case. While there is a lack of depth in training in geospatial, and while there is a lack of those trained in management of GIS and some of the more arcane issues associated with standards, there is a pool of expertise upon which to build. This is especially so as silos between departments of government are broken down and as expertise is shared. This sharing of expertise is one of the key elements of the program and one that is well suited to a close-knit society where almost everyone knows everyone else.

What emerges in geospatial is the presence of a broad (if not deep) knowledge pool within country – ranging from a Ph.D. in remote sensing and Ph.D. (ABD) in GIS and several technically trained individuals. If there was no-one trained, if there was no expertise, the project would be doomed. But there is a foundation upon which to build, and there is a commitment to build through advanced training.

A commitment to training is part of the national GIS program. While this will help propel the National Program forward, as the value of the training becomes more obvious, more people will be sent on training course of the sort people have already attended, including those from the Ministry of Fisheries and the Marine Research Institute.

The Use of Best Practices and Appropriate Planning Tools

User requirements were gathered from key stakeholders and used to drive the national GIS system design. The system design was architected to be phased-in over a three-year period, with each subsequent year building on the investments made in the previous year. This phased-in approach was adopted to not only align with the training activities scheduled for key staff of the various stakeholders, but also based on when GIS functions/capabilities were required by the GIS user community, as defined by the user requirements gathered. The alignment of the implementation of the national GIS with training activities is a critical success factor since it would be counterintuitive to implement and enterprise GIS without having in place properly trained staff to manage and maintain it.

The system architecture was based on ESRI GIS technology. This technology was selected as the basis for the system architecture primarily because of the familiarity with this GIS technology by the existing in-country GIS user

community. To propose the use of an alternative GIS technology and subject the existing in-country GIS expertise to re-training was deemed an unwarranted risk. To ensure that the system architecture would meet user and performance requirements, a Capacity Planning Tool (CPT) developed by ESRI was used. Given a defined system architecture, the CPT matches user workflows against user requirements, and identifies problem areas (e.g., network bandwidth issues, un-optimal software configurations, and weak points in server configuration) in the system architecture, thereby allowing system architects to make adjustments before any implementation activities take place. After the system design was validated, a detailed implementation plan was developed, which spelled out when key activities had to take place and milestones realized, in addition to a breakdown of costs by implementation year.

In developing countries, where opportunities to implement a national GIS are far and few, it is critical to ensure that best practices and the best planning tools be brought to the assignment by the consulting team to mitigate risks and increase the likelihood of a successful implementation.

CONCLUSION

We have outlined the approach used to develop a national GIS and provide the foundation for a spatial data infrastructure for the Republic of the Maldives. The lessons learned and the approach used is, we believe, capable of being replicated in other developing countries and has the potential to form the basis of best practices for the introduction of geospatial data in the developmental context.

REFERENCES

Atwood, D., K. Mayall, and R.A. Ryerson, 2009. Towards Cooperative SDI in Small Island Nations: The Experience in Bermuda, in *Proceedings of the American Society for Photogrammetry Annual Conference*, Baltimore, MD, USA.

Ministry of Planning and National Development, 2008. *Official Atlas of the Maldives*, Male, Republic of the Maldives, November 2008. ISBN 99915-95-40-6.

Ryerson, R.A., and E. Quiroga, 2000. Taking Remote Sensing from Development Projects to Operational Use: Some Common Attributes of Successful Projects, Session Keynote Paper in *Geo Asia Pacific Conference*, Bangkok, Thailand, October 2000. Also presented at the *23rd. Canadian Symposium on Remote Sensing*, St. Foy, Quebec, August, 2001.

Ryerson, R.A., 2005. Making Remote Sensing Operational: A Changing World Requiring Changing Approaches to Data Policy, Invited Key-note Paper in *First International Symposium on Remote Sensing for Cloud-prone and Rainy Areas*, Hong Kong, October pp 5-19.

Ryerson, R.A., and C. Peanvijarnpong, 2007. Comparative Analysis of Thailand's Successful National Program in Remote Sensing: Government Policy, Applied Research, Commercialization, and Operationalization, Invited Opening Plenary Session Keynote Paper in *Asian Conference on Remote Sensing*, Kuala Lumpur, Malaysia.