Published by:

Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

In cooperation with

Spatial planning and applications of GIS and remote sensing for IDDRSI

Vol II:

Module 1: Agro-Pastoral Production Systems and Natural Resources Management;

1.1 WATER RESOURCE MANAGEMENT

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MODULE 1: AGRO-PASTORAL PRODUCTION SYSTEMS AND NATURAL RESOURCES MANAGEMENT

1. GENERAL

The reference to the word 'agro-pastoral' is done in a generic way and includes both pastoral and agro-pastoral livelihoods. Module 1: 'Agro-Pastoral Production Systems and Natural Resource Management' includes sub-priority intervention areas from PIA 1 and PIA 3a (see figure 20). PIA 1 is defined as: "Environment and Natural Resources Management ". It has the strategic objective to "promote sustainable ecosystem rehabilitation, management and equitable access to environmental resources including water, pasture, range and land". PIA 1 includes the following thematic areas[1]:

1.1 Water resources development and management;
1.2 Pasture and land management;
1.3 Securing equal access to natural resources;
1.4 Environmental management (including renewable energy and bio-diversity);
1.5 Strengthening pollution control in IGAD region.

It was decided to combine this with the productive functions of pastoral land use in PIA 3a: Livehood support and Basic Social Services. Specifically the following sub-themes are included in Module 1:

3.1 Livestock production;
3.2 Agriculture production;
3.13 Develop and implement an integrated development plan for trans-boundary pastoral area.

Above thematic content of this Module 1 is structured into three chapters describing **spatial planning** for:

- **1.1 Water resource management**
- **1.2 Livestock and crop production and**
- **1.3 Ecosystems and natural resource management**

[1] IGAD IDDRSI strategy January 2013.

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1. INTRODUCTION

Especially in IGAD’s Arid and Semi-arid Lands (ASALs), fresh water resources include especially surface water, groundwater and open water bodies including sizeable wetlands in Uganda, Ethiopia and South Sudan and Sudan. Water resources provide multiple functions including drinking water and sanitation, agriculture, manufacturing, transport and fisheries – by providing habitat for fish species for food and trade. Key problems of water resources in IGAD countries relate to water shortages and surplus through drought –aggravated by climate change- in combination with overuse and flooding. Invasive species have increased water uptake in certain areas. Rapid urbanization has led to urban encroachment into areas previously covered by surface water and riparian areas. Waste water treatment and sanitation are poor in many areas negatively impacting water quality. Poor sanitation practices also leads to increased risk of waterborne diseases. Many water related problems are the result of disordered and ill-conceived land use developments. Land and water resource management are closely related, in both rural and urban settings. Water resources in IGAD region are characterized by trans-boundary rivers, catchments and aquifers. Water management has an important cross border dimension and requires collaboration between member states. This is illustrated in box 1.

In this chapter we discuss the specifics of spatial planning for water resources management. Below cross cutting aspects are highlighted. Subsequently, following the steps presented in chapter 4, we reflect on specifics of spatial planning for water resource management.

2. CROSS CUTTING ASPECTS

2.1 DISASTER RISK MANAGEMENT

Water resource management is a crucial aspect of disaster risk management in IGAD where weather related disasters drought and flooding occur frequently. Increasing variability in rainfall leads to increasing occurrence of flooding. Remote sensing and GIS are indispensable for the monitoring of weather and other hydrological variables and for mapping of areas with flood hazards and risk. Hazards map timing, duration, extent and depth of flooding, whereas risk includes the location and characteristics of people, property, infrastructure and social services that either aggravate risk, or can be used in case of evacuations. Spatial planning helps to reduce hazards by reserving sufficient space for flood areas by zoning and planning of dykes and other protection measures to reduce risks for loss of live and damage to buildings and infrastructure. Drought risk is the other important aspect and drought monitoring and contingency planning of water resources in drought conditions is to be included on spatial planning for water resources management.

2.2 CONFLICT

Access to water is one of the most important reasons for regional and local conflicts in IGAD member states. Equitable access to water is seen as a pre-condition for absence of conflict. Integrated Water Resource Management (IWRM) is considered a post conflict approach by the United Nations Environment Programme (UNEP). In ASALs, water related conflicts occur and need to be addressed at different levels. For instance, use of trans-boundary rivers for hydro-electric power and especially irrigation schemes may create conflicts and diplomatic challenges between (member) states. At the local level, increasing competition over limited water supplies turns traditional dug-outs into 'flashpoints' for conflicts between farmers and pastoralists [UNEP, 2008[2]]. Cap-Net (2008) related the cause of many conflict to sectoral development, based in a narrow understanding of water into development. It presents IWRM as a means for conflict resolution by bringing together sectoral interests that are to be managed holistically for benefit of all. Also, it argues that while conflicts over water develop, there a more encouraging examples of successful cooperation leading to agreements and consensus over use of water resources.

2.3 GENDER

Roles and responsibilities of water management at local level are gender dependent. In many communities women are responsible for collecting water for the households. Dwindling water sources means more time is spend on fetching water than on other tasks. Gender dis-aggregated participation is crucial in spatial planning for water resource management to get relevant and accurate information on location of water points, the time required to get to these water points, issues regarding access, risks and security they face on the way. All these aspects can be depicted on maps so spatial planning can consider them. This should lead to interests of women as specific stakeholders be included in decision on locations for water services.

[2] UNEP, 2007. Sudan Post-conflict Environmental Assessment. http://postconflict.unep.ch/publications/sudan/10_freshwater.pdf

BOX 1: IGAD REGIONAL WATER PROTOCOL

IGAD, together with the International Union for the Conservation of Nature (IUCN) work on improving cross-border water management in IGAD. End 2015, IGAD established a committee to negotiate and finalize the **IGAD Regional Water Protocol.** The overall objective of the Protocol is to promote closer cooperation in the equitable, sustainable and coordinated utilization, protection, conservation and management of trans-boundary and shared water resources in the IGAD region[1]. The Protocol requires member states while using shared water resources to take measures to prevent the causing of significant harm to other IGAD countries. 'A basin or catchment approach is taken into account when water resources developments are planned and implemented, territorial boundaries notwithstanding'.

Data and information is a prerequisite for the planning, management and development of shared water resources and related projects. As such, the protocol requires IGAD member states sharing transboundary water resources **to regularly exchange data and information** on conditions of their trans-boundary water resources, and in particular data and information of a hydrological, meteorological, hydrogeological and ecological nature[2].

The Protocol provides for the establishment and operationalization of a set of institutions with responsibility for different aspects of implementation protocols such as monitoring and coordination of activities, policy making, technical support and the design of regional strategic plans.

1) : http://igad.int/
2) : http://www.iucn.org/news_homepage/all_news_by_theme/water_news/?21715

3. SPATIAL PLANNING FOR WATER RESOURCE MANAGEMENT

Spatial planning is an important instrument to achieve goals in improved water resource planning and management. To address the need for multi-sector approach this instrument is referred to as Integrated Water Resource Management (IWRM). IWRM is an internationally renowned approach that promotes:

- Management of the whole resource on a catchment basis; integrating domestic, agricultural, industrial and environmental needs rather than considering each demand in isolation;
- Participatory processes with representation of water users;
- Emphasising the role of women in water management; and
- Balancing economic efficiency, ecosystem sustainability and social equity.

Land and water resources are closely related and water management issues have a strong spatial dimension. Through Water Assessment as part of Integrated Water Resources Management, water issues can be integrated into spatial planning. This process is elaborated according to the ten steps of spatial planning in paragraphs 3.1 -3.10 below.

3.1 IDENTIFY NEED AND AUTHORITY

3.1.1 Establish the need for spatial planning for water resource management

Specific issues to be addressed through special planning need to be defined. These could include

- Access to safe drinking water and inadequate sanitation;
- Pollution of surface and groundwater;
- Irrigation and agricultural yields;
- Hydro-power production;
- Navigation and fisheries;
- Flooding problems.

3.1.2 Establish the appropriate authority

The initiative for the planning may have been taken by the responsible authority for the water sector, a Ministry or Department of Water or Environment. Nevertheless, it is important to establish the ***authority for the planning exercise*** with the institution and legislation through which the plan can be enforced. This will be described in a country's land or spatial planning policy.

Integrated catchment based management is considered the most appropriate tool to deliver IWRM[3]. A spatial plan in this context coordinates water sector management in an integrated multi-sector plan. Therefore river basin or catchment organizations are increasingly promoted as vehicles to implement these plans and assume the ***authority for implementation***. River basin or catchment authorities can be structured in different ways, with different levels of legal power and functional responsibility, see table 1.

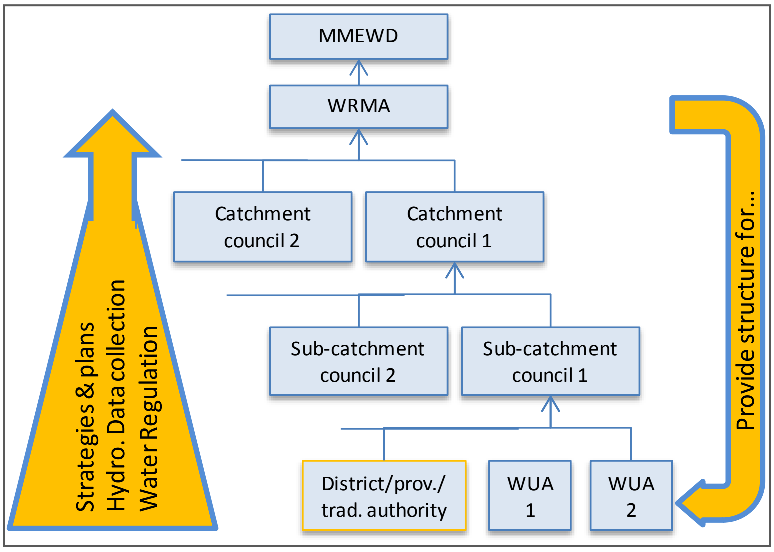
[3] Jaspers, K. 2014. Towards Integrated Water resources Management. International experience in development of river basin organizations. UNEP. http://www.unep.org/

Table 1: Types of catchment or river basin authorities[2])

Type of Organization	Mandate	Law
Commission	Council, committees with coordinating mandate	Jurisdiction from central government
Authority	All mandates of independent, single purpose organization	Jurisdiction attributed by law establishing it.
Agency	Specially created bodies created at arms-length and under direct supervision of government	Special law required to equip these agencies.
Partnership	Voluntary organization	Private law, little jurisdiction

An example of how the water sector is structured and mandated is the recently restructured Ministry of Water in Zambia which prepared an Act partly replacing its Department of Water and Provincial Water Departments by a Water Resources Management Authority under which Catchment and Sub-catchment Authorities -multi-stakeholder authorities – resort. These are linked with water institutions in administrative units as represented in figure 21. Decision making is decentralized to the level of sub-catchment authorities, with a strong role for water users represented by Water User Associations including local level organizations like irrigation committees, town water councils and rural district council.

Figure 1: Institutional framework for water resource management (GFA Zambia, int comm 2015)



3.2 PREPARE FINANCIAL PLAN

Funding sources for implementation

A proportion of the costs for water use for irrigation, domestic and industry uses should be recovered through fees charged to water users. Many governments have permit systems in place to manage this system. Also discharge of effluent and wastewater can be managed through licensing and revenue systems that put the principle 'polluter pays' in practice. Payment for ecosystem services can be put in practice in water management. Upstream soil and forest conservation increases potential water availability and quality. Downstream water users and dam operators can contribute to funds that are used as incentives for water and soil conservation measures by upstream land owners.

3.3 ORGANIZE THE PROCESS AND PLAN THE PLAN

3.3.1 Build spatial planning team

In addition to key functions listed in table 2 in the overall booklet, specific water related expertise is to be added to the team. In IGAD ASAL areas, expertise might include surface and groundwater hydrologists. Experts in pastoral water use may need to be added, as well as community development and gender, given the strong division of tasks between men and women related to water collection.

3.3.2 Develop the work plan

The plan for the spatial planning for water resources will contain the same steps as in paragraph 4.3. The design of the corresponding information system is closely linked to that of IWRM. An example of an Integrated Water Resource Management Information System provided in box 14.

3.3.3 Boundaries

Spatial planning for water management benefits from logical boundaries. Logical boundaries of planning units would comprise of (sub-) catchments or watersheds. This is because upstream resource use determines the potential water use downstream. Groundwater resources have their own recharge sources, which may be a long distance from actual springs, wells and boreholes.

IGAD's ASAL areas host some large cross border catchments notably Victoria-Nile basin-, Juba-Shabelle basin, and Turkana basin, see figure 23. In cross border catchments countries need to cooperate to manage droughts or floods. Transboundary water resource management requires shared responsibilities and cooperation leading to joint resource management. The main problems to make this work include[4]:

a) conflicting agendas and lack of trust and political willingness between countries;
b) climate change, population growth, increasing challenges in eco-systems, energy, food-supply;
c) data sharing is limited;
d) investment in upstream countries affects water quantity and/or quality downstream.

Planning units and corresponding scales can vary from the large international transboundary basins to small watersheds. Whichever the scale, spatial planning and IWRM must link between different levels as well as integrating multi-sector and stakeholder dialogue by level[6].

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[4] Global water Partnership. Toolbox Integrated water resources Management. http://www.gwp.org/en/ToolBox/CROSS-CUTTING-ISSUES1/Transboundary/

BOX 2: INTEGRATED WATER RESOURCE MANAGEMENT INFORMATION SYSTEMS (IWRMIS)

IWRMIS or Water Information Systems enable water resource management authorities to bring together and manage all information that is important for IWRM. They contain modules for:

- Meteorological data;
- Surface water hydrology;
- Hydro-geology and groundwater hydrology;
- Water usage and water rights;
- Water quality.

An example is the South Sudan Water Information Clearing House (SSWICH) [9] and a similar IWRMIS in Zambia [10] which includes a hardware component and software tools that integrate a hydro-meteorological information system (HIS) fed by hydrometric data on meteorological, surface and groundwater conditions, with water use and data from other sectors into an sequence of systems for: Water Information management (WIS)=> decision support(DSS) => knowledge management (KMS). These include GIS and database, procedures for collecting, storing, analyzing and disseminating water related information, links to water usage and permitting in order to support the generation of yearbooks with water balances, catchment plans and decisions on water permits as well as links to parallel systems, see figure 22. In IGAD the **Hydrological Cycle Observing System (HYCOS)** project is designed to promote sustainable and integrated water resources development and management in the IGAD region through enhancement of regional cooperation and collaboration in the collection, analysis, dissemination and exchange of hydrological and hydro-meteorological data and information for water resources assessment, monitoring and management. For that purpose the project aims at providing adequate infrastructure for hydrological observations and appropriate regional cooperation in information exchange among the IGAD countries [IGAD, 2012b].

Figure 2: Example of a Water Information System including geo-information components

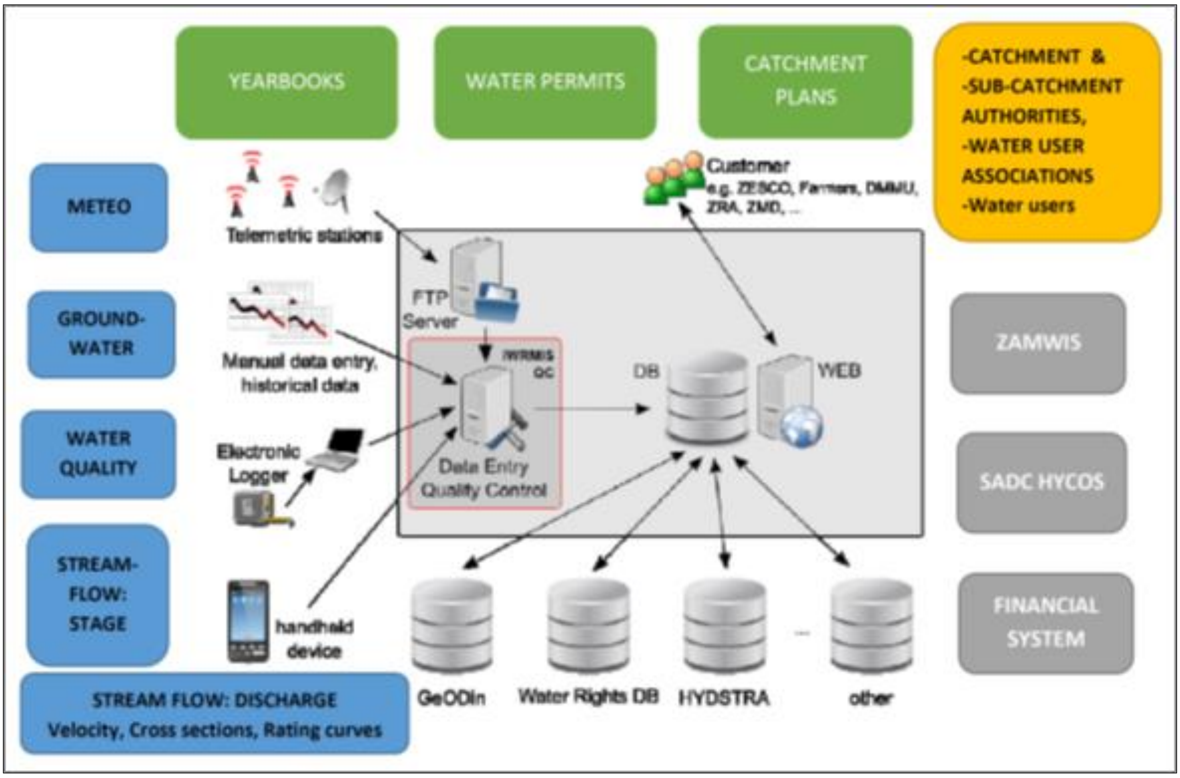


Figure 3: Location and rainfall in three main cross border catchments in IGAD region:
1: Juba Shabelle basin, 2: Turkana basin; 3 Nile-Victoria Basin: location and rainfall [5].

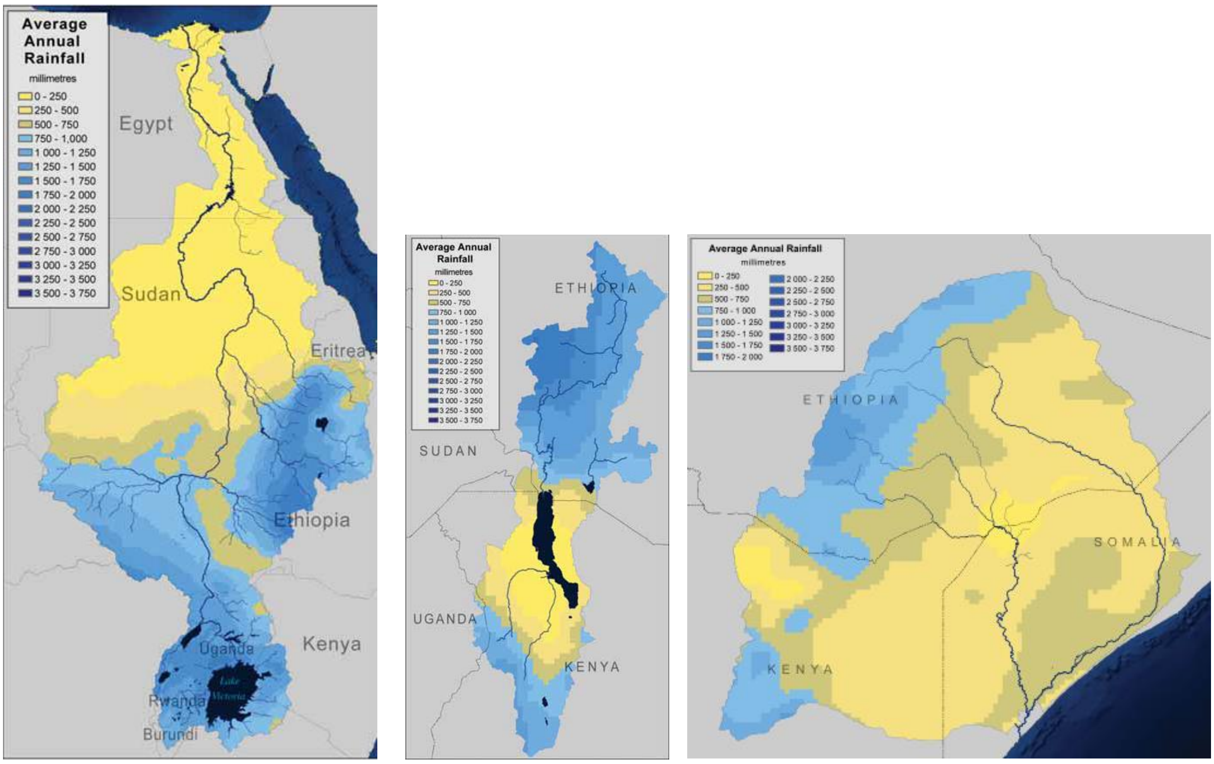
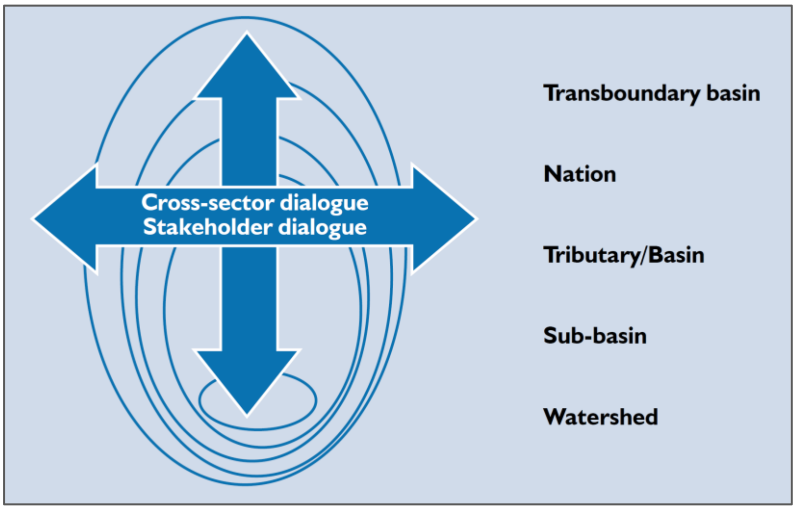


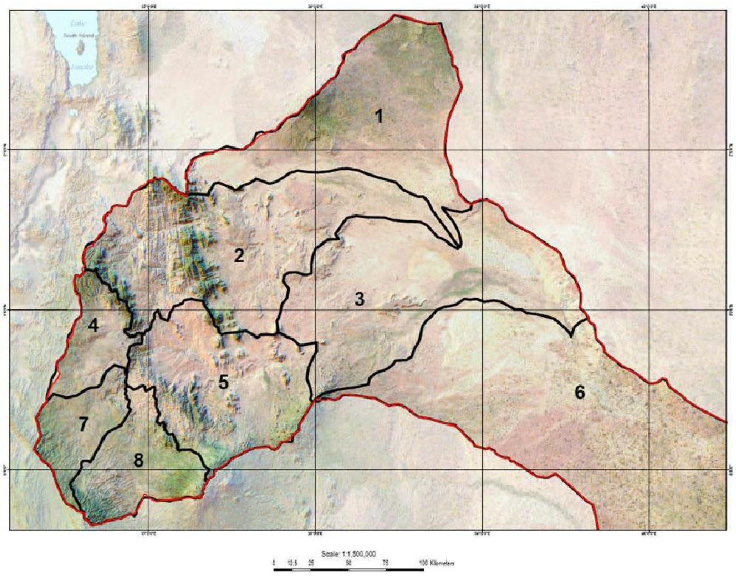
Figure 4: Vertical and horizontal integration in IWRM and spatial planning [Ehler, 2009]



At more detailed levels, boundaries of (sub-) planning areas can be delineated using remote sensing data. For the Ewaso Ng'iro basin in Kenya sub-catchments were delineated using a digital elevation model (DEM) derived from ASTER data [Ericksen et al, 2011]

[5] UNEP, 2010. Africa Water Atlas.

Figure 5: Eight sub-catchments of Ewaso Ng'iro catchment obtained from ASTER data.



3.3.4 Guiding principles

Guiding principles help to guide the spatial planning approach and balancing of competing land uses. The so-called Dublin Principles of 1992 have become guiding principles for IWRM and are a widespread interpretation that IWRM is to achieve [Smit % Clausen, 2015]:

1) that fresh water is a finite and vulnerable resource, essential to sustain life, development and the environment;
2) that water development and management should be based on a participatory approach, involving users, planners and policy-makers at all levels;
3) that women play a central part in the provision, management and safeguarding of water;
4) that water has an economic value in all its competing uses and should be recognized as an economic good.

3.3.5 Main goals:

Water resource management is a key element of PIA 1. The goals of the IDDRSI strategy in relation to water was defined as: "Sustainable water resource management and regional cooperation in water management in the ASALs". IGAD Regional programming paper results framework summarizes the following with regard to water management[6]:

Outputs: Water resources are managed sustainable and equitable access is ensured

Indicator: Number of hydrological assessments conducted covering IGAD region and disclosed water resources maps.

Baseline: less than 15% of people and 20% of livestock access water easily.

Priority interventions and key activities:

1.1) Development and sustainable management of trans-boundary surface and underground water resources

1.2) Mapping of shared resources and feasibility studies

[6] IGAD Regional Programming Paper (RPP) for the Drought Disaster Resilience and Sustainability Initiative, January 2013.

1.12) Development of strategic water points [+grazing areas…] along pastoral and trade routes;
1.16) Development of watershed management in potential trans-boundary areas.

Above are goals that can help to define the aims of a spatial plan at regional level. At other levels, national, district or local level goals will need to be adapted to the specific issues and conditions in the area where the spatial planning is undertaken.

3.4 ORGANIZE STAKEHOLDER PARTICIPATION

Stakeholder participation is crucial in water resource management. Without participation of stakeholders in decision making this process is highly ineffective. Lack of participation may lead to issues in implementation and lack of enforcement of planned management measures. Stakeholder participation is strongly related to the need to decentralization of water management at the lowest level. Therefore representation of stakeholders can best be organized by including them in the way catchment based, or river basin authorities function. They include water users and water suppliers and can include individual farmers, private sector, hydropower companies, drinking water companies. These users can be organized in water user groups or associations, but often small farmers, though credible water users, are not organized and not part of the process. One should be careful to include these small water users. Also, it is vital to include downstream stakeholders in the plan process. At government level, responsibilities in water management and irrigated agriculture can between ministries responsible for: water resources, dams, hydropower, irrigation; agriculture, forestry; lands, physical planning, environment.

3.5 DEFINE AND ANALYZE PRESENT SITUATION

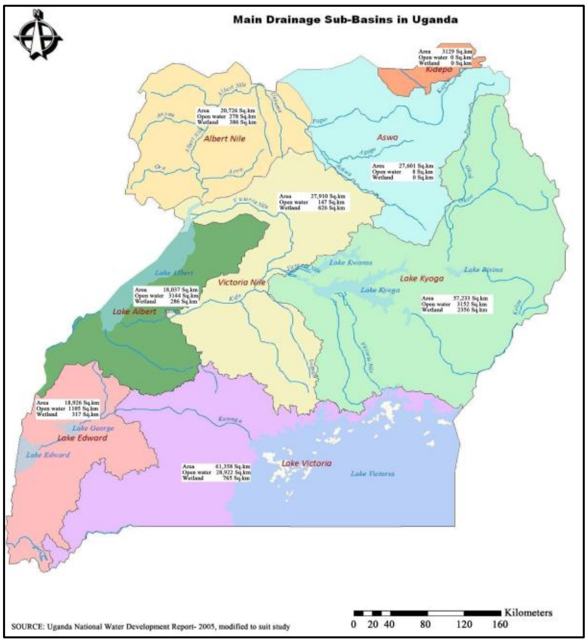
3.5.1 Baseline information on important themes for water resources

It is important to define the information to be presented and collected in relation to the objectives and goals of the planning program. Baseline data includes:

- Baseline statistics:
  Administrative areas, topographic features including infrastructure, built up areas, contour lines, utilities. Rivers, stream, water bodies, lakes;
- Agriculture areas, livestock movements;
- Climate: rainfall, temperature, seasonality, evaporation, wind speed;
- Land use and land cover;
- Social and economic: population, GDP, migration, urban-rural population;
- Surface water resources, Wetlands, Rivers;
- Groundwater systems: groundwater catchments, seepage and infiltration areas;
- International water issues: rivers and aquifers.

Surface water resources are accessed by basin. Each basin can be subdivided into river systems that can be perennial or seasonal. Figure 26 gives an example from Uganda on how GIS is used to analyze and present this data from Uganda.

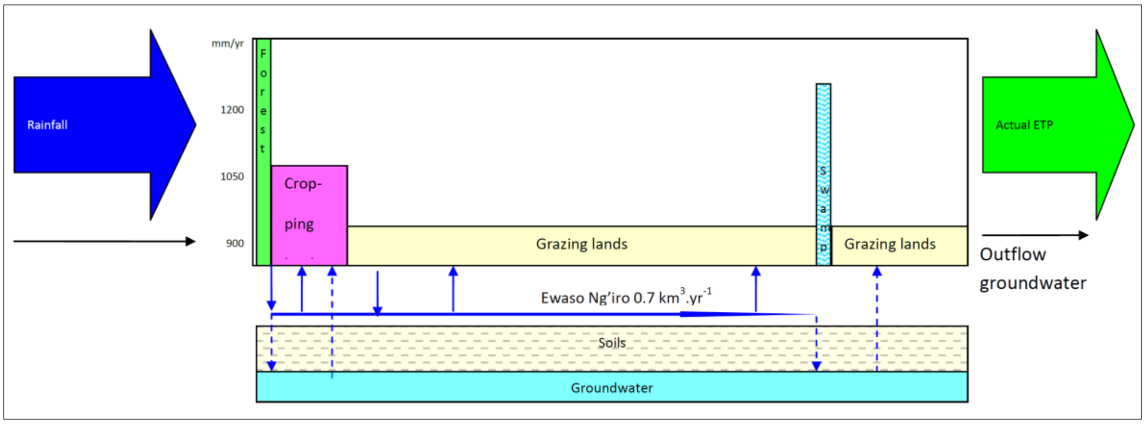
Figure 6: Main drainage basins in Uganda with area statistics [Nsubuga et al 2014]



Water resources of renewable freshwater resources includes figures from **water balances** (see figure 27) that relate input from rainfall, losses from evaporation, unavailable amounts from cross border (international or sub-national) agreements, and amounts available to users [7]:

- Precipitation in mm/yr and m3/yr;
- Internal renewable water resources (long term average) in m3/yr;
- Dependency ratio (% of total renewable water originating outside the area -country);
- Total renewable water resources per inhabitant (in m3/yr), called TARWR, which indicates the human pressure on renewable water resources;
- Total dam capacity.

Figure 7: Model of hydrological balance of Ewaso Ng'iro catchment, Kenya [Ericksen et al 2011]

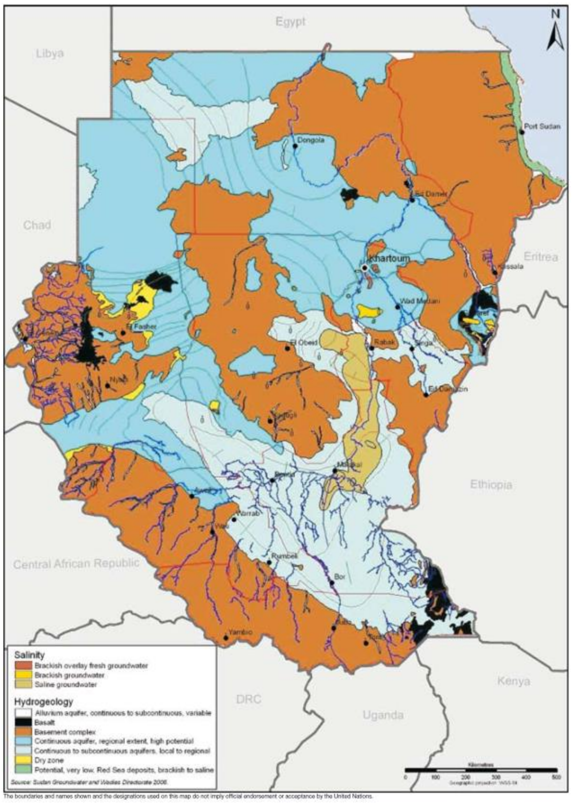


Also groundwater resources need to be assessed and mapped including depth of aquifers, quality and salinity, recharge, for example as in figure 28. In addition several other important themes need

[7] FAO, 2015. Aquastat: http://www.fao.org/nr/water/aquastat/countries_regions/SSD/index.stm

to be incorporated in the baseline: catchment boundaries, locations of streams, rivers, water bodies, wetlands, land-cover including forest area, agriculture, build up areas, industry.

Figure 8: Groundwater resources Sudan[8]



3.5.2 Collection and mapping of current water use, policy and regulations

Water use defines the total amount of water that is withdrawn from the plan-area. It is indicated by sector including agriculture, municipal and industry. Water use can be standardized in m3/yr per inhabitant.

a) Water use can be summarized as:
- Total water withdrawal (m3/yr) by Agriculture, Municipal, Industry;
- Total water withdrawal per inhabitant (m3/yr);
- Surface and groundwater withdrawals (m3/yr);
- As % of total renewable water resources (%);
- Non-conventional sources of water (re-used);
- Location of improved drinking water & sanitation.

b) Irrigation and drainage information includes:
- Potential irrigation areas: lowlands, land bordering riverine floodplains and land around swamps and marshes;
- Current irrigation area, including full control schemes and equipped lowlands and spate (flood) irrigation and sources – surface or groundwater as well as crop type and acreages.

[8] UNEP. 2007, Sudan Post-conflict environmental assessment

c) Information on current zoning and regulations that protect features that are important for water management. These may include:
   - Zoning of upstream, riparian areas forests;
   - Flood control measures by zoning for water retention;
   - Groundwater infiltration areas from pollution;
   - Regulate farming on steep slopes to avoid erosion, siltation;
   - Regulations on access to water points to avoid damage and monopolization.

3.5.3 Current constraints and conflicts

Above facts and distribution of resources and use should be analyzed to identify constraints in water availability and quality, issues of competition, including hotspots for rainfall patterns and intensity Models are used to evaluate planning and management issues associated with water resources development, for instance the Water Evaluation and Planning model (WEAP).
Issues that are commonly listed include:

- Large dams: can be a cornerstone of development (hydropower, irrigation) but also have negative impacts on environment. Especially performance problems because of upstream land degradation and downstream impacts due to altered water flow regime [7]);
- Shortage of drinking water for people and livestock due to restricted access, availability or quality. Competition for water between livestock keepers and farmers;
- Degradation of forest cover in upper catchments, water towers, catchment condition protection and management: water towers;
- Availability of water for irrigation;
- Groundwater quality;
- Water quality: locations of treatment and discharge of sewerage and industrial effluent and waste in relation to water intake points and groundwater infiltration. Reduced hydro-biological quality.
- Flood maps: extent, depth, occurrence.

3.6 DEFINE FUTURE SITUATION AND ALTERNATIVES

3.6.1 Autonomous developments: current trends and needs

Trends in population, water use and withdrawals have been established internationally and at the level of countries. Translating these to local conditions is important to project the situation of indicators by the end of the plan period, 10, 15 or 20 years. One method is to extrapolate historical development under same or accelerated rates.

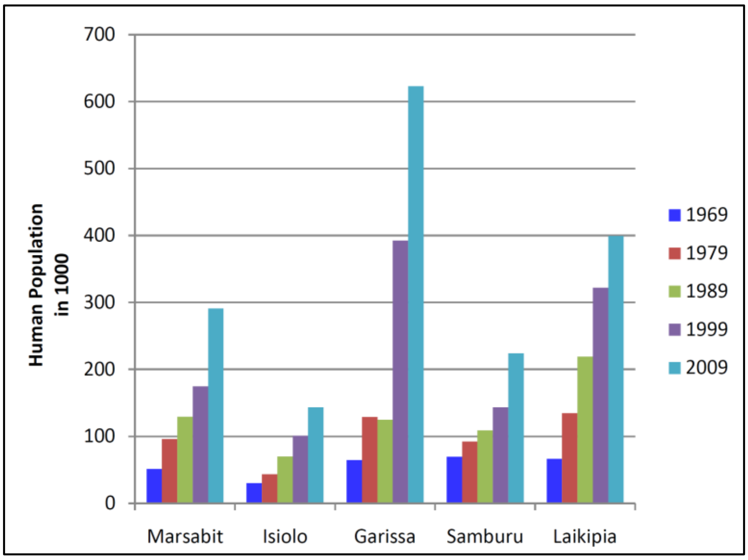
Key trends to include in planning:

- Water catchments' ability to provide water services: rate of land cover and land use change;
- Trends that influence demand (both in upstream and transboundary context):
  -population (see figure 29), migration, urbanization;
  -economic development and related per capita water use;
  -planned industry expansion and industry withdrawals;
  -trends in use of water points, well, pans, ponds used by pastoralists;

-irrigated agriculture: location, number and volume applications for permits;
-energy demand and planning of new dams.

- Water quality:
  -Development in quality of surface and groundwater: Dissolved oxygen Demand (DOD) and Biological Oxygen demand (BOD);
- Streamflow: how is flow projected to change? both peak flow and base flow;
- Flooding: changes in catchment characteristics and rainfall intensity affect the frequency and severity of peak flow and flooding. Flooding is important theme in disaster risk management.

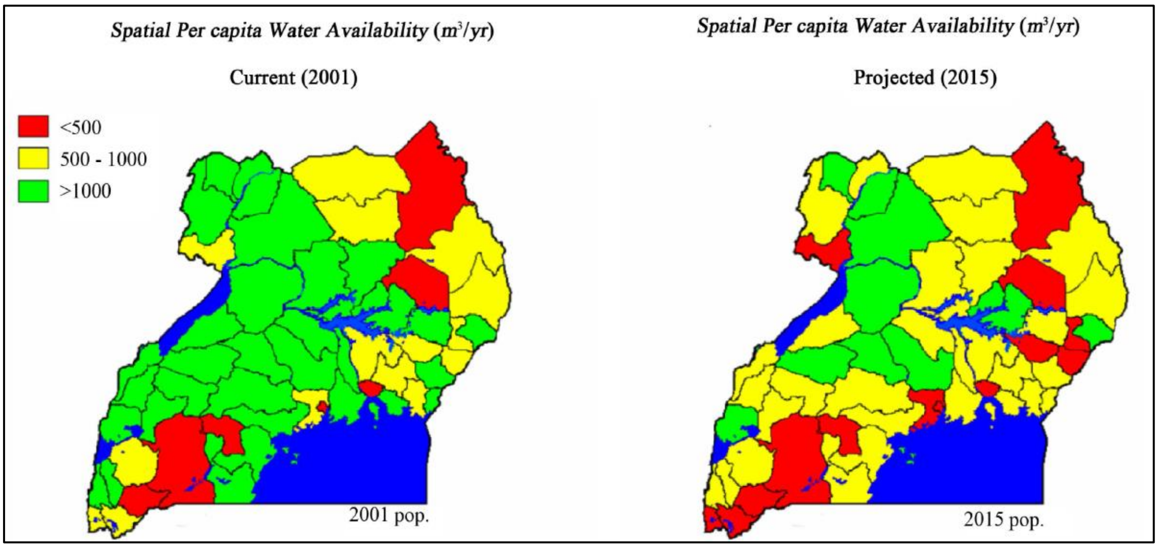
Figure 9: Human population trend in six districts in Kenya between 1969 and 2009 (Ericksen et.al. 2011)



3.6.2 Estimate requirements

- Water withdrawals: how will demand for water develop under above projections (see figure 10)
- What are projections for location and volume of effluent, pollution production;
- Where are development expected to take place.

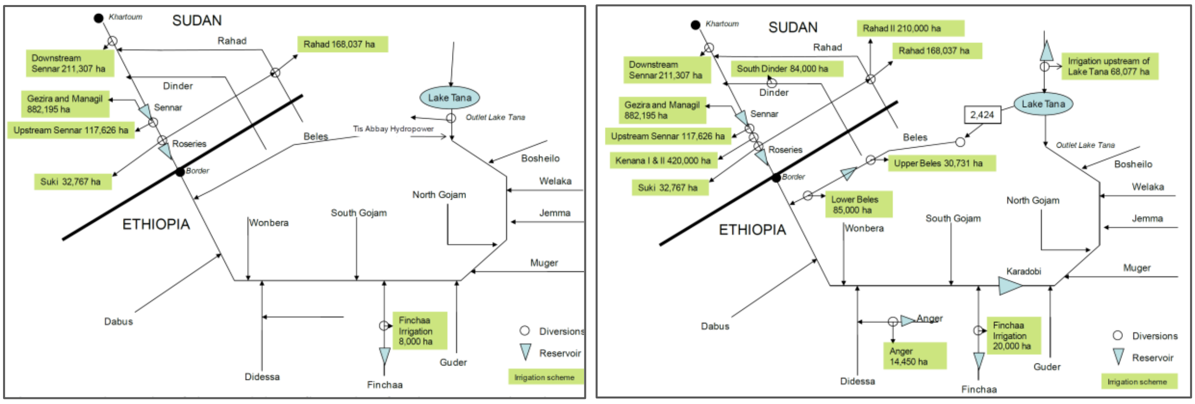
Figure 10: Spatial per capita surface water distribution (m3/yr) projected to 2015[9]



3.6.3 Define alternatives

Alternative water management scenarios can be prepared in the same models that are used to describe baseline situations. WEAP configures a baseline year for which water demand and availability can be reliably established. It then simulates scenarios to assess the impact of different development and management options. Figure 31 shows schematic development of water demand.

Figure 11: Schematic overview of current situation and 2015 scenario for the Blue Nile basin by WEAP [13]



Environmental impact assessment is part of this step. Each scenario is analyzed for reaching the goals as defined in the early steps of the planning and for their impact on environmental aspects. This is especially important for transboundary water resource use. For this purpose IGAD presented a framework of guidelines for impact assessment, highlighting three water sector specific activities[10]: Development of a) water supply, b) hydropower and c) dams and reservoirs.

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[9] Uganda WRM sub-sector reform study report, 2004

[10] IGAD. 2012. Guidelines for transboundary environmental assessment in the IGAD region.

3.7 FORMULATE AND APPROVE SPATIAL PLAN

Based on the assessment of impact and the preferred scenario, this step provides the final definition of improved water resource management measures, criteria for selecting alternative management measures and drafting of a comprehensive management and zoning plan.

3.7.1 Define management measures

Specific water management measures may include run-off and flood control, drainage, irrigation, zoning. Measures can include stream-reconstruction, reservation areas for reconstruction of streams, water-retention areas, protection of natural vegetation in catchment areas and areas where water quality improvement will be undertaken.

Issues to consider in planning and zoning to protect water resources include:

- Site planning: minimizing impervious surfaces, limit alteration of natural vegetation and topography, avoid unnecessary development expenses;
- Landscape planning/design: integrate natural features into development. Ensure water resources are protected and restored: steep slopes, headwater areas, riparian buffers, sensitive groundwater source areas;
- Erosion and sedimentation control: minimize clearing and base soil, promote soil conservation practices and minimum tillage;
- Storm water management: improve water retention revegetating streams and using natural or constructed wetlands;
- Conflict resolution and mediation over competing use of water resources.

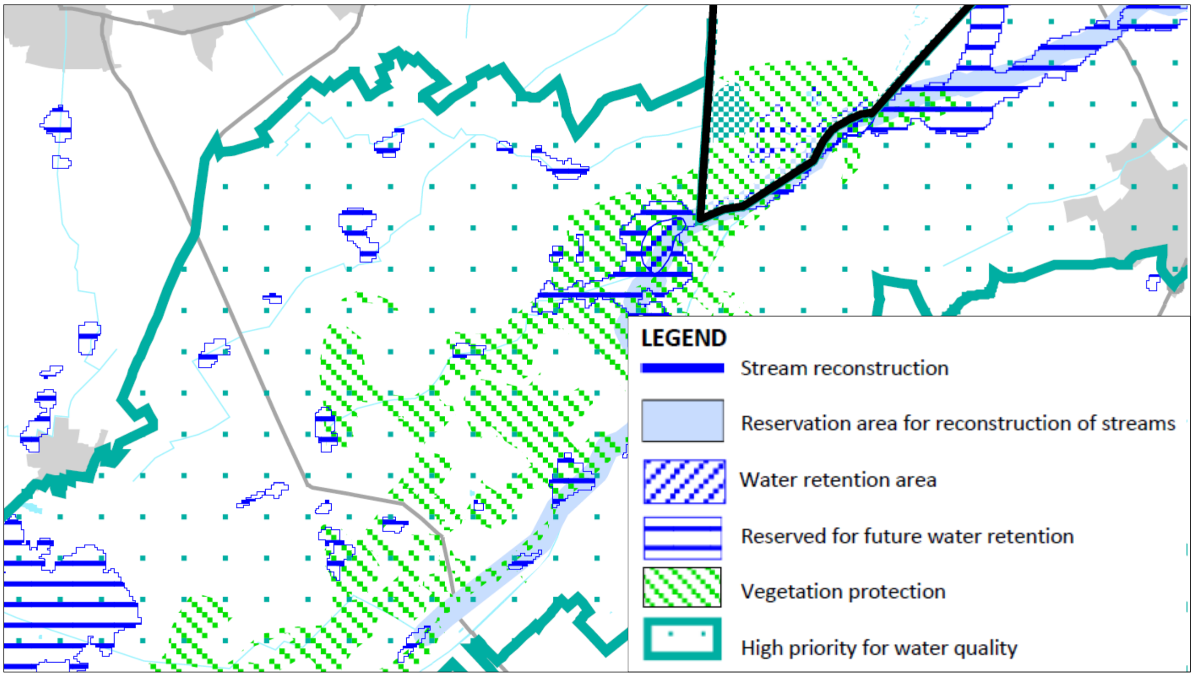
3.7.2 Specify criteria for selecting water management measures

Stakeholders may differ on relative importance of problems, objectives and criteria for evaluating plan alternatives. To ensure transparent decisions making criteria for selection of measures and their relative importance need to be established.

3.7.3 Develop the zoning plan

The zoning plan for water resources management can include areas that are reserved for flood management, groundwater protection, catchment (vegetation) protection, and upstream soil conservation measures. A corresponding map can look like figure 12. The plan should include zones for water protection and water retention, the system of permits for using water, the licensing and rules for the different zones; the compliance mechanism, who manages it.

Figure 12: Plan map with water management measures [PNB, 2015]



3.7.4 Evaluate the plan

Organizing the plan process well, one should relate this component relates to the EIA and SEA procedures that follow in step 6. 'The plan' should ideally be one of the scenario's to be evaluated there. Alternatives should be evaluated against their impact on environment, social aspects, agricultural production and other criteria. Typical factors to evaluate alternatives against are surface water flow (baseflow and peakflow), groundwater level, water quality and with that long term availability of water for various sectors and users. Any subsequent adaptation, combinations of management measures can then be added in this step.

3.7.5 Approve the plan

A formal approval procedure needs to be followed to ensure the plan is approved by key stakeholders, mandated authorities and endorsed by higher level approving and funding institutions. An elaborate and lengthy process of hearings and appeal procedures may need to be followed in the case of plans that are related to national legislation and international treaties. This is one risk of holistic multi-sector and multi stakeholder approaches.

Depending on the nature of the plan and funding sources an alternative approach is to clip a plan into smaller components that could be approved by local authorities and stakeholders, especially when enforcement can be linked to local by-laws.

3.8 IMPLEMENT AND ENFORCE THE PLAN

3.8.1 Implement the water management plan

The coordinating agency responsible for the plan should develop work plans with key stakeholders based on the approved water management plan. Implementing agencies need to be identified and and implementation arrangements need to be developed for each theme including budgeting, capacity assessments, personnel inputs. Water Resource Management authorities or Departments of Water play an important role within countries. Where catchment cross boundaries between countries and other administrative areas, multi-stakeholder Catchment management authorities can play the coordinating role.

3.8.2 Ensure compliance

Compliance of water management zoning and related regulations is to ensure that measures are complied with and that stipulated water extraction and effluent and all related land use measures are in line with the plan.

3.8.3 Enforce the plan

Enforcement of the water management plan includes inspection, reporting parties that are out of compliance. Monitoring of compliance need to be planned and budgeted as without it compliance cannot be expected.

Public participation in reporting of water management related offenses can support enforcement. This could include logging of protection forest, illegal land conversion and water extraction, water pollution and effluent discharge.

3.9 MONITOR AND EVALUATE

Monitoring in water resource management includes both the monitoring of the progress, impacts of the spatial plan, as well as the routine monitoring of hydrometric monitoring of surface water, groundwater and meteorological variables. Remote sensing and GIS are indispensable for the collection, analysis and dissemination of this information. Box 16 gives an example.

3.10 ADAPT THE PLAN

The results from the previous step ‘monitoring and evaluation of the water resource management plan’ should be used to define the outlines of the next planning round. It includes a reconsideration of zoning and implementation measures based on an assessment of accomplishments of the current plan as well as changing circumstances.
Especially changes in demand for water as well as developing water availability as a consequence of changing weather patterns and climate should be considered. These should lead to adjusted goals and objectives for water management and a start of the next planning round.

BOX 3: GIS AND REMOTE SENSING FOR FLOOD MONITORING

Hydrometric monitoring is a key aspect of IWRM. Related information systems can combine monitoring of spatial plan aspects as well the early warning system (EWS), which is part of DRR.

The Nile Basin Initiative (NBI) through its Eastern Nile Technical Regional Office (ENTRO) prepared flood preparedness and early warning bulletins. By linking remote sensing based rainfall estimates and GIS based hydrological models, maps and hydrographs of flood forecasts and flood inundation are prepared that can be downloaded from a website. Figure 33 shows satellite based rainfall in Lake Tana area, Ethiopia and corresponding hydrographs for stream in sub-catchments. Figure 34 shows expected flood extent and depth in relation to the location of settlements and dwellings. FAO SWALIM prepares similar information for Somalia. SERVIR Africa combines satellite data from the Global Precipitation Measurement Mission (GPM, formerly the Tropical Rainfall Measuring Mission TRM) and spatially distributed hydrological model, CREST for several countries in East and southern Africa. UNEP DEWA CLIMWARN project prepared a prototype EWS using CREST output and detailed digital elevation models to translate streamflow debit to local flood extent and depth http://prototype.climwarn.org/nzoia.

Figure 13: Rainfall forecast and expected run-off in Lake Tana Floodplains
[NBI, FPEW Bulletin 01-2014, *http://72.167.42.32/Pages/ENSFMP.aspx*]

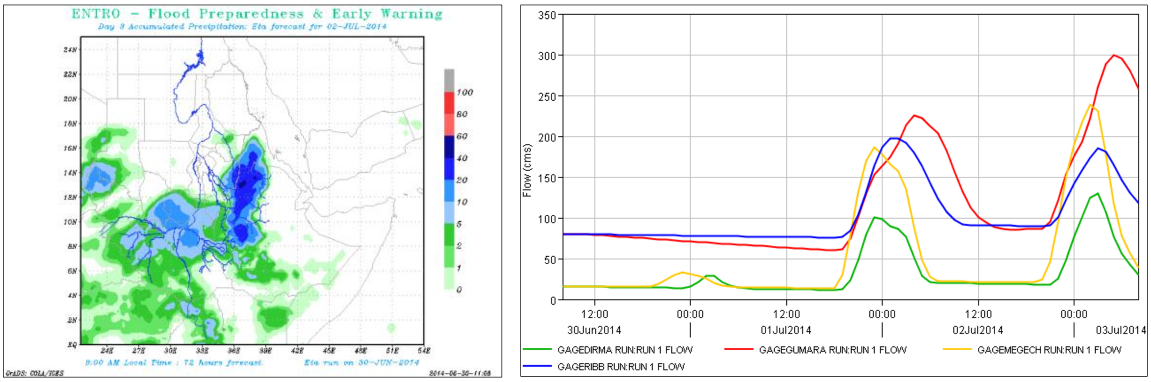
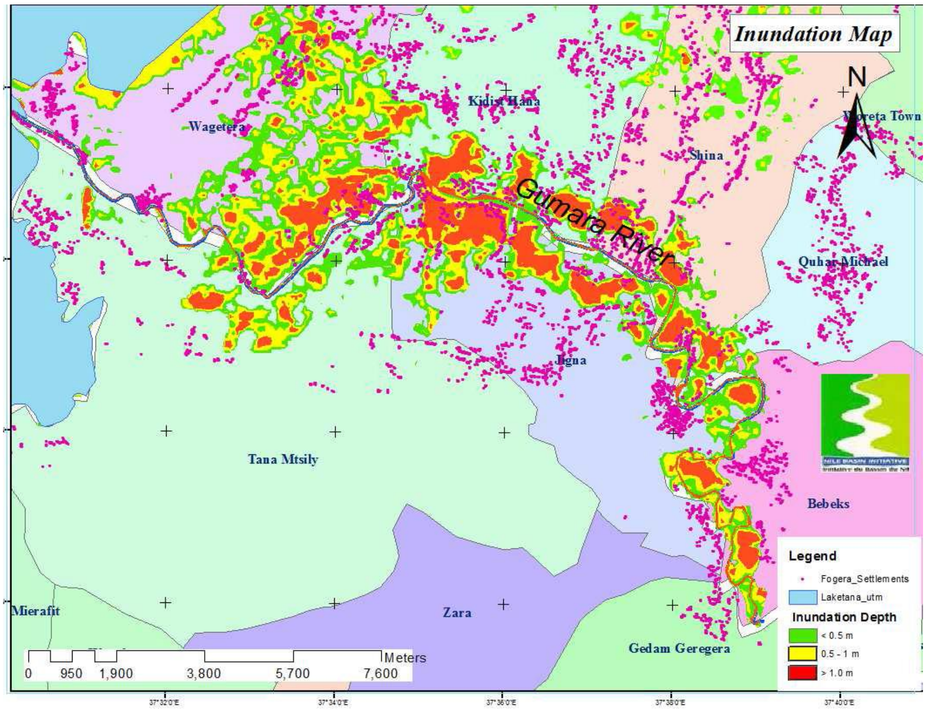


Figure 14: Flood inundation map of Gumara sub-catchment (Eastern Nile),30-06-2014
[NBI, FPEW Bulletin 01-2014]



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