



Blue Gold Program

Technical Report No. 5

Geo information for Blue Gold
Inventory of needs, data collection
and roadmap for implementation

Embassy of the Kingdom of the Netherlands,
Dhaka, Bangladesh
Bangladesh Water Development Board (BWDB)
Department of Agricultural Extension (DAE)

December, 2013



Green corner – Save a tree today!



Mott MacDonald is committed to integrating sustainability into our operational practices and culture. As a world leading consultancy business we are always seeking to improve our own performance and reduce the environmental impact of our business. Meanwhile, many of our staff are committed to living sustainably in their personal lives – as an employee-owned company Mott MacDonald shares their concerns. We feel an ethical obligation to reduce our emissions and resource use and have committed to reducing our per capita carbon footprint by a minimum of 5% year on year.

We print our reports and client submissions using recycled, double-sided paper. Compared to printing single sided on A4 virgin paper, double sided printing on recycled paper saves the equivalent of two trees, over a ton of CO₂ and a cubic metre of landfill space for every 100 reams. By choosing the greener path we have been able to achieve efficiencies benefiting both Mott MacDonald and our customers.

We would like to share some of the principles of our own 'Going Green' initiative:

- When possible we scan rather than print and consider what really needs to be on paper
- We use electronic faxing when practicable
- We work on e-forms
- We use recycled paper when possible
- Reducing paper in the office creates a better working environment for our staff and our clients

We believe that you, as one of our esteemed clients, will share our concern to conserve precious resources for the benefit of our planet and its inhabitants.

Issue and revision record

Revision	Date	Originator	Checker	Approver	Description
01	01-12-2013	Bastiaan Roos	Dirk Smits / Natasha Haider	Dirk Smits	Report on Geo information for Blue Gold

This document is issued for the party which commissioned it and for specific purposes connected with the above-captioned project only. It should not be relied upon by any other party or used for any other purpose.

We accept no responsibility for the consequences of this document being relied upon by any other party, or being used for any other purpose, or containing any error or omission which is due to an error or omission in data supplied to us by other parties

This document contains confidential information and proprietary intellectual property. It should not be shown to other parties without consent from us and from the party which commissioned it.

Contents

Chapter	Title	Page
1.	Introduction	1
1.1	Context _____	1
1.2	Objective _____	2
1.3	Approach _____	2
2.	Geo Information needs and data collection	3
2.1	Project area _____	3
2.2	Component wise information needs and information collection _____	5
2.3	Geo information Layers _____	8
3.	GIS data collection	11
3.1	Data collection _____	11
3.2	Freely available maps and data _____	11
3.3	Procure GIS data _____	12
3.4	Topographical surveys and processing aerial imagery _____	14
3.5	Guidelines for surveys and fieldwork _____	14
3.6	Creation of data in GIS _____	16
3.7	Innovative ways of data collection _____	16
3.8	Consultancy services for specific, information consuming analyses _____	17
4.	GIS infrastructure	18
4.1	Architecture _____	18
4.2	Infrastructure _____	19
4.3	Web-based MIS/ GIS portal Lizard _____	19
4.4	Organization, required capabilities and training needs _____	21
5.	Roadmap	22
5.1	Development steps _____	22
5.2	Step 1: Set up GIS system, GIS data and capacities _____	22
5.3	Step 2: Develop Blue Gold Database and implement web-based MIS/ GIS portal Lizard _____	25
6.	Conclusions and recommendations	26
6.1	Conclusions _____	26
6.2	Recommendations _____	26
7.	Literature	28

Annexes

Appendix 1 Summary of information needs and possible sources	1
Appendix 2 Mission activities	3

List of Tables

TABLE 1: LIST OF SELECTED OR SHORTLISTED POLDERS	4
TABLE 2: SUMMARY INFORMATION NEEDS	8
TABLE 3: INDIRECT INFORMATION NEEDS	10
TABLE 4: USEFUL FREE AVAILABLE LAYERS.	12
TABLE 5: SELECTION OF LAYERS FOR PROCUREMENT FROM THE INTEGRATED COASTAL RESOURCES DATABASE (ICRD)	12
TABLE 6: SELECTION OF LAYERS FOR PROCUREMENT FROM THE NATIONAL WATER RESOURCES DATABASE (NWRD).	13
TABLE 7: LAYERS, WHICH CAN BE CREATED USING AERIAL IMAGERY AND TOPOGRAPHICAL SURVEY.	14
TABLE 8: DATA THAT COULD BE COLLECTED WITH SURVEYS AND COMPONENT STAFF.	15
TABLE 9: GIS LAYERS THAT COULD BE CREATED COMBINING OR PROCESSING INFORMATION.	16
TABLE 10: GIS LAYERS THAT COULD BE CREATED WITH REMOTE SENSING OR SURVEYS WITH SMALL PLANES.	16
TABLE 11: LIST OF ACTIVITIES AND PLANNING OF STEP 1, THE START-UP OF GIS, AND STEP 2, THE DEVELOPMENT OF A WEB-BASED MIS/ GIS PORTAL LIZARD.	24

List of Figures

FIGURE 1: POLDERS IN SOUTHWEST OF BANGLADESH. THE PINK POLDERS AND A SELECTION OF THE GREEN POLDERS WILL BE PART OF THE BLUE GOLD PROJECT.	1
FIGURE 2: EXAMPLE OF A VILLAGE MAP, DEVELOPED TOGETHER WITH THE COMMUNITY.	5
FIGURE 3: EXAMPLE OF SATELLITE IMAGES AND THE CORRESPONDING FIELD SITUATION. WITH THIS INFORMATION CROPS CAN BE IDENTIFIED AND YIELDS ESTIMATED.	16
FIGURE 4: PICTURE OF THE EBEE OF SENSEFLY, A SMALL PLANE (1 METER WIDE, 0,7 KG), WHICH CAN PRODUCE DIGITAL ELEVATION MODELS FOR UP TO 10 KM ² IN A SINGLE FLIGHT WITH AN ACCURACY OF 5 CM.	17
FIGURE 5: COMPONENTS OF THE BLUE GOLD GEO INFORMATION SYSTEM.	18
FIGURE 6: GEO INFORMATION SYSTEM WITH THE MAJOR DATA FLOWS.	19
FIGURE 7: EXAMPLE OF AN MIS IMPLEMENTATION OF LIZARD, WITH ALL KIND OF INDICATORS.	20
FIGURE 8: EXAMPLE OF A LIZARD APPLICATION WHERE PEOPLE CAN SEE OBJECTS, SEARCH LOCATIONS, ASK INFORMATION ABOUT OBJECTS. LIKE GOOGLE MAPS, BUT THEN SPECIFIC FOR THIS PROJECT USING THEMATIC MAPS.	20

List of Abbreviations

BBS	Bangladesh Bureau of Statistics
BWDB	Bangladesh Water Development Board
CEGIS	Centre for Environmental and Geographic Information Services
CGIAR	Consultative Group on International Agricultural Research
DAE	Department of Agriculture Extensions
FFS	Farmer Field Schools
GIS	Geo Information System
GPS	Global Positioning System
IPSWAM	Integrated Planning for Sustainable Water Management
IRRI	International Rice Research Institute
IWM	Institute of Water Modelling
M&E	Monitoring and Evaluation
MIS	Management Information System
NGO	Non-Governmental Organization
O&M	Operations & Maintenance
ODK	Open Data Kit
WARPO	Water Resources Planning Organization
WMA	Water Management Association
WMG	Water management Group
WMO	Water Management Organization

1. Introduction

1.1 Context

Bangladesh, the largest river delta in the world, depends largely for its economic growth on integrated and sustainable water resources management. The three major river systems of the country mark its physiography and life of its people. Efficient management of this immense natural resource remains a continuing challenge and offers at the same time tremendous opportunities.

The essence of the Blue Gold Program is to establish and empower community organizations/water management organizations (WMOs) to sustainably manage their water resources and to make these resources productive. Participatory water resources management is the entry point and the initial driver of the community organization process. The explicit objective of Blue Gold is to reduce poverty of the people living in the polders of the coastal areas by enhanced productivity of crops, fisheries and livestock and increasing incomes by improved processing and marketing of agricultural products.

The Blue Gold Program covers 26 polders, i.e. 9 IPSWAM polders and 17 polders to be selected, in the Southwest of Bangladesh (See Figure 1). Blue Gold is implemented over a period of 6 years, from March 2013 till March 2019.

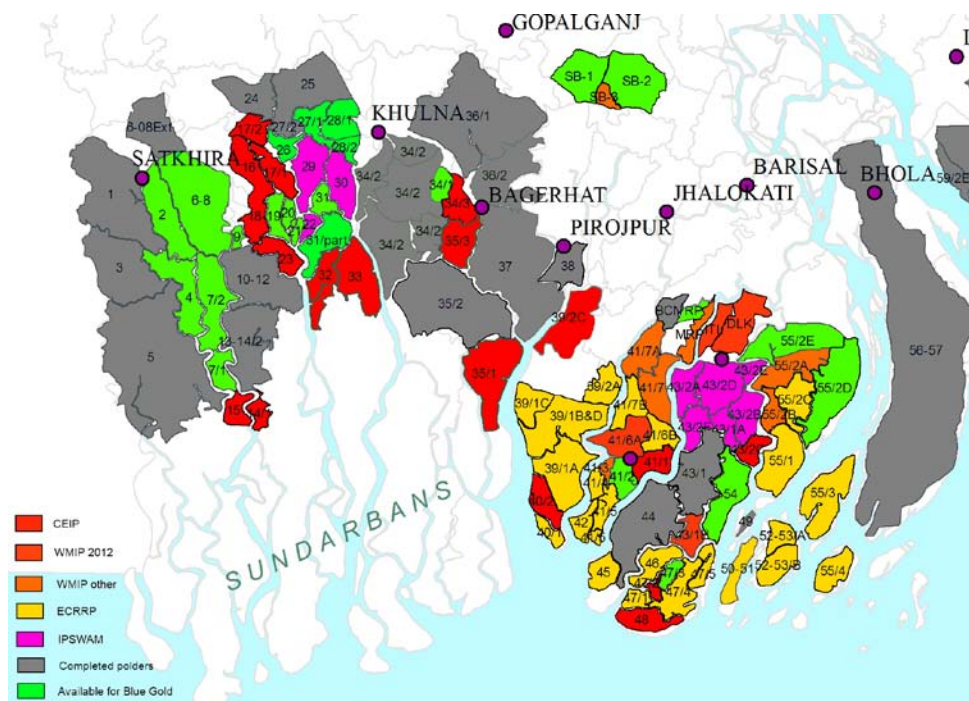


Figure 1: Polders in Southwest of Bangladesh. The pink polders and a selection of the green polders will be part of the Blue Gold Project.

Blue Gold is a complex program, working in different sectors and with a multitude of different stakeholders. Hence, developing a comprehensive and well-functioning Management Information System (MIS) for Blue Gold, to enhance proper management and planning is essential. The MIS can be defined as a set of formalized procedures to provide management staff with appropriate information, based on data from internal and external sources, to enable them to make timely and effective decisions for planning, directing and controlling the activities for which they are responsible.

The Inception Report of Blue Gold mentions the possibility of using a state-of the-art web based MIS platform, which provides web based MIS/GIS functionalities that could be used for presentation of key performance indicators of Blue Gold.

This document provides an inventory of the availability of Geo-Spatial data of Bangladesh' coastal areas, expertise of institutions and/or companies with GIS and mapping experience such as CEGIS, WARPO and IWM and systems developed by other projects (such as the CGIAR consortium) in the Blue Gold project area.

1.2 Objective

The objective of this report is to decide - based on the outcome of the inventory - whether or not to proceed with the development of a GIS platform, including a web-based MIS/GIS portal.

1.3 Approach

The advice for a GIS/MIS design is based on an inventory of the actual (information) needs of the Blue Gold Program, combined with the technical state-of-the-art options. The Component Leaders and senior experts have been interviewed to get a good picture of the (geo) information needs within the project as well as an indication of the information that will be collected by Blue Gold. The results are brought together in a list of required geo information data. This list can be found in Chapter 2.

Subsequently, the major agencies in Bangladesh with geo information capabilities (IWM, CEGIS and WARPO) have been visited to check which information is available, including accuracy and metadata. This resulted in an advice on how to procure or otherwise collect the required geo information data, see Chapter 3.

To enable effective use of the geo information data within Blue Gold, it is essential to have the right instruments, people and capacities. Chapter 4 provides a preliminary proposal for the required infrastructure, tools, organization and training.

Finally a roadmap is made how to get started with GIS, use the system, maintain the system and handover the information for later use, see Chapter 5.

2. Geo Information needs and data collection

In Blue Gold information is needed for analysing problems and possible solutions, development of measures and interventions, monitoring effects and evaluation of measures.

This chapter describes the geo information needs, which are based on the Inception Report and on interviews with senior staff members of Blue Gold. For each component an inventory is made of:

- › (Geo) Information needs;
- › (Geo) Information collected/ surveys carried out in the course of the project;
- › (Geo) Analyses to be carried out.

This inventory is done for the four project Components:

1. Community Mobilization and Institutional Strengthening;
2. Integrated Water Resources Management;
3. Food Security and Agricultural Development;
4. Business Development and Private Sector Involvement.

and for some other issues relevant for GIS:

- › Monitoring and Evaluation;
- › Environment and Disaster Risk Reduction (DRR);
- › Gender;
- › Communication and Knowledge Management.

Based on this inventory, a list of data needs is drafted, see paragraph 2.3.

2.1 Project area

The project is situated in the Southwest of Bangladesh in the Districts Patuakhali, Barguna, Khulna and Satkhira. The initial focus is on the 9 IPSWAM polders; 17 extra polders will be selected in the coming years. Table 1 shows the 9 IPSWAM polders and 13 polders that have so far been shortlisted for selection. The remaining four polders will be identified and selected at a later stage.

When data is procured, it is recommended to do this for the Districts Pathuakhali, Barguna, Khulna and Satkhira or at least for all polders mentioned in Table 1.

Table 1: List of selected or shortlisted polders

SL No.	Name of the Polders	District	Upazila	Remarks
<u>Patuakhali & Barguna Districts</u>				
1.	43/2A	Patuakhali	Patuakhali	Already selected (IPSWAM)
2.	43/2B	Patuakhali, Barguna	Galachipa, Amtali, Patuakhali	Already selected (IPSWAM)
3.	43/2D	Patuakhali	Patuakhali	Already selected (IPSWAM)
4.	43/2E	Patuakhali	Patuakhali	Already selected (IPSWAM)
5.	43/2F	Barguna	Amtali	Already selected (IPSWAM)
6.	43/1A	Barguna	Amtali	Already selected (IPSWAM)
7.	46	Patuakhali	Kalapara	Probable. Not yet selected
8.	47/3	Patuakhali	Kalapara	Probable. Not yet selected
9.	47/4	Patuakhali	Kalapara	Probable. Not yet selected
10.	47/5	Patuakhali	Kalapara	Probable. Not yet selected
11.	55/1	Patuakhali	Galachipa	Probable. Not yet selected
12.	55/2C	Patuakhali	Galachipa	Probable. Not yet selected
<u>Khulna District</u>				
13.	22	Khulna	Paikgacha	Already selected (IPSWAM)
14.	30	Khulna	Batiaghata	Already selected (IPSWAM)
15.	29	Khulna	Dumuria, Batiaghata	Already selected (IPSWAM)
16.	31-part	Khulna	Batiaghata	Already selected
17.	26	Khulna	Dumuria	Already selected
18.	27/1	Khulna	Dumuria	Probable. Not yet selected
19.	28/1	Khulna	Dumuria	Probable. Not yet selected
<u>Satkhira District</u>				
20.	6-8 Extension	Satkhira	Satkhira, Kalaroa	Probable. Not yet selected
21.	2	Satkhira	Satkhira, Asasuni	Already selected
22.	4	Satkhira	Asasuni	Probable. Not yet selected

The remaining 4 polders will be identified later.

2.2 Component wise information needs and information collection

2.2.1 Component 1: Community Mobilization and Institutional Strengthening

As the starting point of the Blue Gold Program, communities in the polders are organised in Water Management Groups (WMGs) at village level and Water Management Associations (WMAs) at polder level, with an aim to create effective cooperatives that are in a position to formulate community priorities. The development of the capacity of the WMG's / cooperatives will build on the training approach and Toolkit developed in the IPSWAM and Southwest Area projects.

At this moment there are in the 9 IPSWAM polders:

- › 246 Water Management Groups (WMG's) linked to village boundaries;
- › 16 Water Management Associations (WMA's).

In the other polders approx. 600 new WMG's and WMA's will be established.

A. Information needs

For establishing and improvement of the WMG's village and polder maps are needed with:

- › Basic socio-economic, physical and environmental data;
- › Hydrological/ water management situation and conditions;
- › Status of environment and primary production;
- › Existing WMO and WMG, including boundaries, names, etc.

To obtain this information and to establish a shared picture of the current situation, village maps are developed together with the communities, see Figure 2.

Relevant information for these village maps comprises:

- a) Geographical, political and/or administrative boundaries;
- b) Key natural/physical landscape features e.g. rivers, hills, mountains, etc.;
- c) Location and features of built-up areas based on land use;
- d) Settlement sites/housing;
- e) Farm fields, ponds, ditches;
- f) Economic areas such as shops, market centres, etc.;
- g) Flood control, drainage and irrigation infrastructure;
- h) Health institutions;
- i) Educational institutions;
- j) Cultural and religious institutions;
- k) Basic services such as electricity/power, water;
- l) NGOs/CBOs, other Project Organizations.
- m) Topography – elevation of land;



Figure 2: Example of a village map, developed together with the community.

- n) Settlements in relation to elevation and location of basic services;
- o) Natural resources;
- p) Location and boundaries of organizations (WMOs, Farmers' Groups, Fishermen Associations, Women's Groups, ...);
- q) Water management problems and conflict in water use areas.

The local communities provide part of the above information. With the use of accurate and scaled base maps, this information could be better geo referenced and made available for further processing and analysing.

B. Data collection

Data generated by Component 1 include:

- > Household survey (initially for 40.000 households – survey is on-going);
- > Every half a year a (self) assessment of WMG's, including updating of village maps;
- > Planning and execution of the support program.

2.2.2 Component 2: Integrated Water Resource Management

This Component enhances flood protection in polders by rehabilitation of the embankments and water intakes and outlets and by improving the water distribution and drainage systems; fine-tunes and rehabilitates the infrastructural works of selected polders; and creates an effective operational partnership between government agencies (BWDB, DAE, DoC and others) and community groups (WMG/WMA). Planning, design and implementation of civil works are based on the principle of participatory water resource management.

A. Information needs

Component 2 is dealing with construction works for restoring and optimizing (a part of) the civil works in the polder. For this work accurate data is needed of:

- > Polder boundaries;
- > Location of drainage and irrigation channels, including cross sections;
- > Location of inlets and outlets and other structures (culverts, etc.);
- > Embankments, including profile, alignment, protection; Elevation maps (5-10 cm accuracy);
- > Land-use, crop maps (for calculation of irrigation needs), road maps;
- > Current (and future) 'boundary' conditions (water levels, salinity levels, etc).

Some examples of analyses of Component 2 are:

- > Determine polder areas (BWDB budgets are based on polder areas);
- > Estimate amount of earthworks (embankments and channel alignment);
- > Divide polders in compartments with different water levels. Part of these analyses will be to determine the required water levels for rice and other agricultural crops (water depths), flow directions and outside water levels.

B. Data collection

Topographical surveys are carried out for the layout of the polder infrastructure, including profiles of channels and embankments. At this moment, the topographical survey is done for four polders and information is available in AutoCAD.

Component 2 will start improvement works, including quality control, which will also generate additional information.

Frequent surveys of the existing infrastructure will be part of the WMG (self) assessments (see Component 1, Chapter 2.2.1).

2.2.3 Component 3: Food Security and Agricultural Production

In this Component Farmer Field Schools (FFS) are organised based on experiences of the DANIDA funded AEC and RFLDC projects. FFS are part of the WMG's in the polders and aim to educate and assist male and female farmers to increase productivity in crops, aquaculture and livestock. The scope for increased productivity is provided by improved water management (polder rehabilitation) and strong WMG's (responsible for O&M in the polders). The FFS and the introduction of Polder Development Plans bring higher agricultural production, resulting in improved supply of nutritious foods at lower prices at local retail markets; improved food security and food use through greater awareness and behavioural change of the polder communities.

A. Information needs

Component 3 focuses on training of WMG's, using the FFS tool. Information needs are:

- › Overview of training given by other projects (lists are available, linked to administrative boundaries or farmer groups);
- › Agricultural activities and land use (crops, aquaculture and livestock) to determine training needs;
- › Demographic data (labour force, employment, gender issues, land tenure).

2.2.4 Component 4: Business development and private sector involvement

A Business Development Plan of each polder will be made for production and marketing of selected farm products. The Business Development Plans assist the WMGs/cooperatives to further professionalise and diversify. This Component focuses on field crops and other agricultural products, for which value chain analyses are made and private sector linkages are established for well-defined services as input for the Business Development Plans. It supports the food security component and aims to develop WMG's as multi-purpose cooperatives, to establish effective service provision for agricultural products and to create employment in agricultural services.

A. Information needs

The focus of Component 4 is on value chains and marketing possibilities of an area, such as the road or river connections between production areas and the markets. Relevant information layers include:

- › Food production areas and existing markets/bazaars (is part of base line survey);
- › Retailers, factories and other businesses in the value chain;
- › Transport (roads, ferries, trains) and the actual status of these transport means. Not only the infrastructure within the polder is important, but also outside the polders, up to the nearest cities.
- › Availability of electricity;
- › Villages and urban areas;
- › Population densities;
- › (Farmer) Cooperatives;
- › Agricultural production data (who and how much);
- › Crop suitability maps (move to more profitable production).

With this information, maps can be made how goods flow and where (spatial) optimization is possible (for example missing businesses in a district or problems with transport).

B. Data collection

Staff of Component 4 visits the project area on a regular basis to collect information. This opportunity will be used to collect actual and relevant information in the field.

2.2.5 Monitoring and Evaluation (M&E)

During the project several surveys are planned:

1. Household census, which started in September 2013. The survey comprises all households in the first 5 polders (40.000 households).
2. Base-line survey and impact surveys. At the start (first quarter of 2014) and at the end of the project.
3. Regular WMG surveys similar to the self-assessments made under IPSWAM. Monitoring of WMG's takes place every 3 to 6 months. It comprises a short survey on social change and development level of WMG's and includes a review of status of infrastructure and village mapping (including problems and bottlenecks).
4. Boundary partner monitoring, as part of Outcome Mapping (see Blue Gold Report No. 4). Each 6 months progress of DAE staff, WMG's in existing and new polders and Bangladesh Water Development Board (BWDB) will be surveyed.

The M&E team are considering to use tablets for the surveys, where GPS data collection could be added. The first survey, the household census, has started without this GPS information, but could be matched using village names. On the tablets the tool 'Open Data Kit' (<http://opendatakit.org/>) will be installed for the questionnaires and for data analysis.

2.3 Geo information Layers

Table 2 shows an overview of the needed GIS layers.

Table 2: Summary information needs

Name	Details	Used for
Polders	Including code	Orientation, overview maps, calculation of polder area's
Embankments	Including current profiles, status (damaged, breach, etc.), material, protection, road on top, drainage on polder side, etc.	Decision of measures, calculation of groundwater
Water bodies (ponds, channels, etc.)	Only spatial location	Used for calculation of storage capacities, land-use, locate of ponds (fish)
Drainage system	Including profiles, outlets, structures + culverts (including dimensions)	Decision on measures of upgrade canal profiles, calculation of groundwater
Irrigation system	Including profiles, inlets, structures + culverts (including dimensions), field inlets, storage basins.	Decision on measures of upgrade canal profiles, calculation of groundwater
Digital elevation models	Precision of 5-10 cm	Make plans for sub polders (compartments in polders with different levels), water depths on rice fields (input for crop suitability)
Crop maps and cropping patterns		Calculating irrigation needs, land use maps, training needs, identification of opportunities
WMG boundaries	For the IPSWAM polders WMG boundaries	

	are connected to village boundaries.	
Administrative boundaries	Up to village level. Including a few social-economic and population statistics.	Linking with tables of trainings performed by other NGO's, base map for determine current WMG's, social economic situation (input for component 1 en 4)
Roads and water ways	Including current state	General orientation on maps, navigation for project, part of connection in business chains
Electricity, water.		Component 4
Hydrological system in polders		Component 1 and 2
Land use		Training needs, business opportunities
Villages and urban area's/houses		General orientation, social structure (component 1 and 4)
Crop suitability maps		Component 3 and 4
Basic services, Health institutions, education institutions, cultural and religions institutions		Component 1
Water pumps, etc.	including quality	Component 1
Active NGO's CBO's and other projects and organizations		All components
Natural resources		Component 4
Locations with water management problems and conflicts in water use	waterlogging areas,	Component 1 and 3
Presence and boundaries of WMA's, Farmers' Groups, Fishermen Associations, Women's Groups,		Component 1, 3 and 4
Historic weather information		Component 2, Dimension of drainage, storage and possible pumps
Satellite images		General orientation

Table 3 shows the information that is not directly needed, but indirectly for boundary conditions.

Table 3: Indirect information needs

Name	Details	Used for
River and river morphology	Including changes over time	
Salinity levels		Irrigation inlets, availability of fresh water for agriculture.
External water levels in river		Embankments, need and dimensions of drainage pumps

3. GIS data collection

3.1 Data collection

To fill the information needs, multiple sources and data collection methods are needed. During the inventory of the available GIS data it became clear that a lot of data is available, but most data do not have the required level of detail or are recent enough for use in Blue Gold. Consequently, a lot of information have to be collected and generated by the project itself. This chapter provides information on which data can be procured or collected.

The recommendation for data collection is to:

1. Start with the freely available maps.
2. Procure GIS data from WARPO (see Table 5 en 6).
3. Make guidelines for detailed topographical surveys of polders based on aerial imagery and field surveys.
4. Create and update (GIS) data during regular fieldwork, formalize data collection with the Open Data Kit (ODK) and digitalization of hand-drafted maps.
5. Create project specific layers by Blue Gold GIS experts, field workers with GPS devices and join layers with available information tables.
6. Look at innovative options, like small planes and remote sensing.
7. Use consultancy services for specific information consuming analyses (IWM/ CEGIS) or advanced processing (IRR).

The next paragraphs describe these points in more detail.

3.2 Freely available maps and data

An inventory was made of the open sources available for Bangladesh. Most free data is only available on 'fixed' maps, which are suitable for the first orientation of an area, but not for the use within a GIS platform (digital GIS data is required).

The two major sources for 'fixed' maps are:

- › **National Land Zoning Project** (<http://www.landzoning.gov.bd/WebMap.aspx>)
Fixed image maps on division, district and upazila level. Maps with: land use (global zones), up to mauza boundaries, hospital, temple, family welfare centres, markets, growth centres, main roads and headquarters.
- › **Local Government Engineering Department (LGED)** (<http://www.lged.gov.bd/ViewMap.aspx>)
Fixed image maps or pdf's on district and upazila level. Maps with: up to municipal boundary (not available for all districts), headquarters, natural and urban zones, up to union village roads, railroads, embankments, growth centres, markets, police stations, upazila health complex, family welfare centres, post offices, colleges and schools and madrassas.

Other free available GIS sources, which could be used in a GIS system, are summed up in Table 4.

Table 4: Useful free available layers.

Name	Description
Google Maps (http://maps.google.com)	Google maps have quit accurate satellite images of most polder areas. The detail level is up to 1-meter resolution.
Open Street Map (http://www.openstreetmap.org/)	Open Street Map is a map that is created by the community. The data can also be downloaded. For Bangladesh the main features are the main roads, and global land-use maps and country boundaries. Open Street Map is possibly a good place to store a part of the collected data at the end of the project.
IRRI/ WorldFish	After verification IRRI will publish their project output maps on the internet. This will be high-resolution crop suitability maps for some polders of the Southwest of Bangladesh. With more detailed data of polders (elevation, irrigation, etc.) these maps can also be made of other polders.

3.3 Procure GIS data

An inventory of available data is made through visits of IWM, CEGIS and WARPO. Most layers are summarised on the WARPO website (http://www.warpo.gov.bd/pdf/ICRD_Datacatalogue.pdf and <http://www.warpo.gov.bd/pdf/Datacatalogue.pdf>).

It is not always possible to get GIS data, but only paper maps. The WARPO layers could be procured with the Data Request Form and Procedure as published on the WARPO website (under 'database').

Table 5 and 6 shows the recommended layers for procurement.

Table 5: Selection of layers for procurement from the Integrated Coastal Resources Database (ICRD).

SL	Layer Name	Need	Area
1	Coastal District Boundary		all districts in Southwest
2	Coastal Upazila/Thana Boundary		districts
3	Coastal Union Boundary		polders
4	Soil Map of Coastal Zone		districts
6	Polder Information		polders
7	Structure Information of Polder		polders
10	Coastal Flooding (2005)	optional	polders
11	Land Zoning of Coastal Area	optional	districts
12	Coastal River		districts + surroundings
13	DEM of Coastal Zone		polders
14	Land use		districts
15	Settlement		polders

Table 6: Selection of layers for procurement from the National Water Resources Database (NWRD).

SL	Layer Name	Need	Area
1	Location of Bridges and Culverts	optional	polders
8	Growth Center (LGED)		districts
9	Mauza Boundaries 2001		polders
12	Location of Inland Waterway Facilities	optional	districts
13	Navigation Route	optional	districts
14	Location of Grid Substations	optional	districts
16	BWDB Embankment locations	optional	polders
27	River Polygon	optional	districts
29	LGED Road (Union)		districts
30	LGED Road (Upazila)		districts
31	LGED Road (Village)		districts
32	National Highway of RHD		districts
33	Regional Highway of RHD		districts
34	Zila Road (RHD)		districts
36	Settlement Location of Khulna Division		polders
37	River Bank Protection Structure	optional	districts
38	Upazila/Thana Headquarter 2001		polders
39	Upazila/Thana Boundaries 2001		polders
40	Digital Elevation Model		polders
42	Union Boundaries 2001		polders
43	Union Headquarter (LGED)		polders
65	Groundwater Level Stations of BWDB	optional	districts
68	Combined Lab Test Results of Arsenic with Locations	optional	districts
69	Groundwater Arsenic with Locations	optional	districts
70	Groundwater Quality Stations of BWDB	optional	districts
71	Groundwater Quality Stations of DPHE	optional	districts
72	Regional Arsenic Survey 2000	optional	districts
80	Social Service Information	optional	districts
81	Agro based industry	optional	districts
82	Agro-Ecological Regions and Sub-regions	optional	districts
93	Geological Map of Bangladesh	optional	districts

96	Agriculture Land Use	optional	polders
97	Information of Livestock	optional	polders

3.4 Topographical surveys and processing aerial imagery

Component 2 will carry out topographical surveys. The topographical surveys are a good opportunity to map a part of a polder and get a lot of the required information. It is recommended to look at the following options:

- › Use aerial imagery, together with topographical surveys, to determine the spatial locations of line elements and other information (like ponds, roads, etc.) more accurately. A possible organization for processing aerial imagery is Decode Map (<http://www.decodemap.com/>).
- › Use survey equipment that can geo-reference the measurements. The last topographical survey was not geo-referenced, which makes the data not suitable for mapping in a GIS system. With the use of Total Station, the measurements can be used on a map.
- › Add some extra data to this survey that are useful for later use or for other Components.

The selection of above options depends on the price, so the first step will be to get some quotations for these options. Table 5 shows the data layers that could be created with the topographical surveys in combination with topographical surveys.

Table 7: Layers, which can be created using aerial imagery and topographical survey.

Name	Based on
Embankment	Aerial imagery/ topographical survey
Embankment elevation profile	Topographical survey
Drainage and irrigation channels	Aerial imagery (location) + field (classification)
Profiles of channels	Topographical survey
Main structures, culverts and field inlets	Topographical survey
Roads	Aerial imagery
Ponds	Aerial imagery
Houses	Aerial imagery
Rivers	Aerial imagery
Land use (optional)	Aerial imagery

3.5 Guidelines for surveys and fieldwork

Within the Blue Gold Program, several surveys will be carried out and also many Blue Gold staff will be present in the field. With the right tools and methods, the surveys and fieldwork can contribute significantly to the available GIS information.

The base line survey will be carried out on tablets with questionnaires using the 'Open Data Kit'. This makes it possible to add a geo-location to questionnaires and also add metadata, like time and who collected the information.

The same tools could be used by the staff of Blue Gold who are frequently in the field. With a tablet and the right forms using 'Open Data Kit', they can start structural data collection. An example is the staff of Component 4, business development: they can fill short questionnaires in each village with information about marketplaces, resellers, factories, waterway connections, and road conditions. This structural data collection, including geo-locations, can be put on maps and could be used to analyse geographical relations between elements in the value chain.

Another way to collect data is to digitize the village maps. The current maps are drawn without real dimensions and points to geo-reference the maps. With a basic map from a GIS system, more exact locations can be drawn on a map, which can be digitalized by the Blue Gold GIS team. The people of Component 1 can also use tablets to map some of the objects directly in the field or use GPS to determine village and other boundaries.

Geo tagged photos can also be a valuable source for GIS information systems.

Table 8 gives an overview of Geo information that could be provided by the field staff. This data collection can be done in multiple visits, first focusing on the most important data.

Table 8: Data that could be collected with surveys and Component staff.

Name	Based on
Social economic data	Base line survey
Market places, factories, resellers, etc.	Staff of component 4 using forms on tablets
Road conditions and water ways connections	Staff of component 4 using forms on tablets
Availability of electricity	Staff of component 1 or 4 or base line survey
WMG, Mouza and village boundaries	WMG survey (component 1), drawing on basic maps or using GPS devices in the field
Basic services, like health, schools, cultural institutions	WMG survey (component 1), drawing on basic maps or using forms with tablets in the field
Boundaries of WMA's, Farmers' Groups, Fishermen Associations, Women's Groups,	WMG survey (component 1), drawing on basic maps or using GPS devices in the field
Water pumps, etc and other facilities	WMG survey (component 1), drawing on basic maps or using forms with tablets in the field
Natural resources	WMG survey (component 1), drawing on basic maps or using forms with tablets in the field
Locations with water management problems and conflicts in water use	1) Initial survey of new polder, identifying problems using tablets and geo-referenced photo's 2) WMG survey (component 1), drawing on basic maps or using GPS devices in the field. 3) All using photos with geo-location or form on tablet
Hydrological situation	Component 2, using GPS to mark boundaries and tablets for specific points
Current situation/ impression	Photos with geo-location tags and timestamp

3.6 Creation of data in GIS

Some data can be created from other layers or combination of layers from different sources. Table 7 shows some of the layers that could be created by the Blue Gold GIS team.

Table 9: GIS layers that could be created combining or processing information.

Name	Based on
Social economic data	1) Mouza and village maps, combined with survey data from PDF documents that can be downloaded from the Bangladesh Bureau of Statistics (BBS). 2) Village maps, combined with the results of the WMG household census
Training maps	Mouza and village maps, combined with Excel tables with training of other NGO's
Catchment areas	Processing elevation map

3.7 Innovative ways of data collection

Some of the data can be best created using innovations. Two examples are:

- › *Remote sensing.* With satellite images, crop patterns, flooded areas and even yields can be determined. For the Dutch funded project 'Remote sensing for crops', also some Blue Gold polders are covered, so this data will be available for the year 2014. Additional data can be bought.

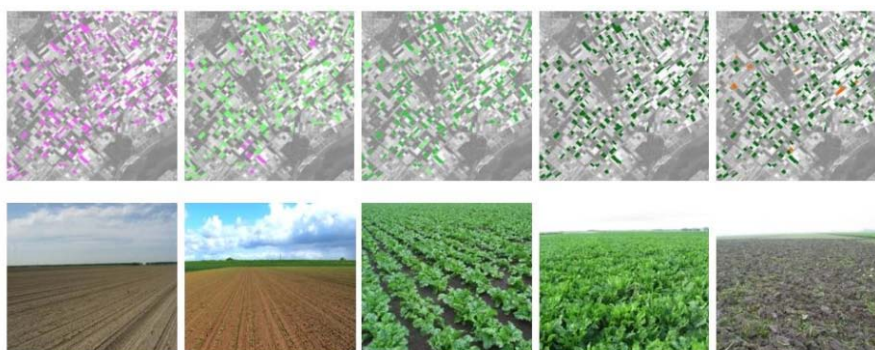


Figure 3: Example of satellite images and the corresponding field situation. With this information crops can be identified and yields estimated.

- › *Small planes for creation of high detailed elevation models (DEM).* Small planes, like the Sensefly (<https://www.sensefly.com/>) are a relatively affordable solution. These technologies could be a good opportunity to get high-resolution elevation data for a larger area. One of the things to find out is if companies with this kind of equipment operate in Bangladesh, if it is allowed to use these planes and what the costs are.

Table 10: GIS layers that could be created with remote sensing or surveys with small planes.

Name	Based on
Crop types and patterns	Remote sensing
Agricultural yields	Remote sensing
Flooded areas	Remote sensing
Detailed areal images	Small planes

Detailed Digital elevation models (DEM)	Small planes
Water depths/ water logging areas	Remote sensing in combination with a detailed DEM



Figure 4: Picture of the Ebee of Sensefly, a small plane (1 meter wide, 0,7 kg), which can produce digital elevation models for up to 10 km² in a single flight with an accuracy of 5 cm.

3.8 Consultancy services for specific, information consuming analyses

It is recommended to use the consultancy services of IWM or CEGIS for specific analyses which require a lot of different information sources. For determining different water related boundary conditions of the polder, including water levels, (change in) salinity levels, river morphology, CEGIS or IWM, which have direct access to these data sources, could be contracted.

Another potential service could be data processing for crop suitability maps, like IRRI did for some polders. If the detailed input is available within Blue Gold, IRRI can develop this kind of maps.

4. GIS infrastructure

4.1 Architecture

The preferred situation is that the geo and management information is easy accessible for the Blue Gold staff and stakeholders. The user can find the required (GIS) information easily and visualise the information in maps, tables and graphs. A state-of-the-art GIS platform, including a web-based MIS/GIS portal for easy access to the data is required to reach this preferred situation. A system, as shown in Figure 5, is recommended. In this system:

- › Geo data is stored and structured in a central GIS database and on a file server (raster data and images). The database also contains metadata of layers and records.
- › Advanced GIS tasks are done with QGIS, an Open Source GIS application, which can be used for all kind of data imports, data processing and advance analyses. Trained staff of the Blue Gold team will operate QGIS.
- › A web based MIS/GIS system (called Lizard) will be the portal for easy access to the data. With Lizard, the user can browse the data using maps, tables and graphs and view object information (like Google Maps). For this system no special software and training is needed, so most Blue Gold staff can use it. External stakeholders can also use this web-based portal.
- › The Open Data Kit survey tool will be used for data collection by the Blue Gold staff. From this tool, the data can be uploaded, directly into the database.

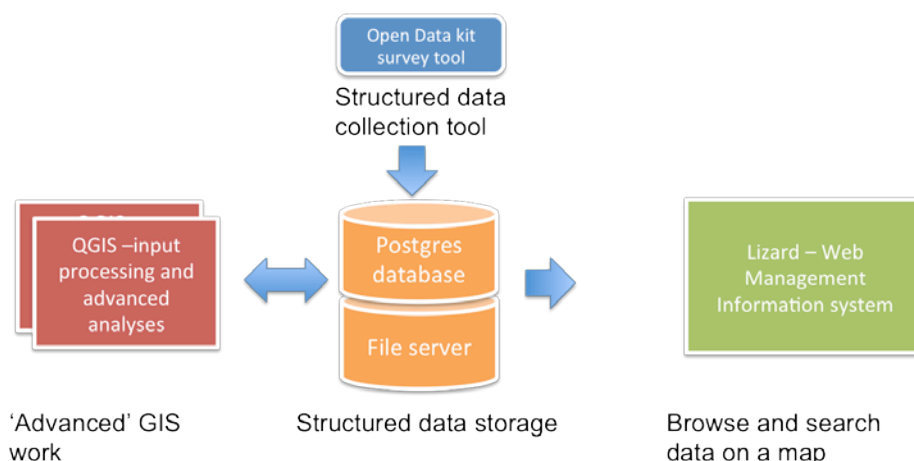


Figure 5: Components of the Blue Gold Geo Information System.

Figure 6 gives a more detailed picture of how the information will flow in the system. With QGIS data is imported into the database, customised maps can be drafted (for the WMG surveys and reports), analyses can be made and data can be transformed to other formats. The data from the Open Data Kit can be imported through the cloud (Google apps/docs) or by sending the survey data by e-mail to the system.

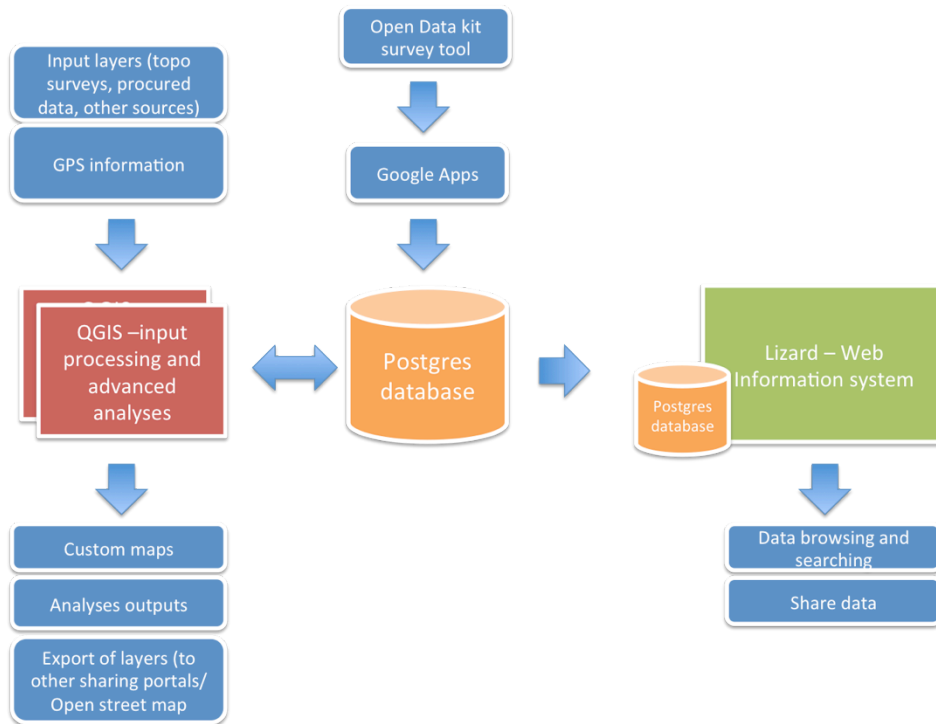


Figure 6: Geo Information System with the major data flows.

4.2 Infrastructure

For the system described in the previous paragraph, the following infrastructure is needed:

- › File server, including daily back-up facilities;
- › Database server;
- › QGIS installed on laptops of the GIS team members. For people working a lot with GIS, it is recommended to have an external monitor with a high resolution.
- › Printer for printing maps for fieldwork or meetings. For village mapping, A1 can be useful, but this can also be outsourced. Otherwise at least a A3 printer is required.
- › High speed Internet connection. This line will be used for a daily synchronization between the database, Google apps and the web-based MIS/ GIS portal Lizard.
- › Hosting environment for Lizard. Preferably somewhere in a datacentre.

4.3 Web-based MIS/ GIS portal Lizard

Lizard is a web-based state-of-the-art MIS/GIS system, used by many water authorities and government agencies in the Netherlands and around the world. Lizard will be configured and customized for the Blue Gold GIS database and needs.

The web-based MIS/ GIS system Lizard will be used to view the current situation, but also for management information (as part of M&E) and to detect trends in time. Figures 7 and 8 show some images of comparable applications based on Lizard.

The exact configuration and further requirements of the web-based system will be described in full detail in a proposal for implementation of a Lizard MIS and Information Portal for Blue Gold.

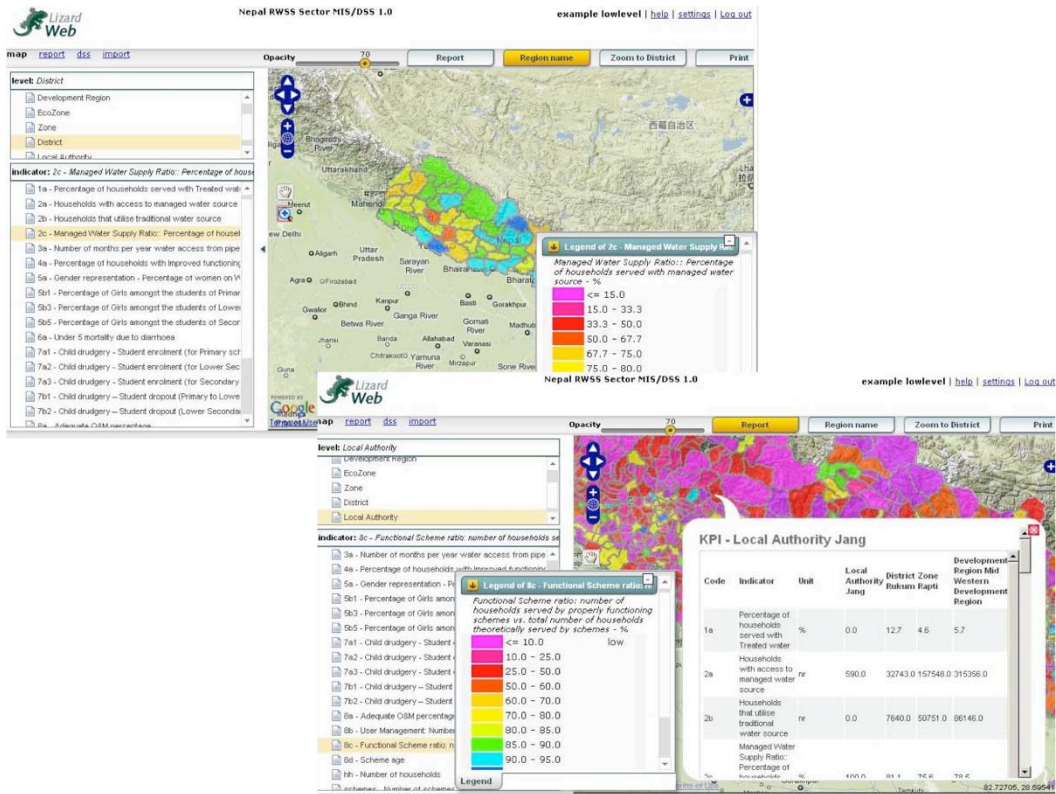


Figure 7: Example of an MIS implementation of Lizard, with all kind of Indicators.

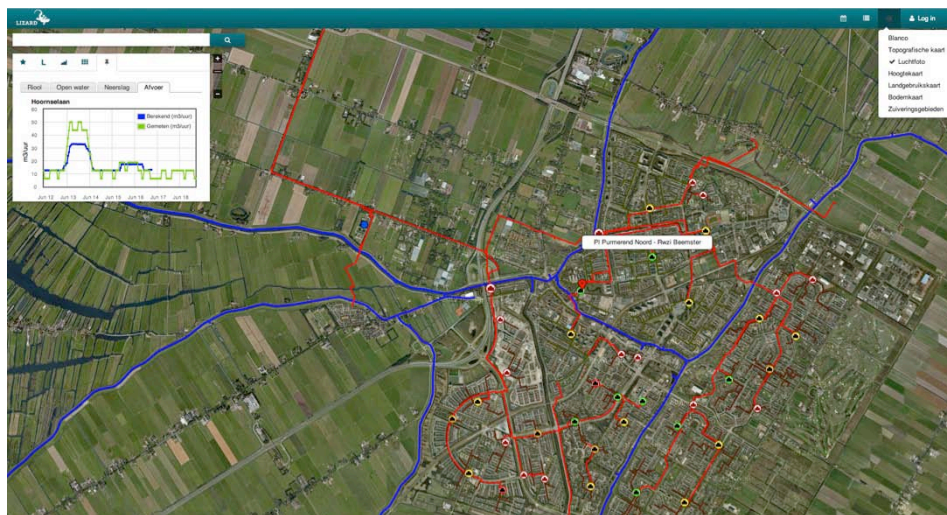


Figure 8: Example of a Lizard application where people can see objects, search locations, ask information about objects. Like Google Maps, but then specific for this project using thematic maps.

4.4 Organization, required capabilities and training needs

For operating the GIS database, perform advanced analyses and support the other users, a Blue Gold GIS team with trained staff is needed.

For the first year, it is recommended that at least three (part-time) people are assigned, who can operate QGIS with support from an (external) GIS expert. The GIS expert is in the lead of setting up the system and builds the capacities of the GIS team. In the following years, the number of people able to operate the QGIS system must be maintained and it is recommended to support the team frequently with GIS experts to get the maximum out of the system and to improve the capacities of the GIS team.

Furthermore it is recommended to have an internal (steering) committee, which will be regularly informed about the progress and possibilities of GIS and could provide ideas and requests from the Blue Gold Components. This committee should consist at least of one person from each Component, a person from M&E and possibly one or two other senior experts.

The following training is recommended for the GIS team:

1. QGIS and Basic GIS knowledge;
2. Data analyses and advanced QGIS use (including analyses with raster data);
3. Making maps (cartography);
4. Working and maintaining Postgres/ PostGIS;
5. On the job training.

And for other staff:

1. GIS for managers. Basics and possibilities of the Blue Gold GIS system;
2. Introduction to Lizard web MIS/ GIS portal;
3. Support in using the system.

Also training in the use of the Open Data Kit is needed.

5. Roadmap

5.1 Development steps

The roadmap of using GIS within the Blue Gold has four major steps:

1. Set up GIS system, GIS data and capacities. The first step is to introduce GIS and GIS data to a small group of trained GIS employees, who can develop and improve the GIS system and GIS data and who can provide the Components with the required data and information. This include:
 - › Installation of GIS software;
 - › Establish GIS team and capacity (including training);
 - › Procure data, start organizing data;
 - › Integrate GIS in data collection.
2. Develop Blue Gold GIS database and make data accessible through a web-based MIS/ GIS portal Lizard. This include:
 - › Development of GIS database;
 - › Set-up portal and configure data visualization;
 - › Fine tuning based on user feedback;
 - › Train the trainer in use of portal.
3. Use, maintain and improve database and system. After the development of the system, it will be used for a few years in the project. Activities include:
 - › Use of GIS system for project activities (data collection, analyses, maps);
 - › Maintain GIS capacities within team and improve GIS analysis capacities;
 - › Maintenance of the system and infrastructure;
 - › Promotion of portal and training of other (potential) users;
 - › Optimise system.
4. Transfer database for data use after project. At the end of the project, the data can be transferred to other databases or organization, so it will be available for (public) use.
 - › Transfer data to other systems;
 - › Handover database to other organizations.

Step 1 and 2 can be realised in 2014. In the next paragraphs, the first two steps are described in more detail. For the second step it is recommended to make a proposal for separate funding through the Blue Gold Water Management Fund. Preferably the development of the database and web-based portal (step 2) is realised in parallel with the introduction of GIS (step 1).

A detailed approach for step 3 should be completed at the end of step 1 and 2 (last quarter of 2014).

5.2 Step 1: Set up GIS system, GIS data and capacities

The first step is to introduce GIS and GIS data to a small group of trained GIS staff, who can develop and improve the GIS system and GIS data and who can provide the Components with the required data and information. Preferably the GIS team gives useful information as fast as possible to engage commitment to

GIS within the project. Also the training of capacities and the use of these capacities 'on the job' must fit to be effective. So a good timing of actions is crucial in this phase.

Table 11 gives a list of actions, including a draft planning. The second step, implementation of a web based MIS/ GIS portal, is added to the planning to match both parallel activities. The establishment of GIS within Blue Gold is divided in four phases:

1. *Prepare*

GIS data and a part of the IT infrastructure is needed for an effective introduction of GIS. The first actions include the procurement of existing GIS data from WARPO (see Table 5 and 6), transform existing AutoCAD data to useful GIS formats and install a central fileserver. Parallel the GIS team and Component staff can start with the design of the questionnaires for structural data collection during fieldwork.

2. *Introduce*

During the introduction the GIS software (QGIS and GIS database) will be installed and some GIS trainings will be given to the GIS team. With the procured GIS data, the GIS team can directly start with organizing and checking the GIS data and make the data available for the Components. During this work, they can get additional training 'on the job'. The outputs are directly useful for the project with an optimal fit between training and bringing the new skills in practice. The central database will be developed based on the procured GIS data and the collected data from surveys and fieldwork. All data will be imported into the central GIS database.

3. *Use*

The system is in place and the GIS team can continue with operating the system, importing new data, check data quality, update metadata, perform analyses and create (custom) maps for the Components.

4. *Improve*

After a few months of operational use of GIS within the Blue Gold Program, the system, the GIS organization, GIS data, and data collection procedures are reviewed and optimised. The final result is a trained GIS team and a GIS system with useful data, which can support the Blue Gold Project during the next few years.

Most activities are carried out by the GIS team, with support of or led by a GIS expert. The design and development of the central GIS database and some advanced training will be a joint activity with step 2, the development of a web-based MIS/ GIS portal.

Table 11: List of activities and planning of step 1, the start-up of GIS, and step 2, the development of a web-based MIS/ GIS portal Lizard.

Description		phase: prepare		Introduce			use			improve		
		jan	feb	mrt	apr	mei	jun	jul	aug	sep	okt	nov
Step 1: Set up GIS system, GIS data and capacities												
<i>Data collection</i>												
Get price indications of data collection with aerial imagery	GIS team											
Get price indications of innovative data collection	N&S/ GIS team											
Procure GIS layers from WARPO	GIS team											
Transform existing topographical survey data (AutoCAD) to suitable GIS format	N&S											
Development of questionnaires for structural data collection of component workers	GIS team/ Components											
Introduction of questionnaires on tablets for component field staff	GIS team/ Components											
Set up guidelines for topographical surveys	GIS team											
<i>System</i>												
Installation of file server	ICT support											
Installation of QGIS	GIS team											
Installation and configuration of central GIS database	GIS expert/ ICT/ N&S											
QGIS introduction training	GIS expert											
QGIS training on the job	GIS expert/ N&S											
<i>Database</i>												
Database development (including survey data, field observations, data of bureau of statistics)	N&S/ GIS team											
Import procured GIS layers	GIS team											
Check layers on accuracy and metadata	GIS team											
Import BBS data	GIS-team/ N&S											
Initial data preparation for use within components	GIS team											
<i>Use and improvement</i>												
Set up maps and some basic GIS analyses	GIS-team											
Introduce metadata guidelines	GIS expert											
Import survey data	GIS team											
On the job training and support	GIS expert											
Improve data collection and processing	GIS team											
Advanced course cartography	GIS expert/ N&S											
Check information needs and improve/ extend database	GIS team											
Step 2: Web-based MIS/ GIS portal Lizard												
Database development (see step 1)	N&S											
Training QGIS with PostGIS	N&S											
Installation of portal and configure data and data visualisation	N&S											
Develop import from Open Data Kit data to database	N&S											
Release first version	N&S											
Demonstration of Portal and collect feedback for improvements	N&S											
Train the trainer (to small group of Blue Gold staff)	N&S											
Improve Blue Gold MIS/ information portal	N&S											
Advanced portal configuration training (to GIS team)	N&S											

5.3 Step 2: Develop Blue Gold Database and implement web-based MIS/ GIS portal Lizard

Parallel with establishing a GIS system for a trained GIS team, a web-portal will be developed for making the data accessible to the other Blue Gold staff and external stakeholders. Activities include:

- › Development of a central GIS database. Together with the GIS team, a design is made of the database. The database will be configured and installed at the Blue Gold Office. The GIS team will be trained in the operating the database and how to add new data and data types;
- › Installation of Lizard and configuration of Blue Gold data and data visualization.
- › Develop import script for data from Open Data Kit questionnaires.
- › Release of first version of the portal.
- › Demonstration to Blue Gold staff and collection of feedback for improvement of the system and configuration
- › A 'train the trainer' training will be given to a small group of Blue Gold staff.
- › Improve configuration and system based on feedback.
- › Finally the GIS team will get an advanced portal configuration training.

6. Conclusions and recommendations

6.1 Conclusions

The objective of this report is to decide - based on the outcome of the inventory - whether or not to proceed with the development of a GIS platform, including a web-based MIS/GIS portal.

The conclusion is that the development of a GIS platform, including a web-based MIS/GIS portal is recommended.

The conclusion from the inventory of the information needs is that maps and the spatial dimension of data are important for all Blue Gold Components.

At this moment, there are no GIS data available within Blue Gold in a digital GIS format. A lot of GIS data are available for the coastal region at WARPO, but most data do not have the required level of detail or are recent enough for use in Blue Gold. Consequently, a lot of data have to be collected and generated by Blue Gold itself. The topographical surveys, the base line survey and data collection during fieldwork could generate a lot of the required data. Guidelines and tools like tablets with GPS and questionnaires are required to collect useful GIS data. With additional data from specific consultancy services or innovative solutions like remote sensing from satellites and small planes, most of the required data can be made available.

The preferred situation is that the geo and management information is easily accessible for the Blue Gold staff and stakeholders. The user can find the required (GIS) information quickly and visualise the information in maps, tables and graphs. A state-of-the-art GIS platform, including a web-based MIS/GIS portal for easy access to the data is required to reach this preferred situation. Pre-condition for such a system is a well-organized GIS database.

A Blue Gold GIS team with trained staff is needed to operate the GIS database, import data, carry out advanced analyses and support the other users.

The GIS platform, including a web-based portal and a lot of the required data, could be developed within a year.

6.2 Recommendations

It is recommended to set up a GIS system, including a web-based MIS/ GIS portal Lizard as soon as possible. The roadmap for setting up such a system is elaborated in Chapter 5. The first steps include:

- > Assign staff to the GIS team;
- > Find a (local) GIS expert to support the development of the GIS system and GIS capacities of the team during the first year;
- > Make a proposal for the web-based MIS/ GIS portal Lizard;
- > Procure the GIS data from WARPO and start other data collection.
- > Start installation of software, training and development of GIS database and web-based portal.

The recommendation for data collection is to:

1. Start with the freely available maps.
2. Procure GIS data from WARPO (see Table 5 en 6).
3. Make guidelines for detailed topographical surveys of polders based on aerial imagery and field surveys.
4. Create and update (GIS) data during regular fieldwork, formalize data collection with the Open Data Kit (ODK) and digitalization of hand-drafted maps.
5. Create project specific layers by Blue Gold GIS experts, field workers with GPS devices and join layers with available information tables.
6. Look at innovative options, like small planes and remote sensing.
7. Use consultancy services for specific information consuming analyses (IWM/ CEGIS) or advanced processing (IRRI).

7. Literature

Documents:

Blue Gold Inception Report

Blue Gold M&E Report, December 2013

WARPO lists and metadata documents (links for download):

http://www.warpo.gov.bd/pdf/icrd_Data_list.pdf

http://www.warpo.gov.bd/pdf/nwrdr_Data_list.pdf

<http://www.warpo.gov.bd/pdf/Datacatalogue.pdf>

http://www.warpo.gov.bd/pdf/ICRD_Datacatalogue.pdf

Websites:

Open Data Kit website: <http://opendatakit.org>

Sensefly website: <https://www.sensefly.com/>

QGIS: <http://www.qgis.com>

Postgres and PostGIS: <http://www.postgresql.org/> and <http://postgis.net/>

Appendix 1 Summary of information needs and possible sources

The Table in this Appendix is a combination of the required GIS data (Chapter 2) and the possible sources to procure or collect this data (Chapter 3). A more detailed list of layers can be found in the paragraphs of Chapter 3.

Name	Get information from
Polders	Procure from WARPO
Embankments	<ol style="list-style-type: none"> 1. Based on Polder layer 2. Refine with Topographical survey and aerial imagery, includes current status and cross sections 3. Update of status with field survey
Water bodies (ponds, channels, etc.)	Topographical survey with aerial imagery
Drainage system	Topographical survey with aerial imagery
Irrigation system	Topographical survey with aerial imagery
Digital elevation models	<ol style="list-style-type: none"> 1. Procure from WARPO 2. Improve with sensing with small planes or with a topographical filed survey
Crop maps and cropping patterns	Low resolution maps: Procure from WARPO High resolution maps: Remote sensing
WMG boundaries	Based on village boundaries. Data collection as part of WMG surveys,
Administrative boundaries	<ol style="list-style-type: none"> 1. Procure from WARPO. 2. Data collection during WMG surveys. 3. Field work with GPS/ digitize maps
Roads and water ways	<ol style="list-style-type: none"> 1. WARPO 2. Topographical survey with aerial imagery 3. Road status and waterways as part of fieldwork of Component 4
Electricity, water.	<ol style="list-style-type: none"> 1. Baseline survey 2. Update: WMG survey
Hydrological system in polders	<ol style="list-style-type: none"> 1. Aerial imagery combined with topographical survey (cross sections, structures and current status) 2. Field work of Component 2 staff using GPS and maps 3. Use elevation maps for identify catchments 4. As part of WMG survey (village mapping). Includes current status of infrastructure and problems
Land use	<ol style="list-style-type: none"> 1. Procure from WARPO
Urban area's/ houses	<ol style="list-style-type: none"> 1. Procure from WARPO (data available for some polders) 2. Optionally based on aerial imagery

Crop suitability maps	Low resolution maps: Procure from WARPO High resolution maps: Process using IRRRI algorithms (with detailed input information of polders)
Basic services, Health institutions, education institutions, cultural and religions institutions	1. Procure from WARPO 2. Update: WMG surveys
Water pumps, etc.	WMG surveys
Active NGO's CBO's and other projects and organizations	WMG surveys/ lists for NGO's (joined to administrative boundaries)
Natural resources	WMG survey
Locations with water management problems and conflicts in water use	WMG survey
Presence and boundaries of WMA's, Farmers' Groups, Fishermen Associations, Women's Groups,	WMG survey
Historic weather information	NOA weather stations http://www.ncdc.noaa.gov/
Aerial images	Google Maps

Appendix 2 Mission activities

Date	Activity	Place	People met
20/11/2013	Start meeting – Specify needs Introduction to Blue Gold	Mott MacDonald office (0,5 d)	Dirk Smits (TL), Mofazzal Ahmed, Aveek Mahmudur Rahman, M Abdullah Abu Diyan
21	Meeting with IRRI – Web Portal and GIS data Meeting with M&E expert	Blue Gold office Motijheel (1 d)	Parvesh Kr Chandna (IRRI) Andrew Nelson (IRRI) Geert Rhebergen (M&E) Kim Janssen (Environment and M&E)
22	Introduction to Blue Gold (Inception Report)/ Refining approach	Hotel (1 d)	
25	Meeting at IWM to identify available GIS data	IWM (0,5 d)	Mr. Esraz UI Zannat (IWM)
26	Identification of needs – Component 2 Inventory of free available data and IWM data	Mott MacDonald office (1 d)	Dirk Smits, Mofazzal Ahmed
27	Meeting at CEGIS to identify available GIS data Identification of needs – Components 3 and 4	CEGIS Mott MacDonald office (1 d)	CEGIS: Malik Fida A Khan A. Kashem Md. Hasan Blue Gold: Hein Bijlmakers (Comp. 3) Karel T' Jonck (Comp. 4)
30	Presentation of Delta alliance		World Fish: Erik H.J. Keus
01/12/2013	Meeting with WARPO Layers, infrastructure and road map Identification of needs – Component 1	WARPO office Mott MacDonald office (1d)	Mr. Siddiqur Rahman (WARPO) Vicki Pineda (Comp. 1)
2	Layers, infrastructure and road map Presentation of Blue Gold GIS plan → Blue Gold staff Discussion with Diyan about follow-up	Mott MacDonald office (1d)	

3	Netherlands Embassy (EKN) Meeting with Dirk Smits about next steps	Dutch Embassy Dhaka Mott MacDonald office (0,5 d)	Martin Bos (EKN) Michiel Slotema (EKN)
4	Departure to the Netherlands		
15	Skype meeting with Diyan	Netherlands	