WATER RESOURCES COMMISSION

PRA RIVER BASIN -

Integrated Water Resources Management Plan

June 2012

PREAMBLE

Right from the establishment of the Water Resources Commission (WRC) a priority task has been to introduce the basic principles of Integrated Water Resources Management (IWRM) at local level in selected river basins. Towards this aim, WRC is elaborating IWRM plans for priority basins, and so far four plans have been prepared, i.e. for the Densu River, the White Volta River, the Ankobra River and the Dayi River Basins during the period 2007-2011.

The Pra River Basin IWRM Plan is the fifth of its kind, and this basin was chosen due to several water resources management issues especially pollution arising out of practices such as the discharge of untreated waste into water bodies from domestic and industrial activities, and illegal artisanal mining ('galamsey').

The Pra River Basin like all the River basins require basin-wide planning approach involving stakeholder participation, awareness raising, capacity building and training, and environmental engineering. It is believed that this approach could lead to the sustainable implementation of effective measures to improve land use practices and management of liquid and solid wastes from the mining activities as well as from the towns and communities within the basin

Several activities have been invested over the past few years in creating a basin-based IWRM structure for the Pra River Basin. The decentralized IWRM structure, which has evolved through a targeted participatory and consultative process, combines the following partners: a broadly anchored stakeholder-oriented coordinating body, i.e. the Pra Basin Board, respective planning officers of the District Assemblies and WRC's Pra Basin office in Kumasi (serving as secretariat for the Board).

In parallel to the organizational arrangements, activities of a more technical nature have been ongoing, which eventually resulted in the present IWRM Plan. This plan should also be viewed as an integral part of the stipulations in the WRC Act 522 of 1996 to "propose comprehensive plans for utilization, conservation, development and improvement of water resources" in adherence with the overall National Water Policy of June 2007.

Inasmuch as IWRM is a cyclic and long-term process, the document can be seen as a milestone in this process, in which the status of the water resources situation is documented – a process that should be subject to continuation and updates as the need arises in the future.

I wish to express my sincere appreciation to all those who worked tirelessly to produce this plan and to the European Union for funding the development of the plan. *It is WRC's sincere hope that this plan can be a useful catalyst towards accelerating concrete water management activities in the Pra Basin, and importantly, may also serve as a source of inspiration to advance collaboration among the stakeholders, namely the riparian communities and the mining operations – who all in one way or another depend on the resources of the basin.*

Paul Derigubaa
Chairman, Water Resources Commission
Accra, June 2012

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ABBREVIATIONS AND ACRONYMS

ADRA	Adventist Development and Relief Agency
AfDB	Africa Development Bank
BOD	Biochemical Oxygen Demand
CBOs	Community Based Organizations
CC	Climate Change
CSIR	Council for Scientific and Industrial Research
CSIR-WRI	CSIR-Water Research Institute
CWSA	Community Water and Sanitation Agency
DANIDA	Danish International Development Assistance
DO	Dissolve Oxygen
EDF	European Development Fund

EPA	Environmental Protection Agency
EU	European Union
FAO	Food and Agricultural Organisation
FC	Forestry Commission
GDP	Gross Domestic Product
GEF	Global Environmental Facility
GIDA	Ghana Irrigation Development Authority
GIS	Geographic Information System
GMet	Ghana Meteorological Agency
GoG	Government of Ghana
GWCL	Ghana Water Company Limited
GWP	Global Water Partnership
HES	Hydro-Environ Solutions Limited
HSD	Hydrological Services Department
IGF	Internally Generated Funds
IWMI	International Water Management Institute
IWRM	Integrated Water Resources Management
IWSPMF	Improvement of Water Sector Performance Management Framework
LI	Legislative Instrument
MC	Minerals Commission
MDAs	Ministries, Departments, and Agencies
MDGs	Millennium Development Goals
MMDAs	Municipal, Metropolitan, and District Assemblies
MoFA	Ministry of Food and Agriculture
MoU	Memorandum of Understanding
MSSP	Mining Sector Support Programme
MWRWH	Ministry of Water Resources, Works and Housing
NAO	National Authorizing Officer
NGO	Non-Governmental Organization
NWP	National Water Policy
NWV	National Water Vision
PBB	Pra Basin Board
RWH	Rainwater Harvesting
RWHS	Rainwater Harvesting Strategy

SEA	Strategic Environmental Assessment
SSDP	Sector Strategic Development Plan (Water)
TDS	Total Dissolve Solids
TSS	Total Suspended Solids
UNEP	United Nations Environmental Programme
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organisation
VRA	Volta River Authority
WD	Water Directorate
WQI	Water Quality Index
WRC	Water Resources Commission
WSS	Water Supply and Sanitation

1.0 INTRODUCTION

1.1 IWRM in an international context

The process of integrated water resource management (IWRM) is now a well-established international practice, which is key to meeting the challenges of rapidly growing urban water demands and wastewater discharges; to securing water for increased food production; to reducing vulnerability to floods and droughts; to reducing risk to human health and protection from diseases and hazards; to ensuring water for industry and other economic activities; and to protecting the resource base and vital ecosystems from negative impacts of developments.

The term integrated water resources management has been subject to various interpretations, but the definition by the Global Water Partnership (GWP)[1] has been adopted in the Ghanaian context (see Box 1).

Integrated Water Resources Management (IWRM) is a process that promotes the coordinated development and management of water, land and related resources, in order to maximize economic and social welfare in a balanced way without compromising the sustainability of the ecosystems.

IWRM is not an end in itself but a means of achieving three key strategic objectives of ***Efficiency*** (attempt to maximize the economic and social welfare derived not only from the water resources base but also from investments in water service provision); ***Equity*** (in the allocation of scarce water resources and services across different economic and social groups) and ***Sustainability*** (as the water resources base and associated ecosystems are finite).

Global Water Partnership, 2000

Box 1: Definition of IWRM by GWP

Due to competing demands for the water resource (in the worst case resulting in limiting economic development, decreasing food production, or basic environment and human health and hygiene services), the IWRM process is intended to facilitate broad stakeholder input in order to build compromise and equitable access. This is particularly the case for a developing country like Ghana, which allocates much effort in addressing poverty reduction and in achieving the UN Millennium Development Goals (MDGs).

At the World Summit on Sustainable Development (WSSD) held in Johannesburg in 2002 (Rio+10), the international community took an important step towards more sustainable patterns of water management by including in the WSSD Plan of Implementation, a call for all countries to "*develop integrated water resources management and water efficiency plans*". The "*water efficiency plan*" is considered as an important component of IWRM, and hence as an integral part of an IWRM plans. The goal of preparing IWRM plans as called for at the WSSD set the tone for a worldwide initiative, which Ghana has adopted with the purpose "to promote an efficient and effective management system and environmentally sound development of all its water resources"[2] based on IWRM principles.

1.2 IWRM planning in the Ghanaian context

While Ghana is yet to develop a National IWRM Plan following the recommendations of WSSD Plan of Implementation, the country has already put in place a good part of the basic political, legal and institutional frameworks, which may eventually sustain the IWRM planning and implementation. Some notable programmes and action already in place include:

[1] *Global Water Partnership (GWP): Integrated Water Resources Management, Technical Advisory Committee, TEC Background Paper No. 4 (2000)*
[2] *Ghana National Water Policy, 2007.*

- i) the establishment of the Water Resources Commission by an Act of parliament in 1996; ii) the passing into Law of the 2007 Water Policy; iii) the development of three national river basin plans and corresponding River Basin Boards (RBBs) between 2003 and 2008; and iv) the active involvement with neighbouring countries on trans-boundary issues (Ghana-Burkina on the Volta Basin). In addition, substantial capacity building has taken place within the key institutions involved in water resources management.

Ghana's approach to IWRM planning is to initiate the planning from the river basin level, starting with the most "water stressed" basins of the country. At a later stage, the lessons learnt in implementing these basin plans will provide input to the preparation of a National IWRM Strategy/Plan incorporating trans-boundary water resource related issues. The IWRM Plans and Strategies shall be prepared with the overall purpose of addressing major problems at a river basin level related to:

- Water resource availability;
- Water quality; and
- Environmental/ecosystem sustainability.

Due account shall be taken of water use, and the social and economic implications of implementing an IWRM plan. Actions to be taken as a consequence of the planning shall be prepared based on scenarios describing different approaches for solving major management problems (that might be described with natural resources, sociological/cultural, economic and regulatory, administrative and institutional indicators) within a defined time period.

As such most of the outputs to be provided are prioritised and ranked sets of programmes/actions that from a political, legal, technical, sociological and economic point of view, are considered as the most sustainable and efficient solutions.

Political (democratic) aspects of IWRM planning in this regard require, that plans shall be elaborated in a participatory manner guided by principles, which are imbedded in the concept of Strategic Environmental Assessment (SEA). Generally, SEA is applied with two purposes, viz:

- To evaluate environmental impacts and to rank the environmental effects of plans and programmes; and
- To evaluate conformity and/or conflicting stipulations between various related plans and programmes.

SEA tools have been applied in Ghana during the formulation of the National Water Policy and in assessing the first Ghana Poverty Reduction Strategy. As a continuation of these approaches, a SEA Practical Guide[3] has been prepared, which presents a number of SEA tools applicable to the water and sanitation sectors, including water resource planning, development and management. Key aspects therefore, in the IWRM-SEA process is a participatory approach involving users, planners and policy makers to build commitment; a holistic view that calls for cross-cutting interaction within basins; an integration in terms of upstream-downstream catchment implications; and recognition to the fact that water is an economic good.

[3] *SEA of Water and Environmental Sanitation – a Practical Guide. Ministry of Water Resources, Works and Housing; Ministry of Local Government, Rural Development and Environment; and Environmental Protection Agency (final draft, October 2006).*

As part of a process, the basin-based IWRM plan shall form a widely accepted and easily understood document describing the current state of the water resources and outlining strategies that enable basin-specific management to adhere to the stipulations given in the National Water Policy (NWP). Thus, the IWRM plan should be considered a "blueprint", which describes steps to be taken towards realising the National Water Vision (NWV).

Currently, WRC is in the process of extending the implementation of RBBs to more basins including Pra and Tano Rivers from 2011. This framework plan has been prepared specifically for the Pra River Basin. It is based on a rapid assessment of the status of water resources in the basin, including the present and planned levels of water utilization, as well as issues of environment, water conservation, and sustainability. It presents the outline structure within which a number of other more detailed medium to long term actions will be prepared by the Pra Basin Board (PBB).

1.3 Purpose and institutional setting of the basin IWRM plan

The target groups of the basin-based IWRM plans are the planners and decision-makers operating in the water sector, including the river basin boards, who are provided with a tool for "what to do" and for detailing activities and programmes concerning specific interventions. More specifically, the purpose of the IWRM plan is to:

- Contribute to the provision of sufficient supply of good quality surface water and groundwater as needed for sustainable, balanced and equitable water use;
- Prevent further deterioration and protect the status of aquatic ecosystems with regard to their water needs;
- Protect terrestrial ecosystems directly depending on the aquatic ecosystems;
- Contribute to mitigating the effects of floods and droughts; and
- Provide appropriate water management with efficient and transparent governance in the sector whether at local, district or basin-based level.

For the IWRM plan to be successfully implemented, it is imparative that the WRC collaborates with institutions affected by the plan. This is because the plan impacts on a variety of socio-economic and regulatory aspects, viz; utilisation and protection of natural resources, social and cultural situations, economics and production, and the legal, administrative and institutional frameworks. This is reflected in the composition of the WRC and the RBBs, which is made up of technical representatives of all the main stakeholders involved in development and utilisation of water resources, including the following:–

- Metropolitan, Municipal, District Assemblies (MMDAs), Community Water and Sanitation Agency (CWSA) and Ghana Water Company Limited (GWCL) in water demand projections;
- Minitries, Departments and Agencies (MDAs), Lands Commission (LC), Minerals Commission (MC), Environmental Protection Agency (EPA), Ministry of Food and Agriculture (MOFA) and Traditional Authorities in catchment management;
- MMDAs and EPA in controlling various wastes into water bodies; and
- EPA, Forestry Commission (FC), Fisheries Department (FD), Water Research Institute of the Council for Industrial Research (CSIR-WRI) and Hydrological Services Department (HSD) in assessing environmental flow requirements.

The overall institutional setting as it relates to planning and implementation of the activities outlined in a typical IWRM plan is depicted in Figure 1.1.

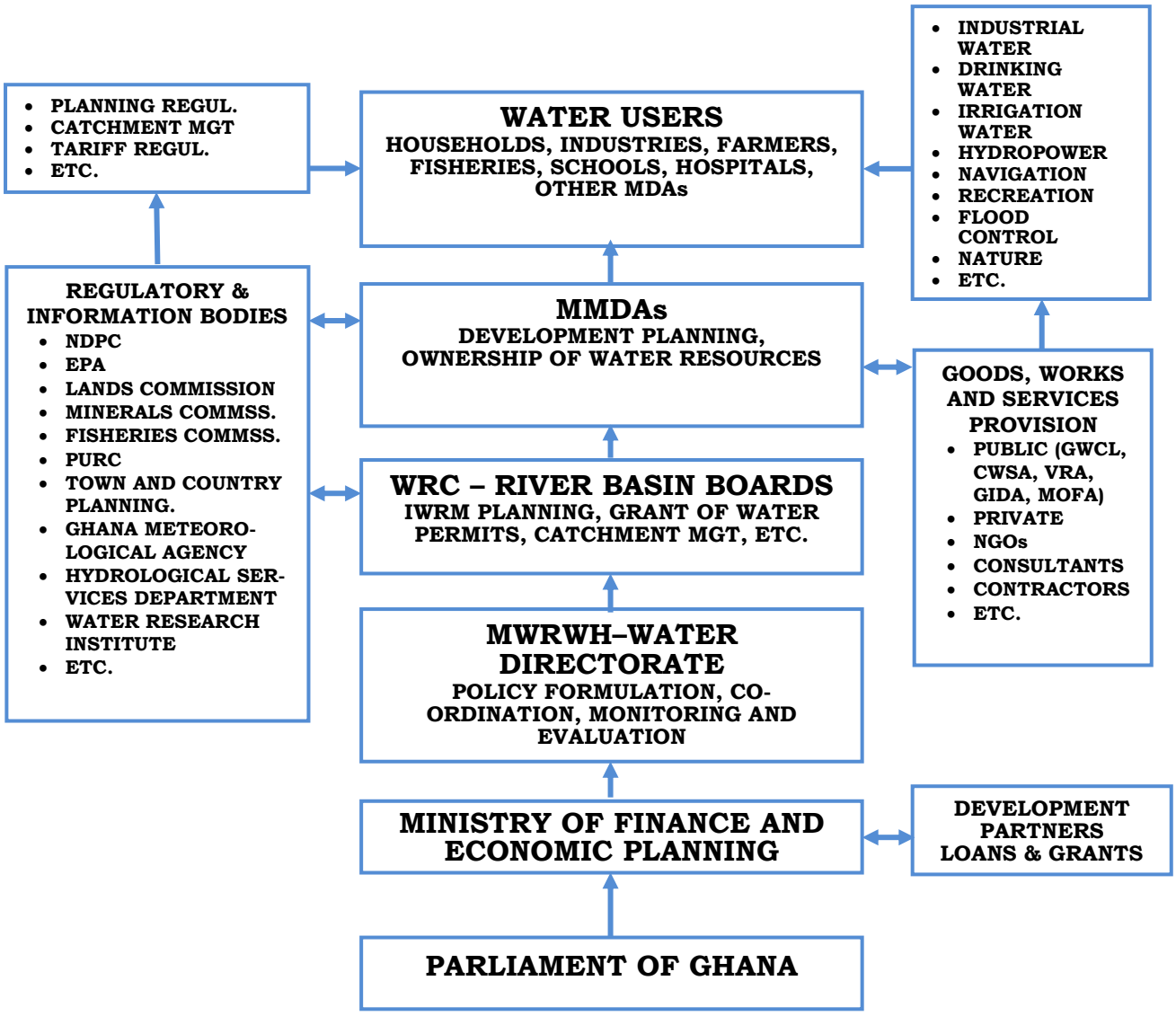

Figure 1. 1: Institutional Framework for IWRM Planning and Implementation
Source: WRC (March 2009): Ankobra Basin IWRM Plan

1.4 Preparation and structure of the Pra Basin IWRM plan

The plan for the Pra River Basin has been elaborated as part of WRC's mandate[4] to "*propose comprehensive plans for utilisation, conservation, development and improvement of water resources*" with due consideration to stipulations in the National Water Policy and the Water Sector Strategic Development Plan (WSSDP).

A number of consultative meetings and workshops were organised during the course of preparation of the plan as part of procedures and application of the SEA "tools", specifically targeting local stakeholders and planners of the basin towards identification and ranking of

[4] *Water Resources Commission Act N^{o} 522 of 1996*

water resource management problems and issues as perceived by them. The consultative workshops were also used as training sessions on IWRM as many of the stakeholders were not conversant with many aspects of IWRM.

To ensure local ownership of the basin plan, the WRC first established the Pra Basin Board (PBB) constituted by a wide sphere of interest groups within the Basin to actively participate in the planning process at the initial stage. The PBB members include the following:

a) Representatives of MMDAs in the basin

b) A Representative of the Ashanti Regional Coordinating Councils

c) A Representative each of Regulatory Institutions in charge of Mining, Forest, Environment, etc

d) A Representative each of major water users (Domestic water supply, Agriculture and Mining)

e) A representative of Traditional Rulers

f) A Representative of Civil Society Groups that is active in the sub-basin.

g) A Representative of Women/Youth groups

#(See section 6.1 for detailed membership of the PBB)

In addition, the preparation of the basin plan drew upon on a number of baseline studies carried out as components of the EU funded project – "Development *of National and River Basin Integrated Water Resource Management Plan" (*WRC/EDF9/3U1/2010), which comprised of the following:

- Catchment-Based Monitoring Project in Ghana
- National Baseline Studies and Institutional Analyses towards the Development of the National IWRM Plan
- Baseline Studies and Water Balance Assessment for Pra and Tano basins towards the Development of National IWRM Plan
- Strategic Environmental Assessment (SEA) for the Pra, Tano basins and the National IWRM Plan

The basin plan report is presented in six chapters as follows:

Chapter 1 provides an introduction and puts IWRM in context and explains the approach adopted for the plan preparation. ***Chapter 2*** outlines baseline situation in the basin. Analyses of water availability and demand projections are carried out using the WEAP model in ***Chapter 3.*** Furthermore, in this chapter a number of scenario analyses are presented comprising different development options and strategies for the utilisation of the basin's water resources, including likely climate change impacts on the water resources. In ***Chapter 4*** the consultations that lead to the identification of the water resources management issues and challenges are outlined. The broad objectives for the management of the Pra Basin are set and corresponding management actions that will be taken to achieve the objectives are spelt out in ***Chapter 5. Chapter 6*** provides the institutional arrangements and modalities for implementation of the Plan.

2.0 BASELINE DESCRIPTION OF THE PRA BASIN

2.1 Location and Physical characteristics

The Pra Basin is located between Latitudes 5^0 N and 7^0 30' N, and Longitudes 2^0 30' W, and 0^0 30' W, in south-central Ghana The Pra River, together with its tributaries, forms the largest river basin of the three principal south-western basins systems of Ghana (i.e. Ankobra, Tano and Pra).

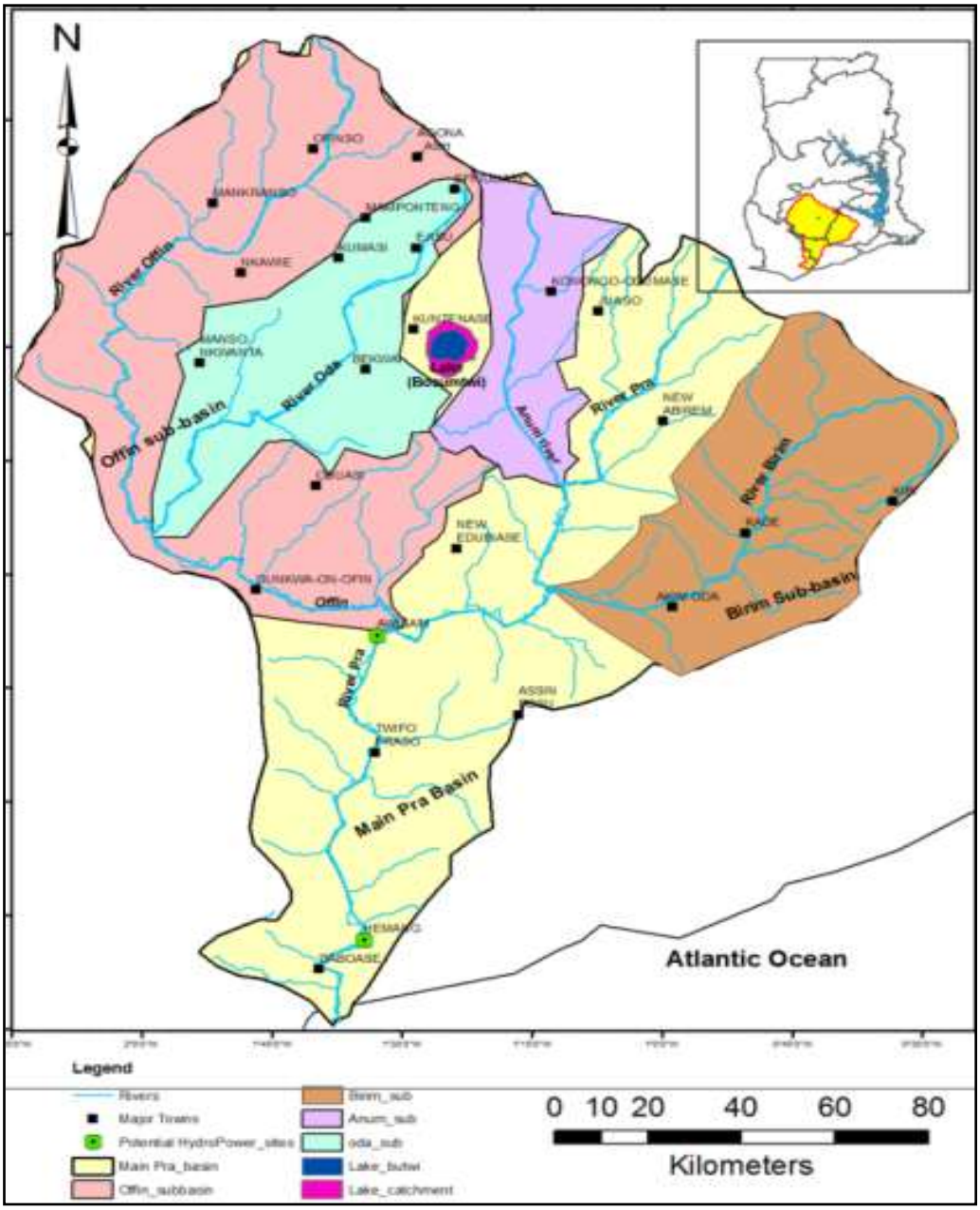

Figure 2. 1: Location map of the Pra River Basin

Its total basin area of approximately 23,200 km² extends through almost 55% of Ashanti, 23% of Eastern, 15% of Central and 7% Western Regions (Figure 2.1).

The Pra River and its major tributaries–(Rivers Anum, Birim, Offin and Oda), originate from the eastern and north-western fringes and flows southwards. The main Pra River takes its source from the highlands of Kwahu Plateau in the Eastern Region and flows for some 240km before entering the Gulf of Guinea near Shama in the Western Region. In addition to the river network is the only significant natural freshwater lake in Ghana (Lake Bosomtwe), which is a large crater lake with maximum depth of nearly 80m and a rim diameter of about 8km across. The catchment area of the lake is about 106 km^2, of which the lake occupies 52km^2. It is situated at nearly 30 km south-east of Kumasi and is a popular tourist facility.

Most of the towns in the basin are prominent for their mining activities. The AngloGold Ashanti mine at Obuasi is one of the largest in Africa. Gold is also mined at Konongo and from the channel of the Offin River at Dunkwa. Akwatia in the Birim sub-basin is a prominent diamond-mining town. In the 1950s and 1960s the Akwatia area produced more than 2,000,000 carats of diamond per annum.

Apart from the mining towns, the other towns are highly urbanized with large populations. Kumasi for instance is the second largest city in Ghana and is also the second most populated in the country. Many other towns including Twifo-Praso and Kade are prominent in agriculture.

The basin is endowed with a unique mixture of tourist attractions, which ranges from National parks (Kumasi Zoo), Lake Bosomtwe site, and Cultural heritage sites (chieftaincy institution, traditional durbars/festivals, art and craft villages etc). Harnessing these opportunities and dealing with the challenges of catchment degradation and water pollution from increased tourism is of utmost importance, and is particularly significant for sustainable natural resources management.

A summary of some basic characteristics of the Pra Basin is given in Table 2.1 below.

Table 2. 1: Basic characteristics of the Pra Basin

Basin Area	**23,188 km^2**	
Inhabitants	4,180,387 (2000 Census); 180.3 pers/km^2	Population Growth Rate for the basin (1994- 2000) is 2.2%/year
Length main Pra River	240 km	
Key tributaries	Rivers Offin, Birim, Anum and Oda	
Natural Lake	Lake Bosomtwe - the only significant natural freshwater lake in Ghana. It is a closed hydrological basin and also a popular tourist facility.	
Important water uses and services	Water abstraction (mining and irrigation), water supply (domestic & industrial	

2.2 Topography and Land use pattern

The topography of the Pra Basin is characterised by relatively flat land in the southern half, which gives way to few peaks in the mid to northern sections of the basin. The highest elevations in the basin are located in the northern sections and the fringes of the eastern parts where elevations of up to 800 metres above sea level are common.

Vegetation of the basin is of moist semi-deciduous forest type. More than 50 percent of the original forest area in the 60's has been converted to agricultural land and for human settlements. Currently, the main land cover types are estimated as follows: Agricultural (60%), forest (30%), grassland and human settlement cover 10%. Some isolated forest reserves (e.g. Atiwa Forest Reserve) and large established commercial tree plantations contribute to the share of the remaining forest**.** Coconut plantations were also abundant in the southern portions towards the coastal areas until the onset of the Cape Saint Paul's Wilt disease that has rapidly destroyed vast areas of plantations and virtually collapsed the coconut industry.

2.3: Socio-economic characteristics of the basin

2.3.1 Demography, Administrative setting and settlement patterns

The Pra Basin supports approximately 4.2 million people, who live and work in the various villages, medium sized towns and metropolitan cities within the basin. Population growth rate is estimated to be 2.2%/annum[5].

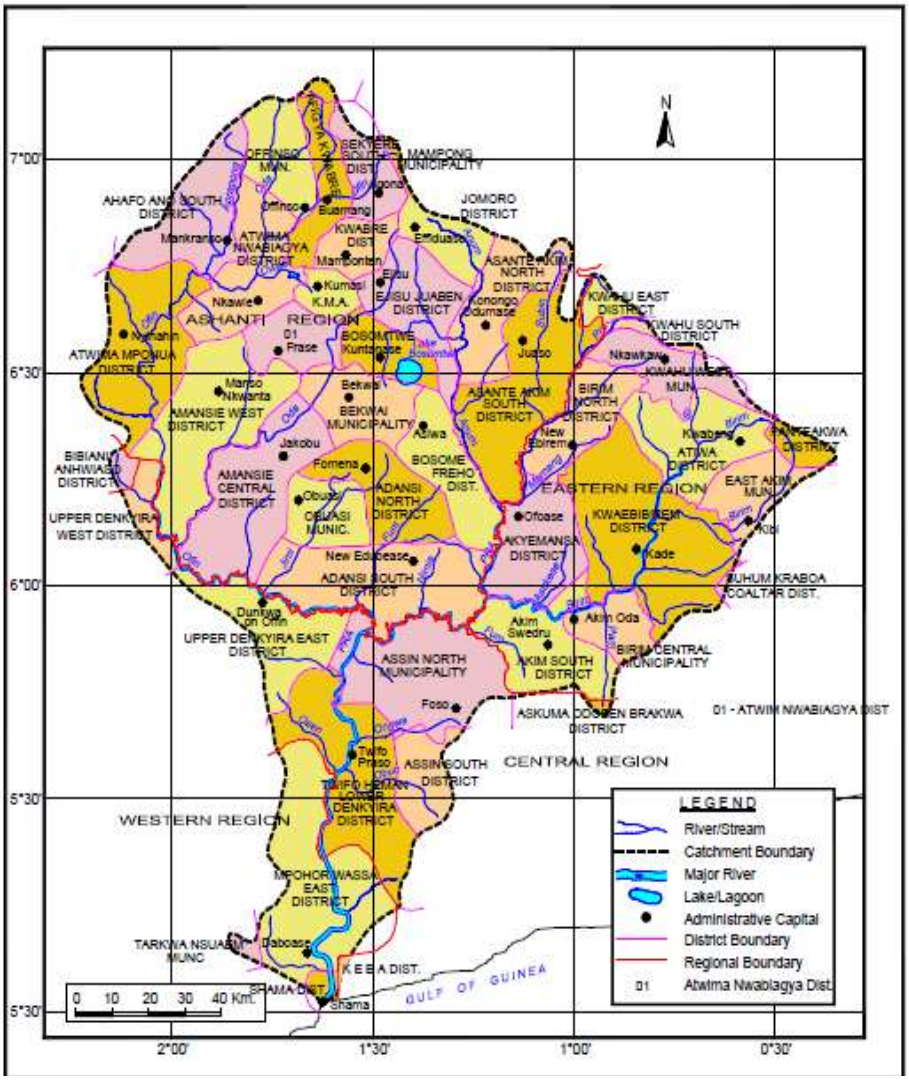

Figure 2.2: Geo-political composition of the Pra Basin

Source: WRC (2010), National Baseline Studies and Institutional Analyses towards the Development of the National IWRM Plan Report

[5] Ghana Statistical Service (2000), Housing and Population Census.

There are 43 administrative districts divided as follows: 21 in the Ashanti Region, 7 in the Central Region, 11 in the Eastern Region and 4 in the Western Region (Figure 2.2).

Ashanti Region has the highest representation in terms of the total population, accounting for about 68% of the total population of the Basin. The Kumasi Metropolis has the highest population density of nearly 5,000 persons per square kilometres, while the lowest population density is in the Asikuma/Odoben/Brakwa District of the Central Region where the population distribution is relatively sparse.

The rate of urbanization in the basin is about 32%, with districts in Ashanti Region accounting for the highest average rate. For example, the Kumasi Metropolis (KMA), Bosomtwe and Atwima Districts of the Ashanti Region and the Shama-Ahanta East District of the Western Region are 100% urbanized, with the characteristic high population densities. On the other hand, the Ashanti-Akyem North District of the Ashanti Region is wholly rural.

Districts coverage in terms of human settlements in the basin is summarised in Table 2.2

Table 2.2: Coverage of the Districts in the Pra Basin

DISTRICT	REGION	CAPITAL	Basin Area in District (km^2)	Estimated Population	Share of settlements in the Basin		
					%area in district	Pop density ($pers/km^2$)	%Urban
Adansi East	Ashanti	New Edubiase	1372.71	129,308	5.92	94.2	12
Afigya Sekyere	Ashanti	Agona	586.63	119,093	2.53	203.01	36
Ahafo Ano South	Ashanti	Mankranso	656.6	133,632	2.83	59.42	9
Amansie West	Ashanti	Manso Nkwanta	1174	108,726	5.06	92.61	0
Asante-Akim North	Ashanti	Konongo-Odumase	645.55	126,477	1.24	40.31	56
Asante Akim South	Ashanti	Juaso	1151.72	96,868	2.1	84.11	16
Ejisu/Juabeng	Ashanti	Ejisu	599.27	124,176	2.69	207.21	26
Kwabre	Ashanti	Mamponteng	277.6	164,668	3.57	593.19	39
Offinso	Ashanti	Offinso	492.61	138,676	0.98	30.25	31
Sekyere West	Ashanti	Mampong	32.45	143,206	0.04	4413.13	39
Bosomtwe/Atwima/ Kwanwoma	Ashanti	Kuntenase	702.26	146,028	3.16	207.94	5
Kumasi Metropolitan	Ashanti	Kumasi	238.54	1,170,270	25.35	4905.97	100
Sekyere East	Ashanti	Effiduase	287.64	157396	0.28	3.74	34
Atwima Mponua	Ashanti	Nyinahin	831.66	146028	1.56	42.78	
Atwima Nwabiagya	Ashanti	Nkawie	764.99	146028	3.16	190.89	21
Amansie Central	Ashanti	Jacobu	1004.7	225309	4.88	224.25	12
Amansie East	Ashanti	Bekwai	979.94	225309	4.88	229.92	12
Obuasi Municipal*	Ashanti	Obuasi	348..4	-N/A	1.5	N/A	N/A
Adansi North	Ashanti	Fomena	613.44	238440	2.64	338.79	
Asikuma/Odoben/ Brakwa	Central	Breman Asikuma	19.25	89395	0.08	0.11	32
Komenda/Edna Eguafo/Abirem	Central	Elmina	71.26	112437	0.36	35.32	30

DISTRICT	REGION	CAPITAL	Basin Area in District (km^2)	Estimated Population	Share of settlements in the Basin		
					%area in district	Pop density (pers/km^2)	%Urban
Twifo-Heman /Lower Denkyira	Central	Twifo-Praso	1201.65	110352	1.93	59.73	14
Upper Denkyira	Central	Dunkwa On Offin	664.88	108444	1.45	62.06	24
Assin North	Central	Assin Fosu	1039.03	196457	4.13	178.38	
Assin South	Central	Nsuaem-Kyekyewere	305.94	196457	1.22	52.55	
Birim North	Eastern	New Abirem	1197.47	123462	2.67	103.1	10
Birim South	Eastern	Akim Oda	969.75	179349	3.05	114.06	49
Fanteakwa	Eastern	Begoro	155.09	86154	0.29	13.32	18
Kwaebibirem	Eastern	Kade	1213.34	179209	3.88	147.7	39
West Akim	Eastern	Asamankese	247.64	154161	1.02	57.91	32
Kwahu West Municipal	Eastern	Nkawkaw	342.27	217482	1.48	452.81	38
Kwahu South	Eastern	Mpraeso	208..31	217482	0.90	24.94	38
Atiwa*	Eastern	Kwabeng	896.68	N/A	3.87	N/A	N/A
East Akim Municipal	Eastern	Kibi	329.13	190,347	1.85	116.44	37
Bibiani/Anwiaso/ Bekwai	Western	Bibiani	41.53	103,256	0.11	6.29	37
Mpohor Wassa East	Western	Daboase	1431.2	122,595	1.72	35.97	13
Shama Ahanta East	Western	Sekondi	138.81	369,166	3.06	389.58	100
Wassa Amenfi East	Western	Wassa Akropong	30.24	234,384	0.11	3.71	49

Data Source: WRC (2010), Baseline Studies and Water Balance Assessment for Pra and Tano basins towards the Development of National IWRM Plan Report
** No data was available for new districts created after the 2000 Population and Housing Census, thus relevant statistics not available (N/A)*

2.3.2: Employment profile in the basin

The Pra Basin has considerable potential for development in agriculture, forestry, tourism, and mining, and provides livelihoods for many through these. Over 63% of the population is engaged in the Agriculture and related sectors of the economy. Both commercial and subsistence agricultural activities are practiced, with cocoa being the main commercial crop. Cocoa accounts for 70-100% of household incomes of cocoa farmers[6]. In the districts where large scale cocoa farming is practiced within the basin, annual returns in terms of family income are high and the standard of living is appreciable.

Subsistence agriculture is largely practiced with production of food crops such as cassava, plantain, and maize. The average food crop farmer has limited contact with the product markets and is unlikely to use fertilizers, insecticides or high yielding seed varieties.

The use of irrigation technology is not widespread in the basin, and where harvest outstrips family needs, the excess food is sold to provide extra income for the family.

[6] *International Centre for Tropical Agriculture (CIAT). "Predicting the Impact of Climate Change on the Cocoa-Growing Regions in Ghana and Cote d'Ivoire", Final Report, September 2011.*

Menial short term sources of employment such as daily labour on farms constitute the next highest average source of employment in the basin, employing an average of 37% of the population. These jobs are usually not captured as major employments due to the fact that they are very short term and not as sustainable. Manufacturing and wholesale are the other sources of employment to the population, offering employment to between 8.5% and 9.5% of the total population of the basin. A summary of the employment profile is presented in (ANNEX 1).

2.3.3 Traditional knowledge[7]

The riparian communities have sophisticated traditional knowledge and practices relating to water, its use and management. Through respect for the spirit of nature and protection of forests, the communities ensured that vital water sources are protected and conserved. For example, the people of Akyem believe that their spiritual and philosophical sustenance derives from Birim River. The river is revered by the people and the Ohum festival of the people is devoted to the conservation of the ecology of the Birim Basin. It is forbidden to swim or fish in the river on Tuesdays.

Similarly, the communities on the banks of Lake Bosomtwe believe that the 'children' of the lake abhor excessive noise, therefore the use of motorised boats on the Lake is forbidden. Wooden planks are used both for fishing and transportation on the Lake.

Today, most of these relationships have been disrupted by 'development', and it is only through the participation of traditional authority and fusing indigenous and scientific knowledge that harmonious basin management can be restored.

2.4 Water Resources Potential

2.4.1 Climatic characteristics

The climate is sub-equatorial wet, with two rainy seasons (May-July and September-November). A typical seasonal variation of rainfall at Twifo-Praso meteorological station is illustrated in Figure 2.3.

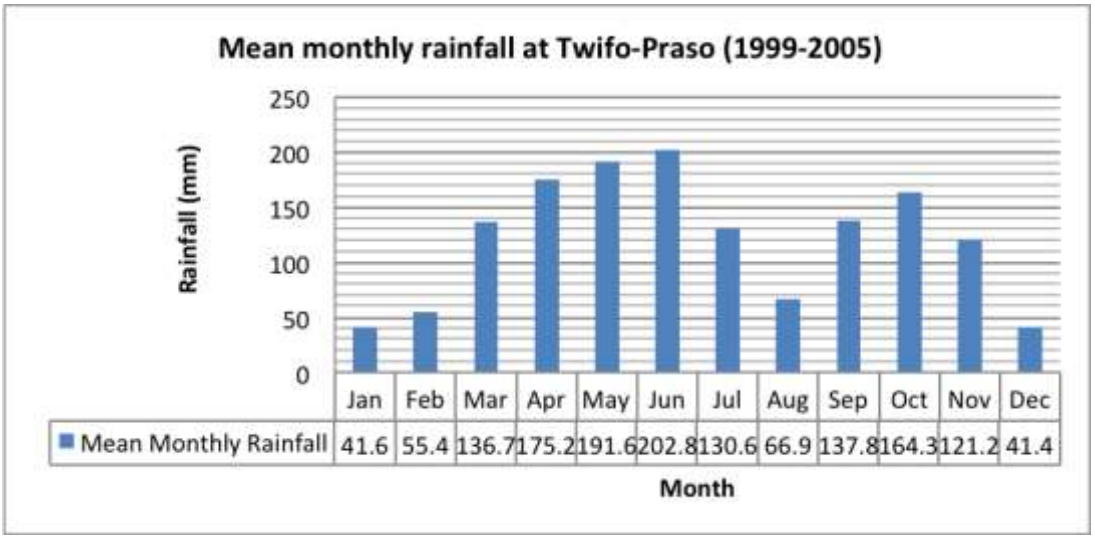

Figure 2.3: Seasonal variation of rainfall in the Pra Basin

[7]Kwame Odame-Ababio, (2002). "*IWRM, Environment and Equity in National Water Laws – the Case of Ghana*", in Madiodio Niasse, Alejandro Iza, Amidou Garane and Olli Varis (ed), Proceedings of workshop on Water Governance in West Africa organized by IUCN in Ouagadougou, Burkina Faso, 25-27 September 2002.

The mean annual rainfall is relatively high, about 1,500mm but is also very variable, ranging between 1300 mm and 1900 mm. Both the spatial and temporal distributions are high and increase westwards and south-westwards (Figure 2.4).

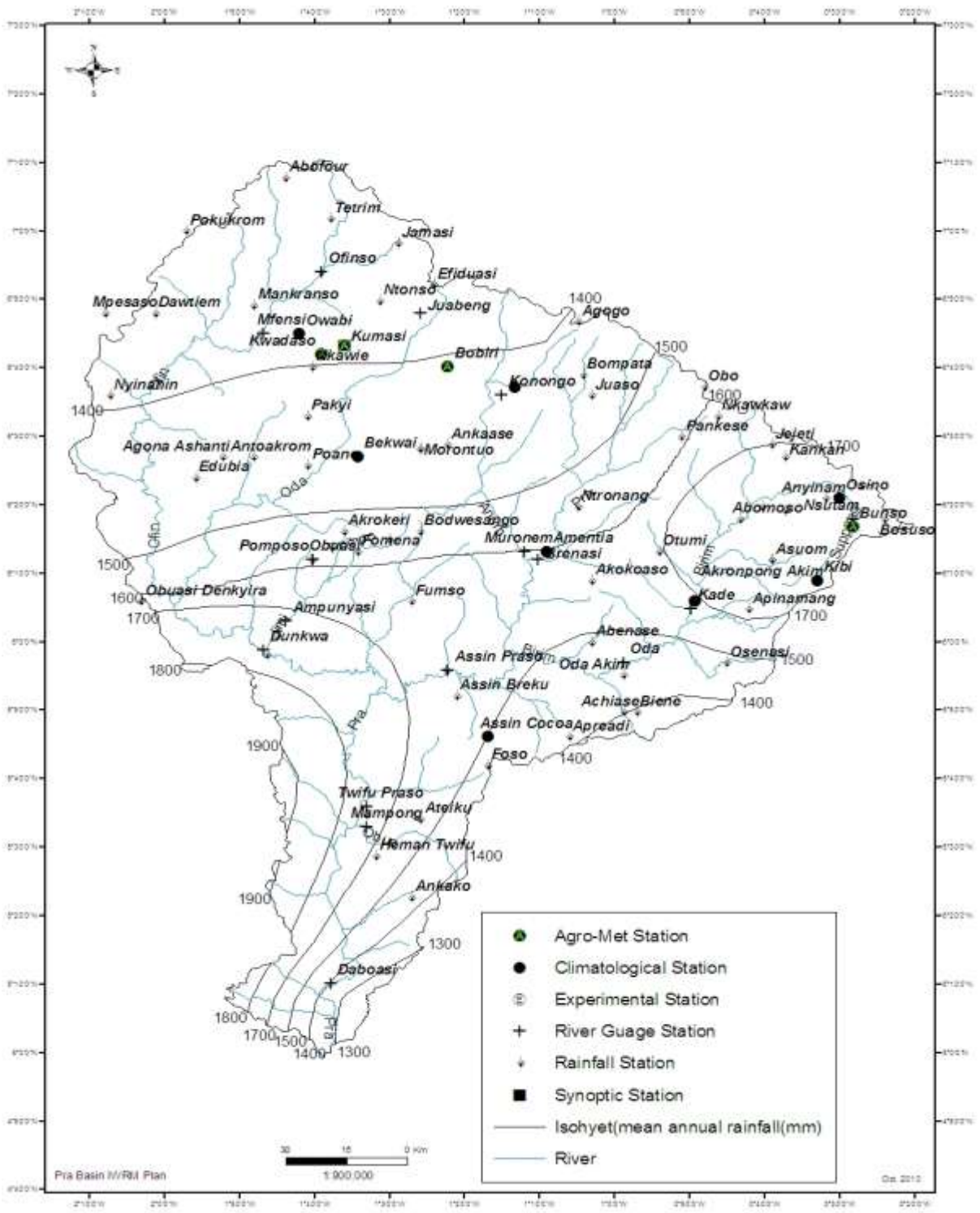

Figure 2. 4: Annual Rainfall distribution in the Pra Basin

Data Source: WRC (December 2010): Baseline Studies and Water Balance Assessment for Pra and Tano basins towards the Development of National IWRM PlanReport

The basin is warm and moist throughout most of the year. Relative humidity is between 70%-80% throughout the year. In the drier seasons, temperatures are around 26°C in August and 30°C in March. The meteorological statistics show that the mean annual number of rainy days is between 90 and 100 days.

2.4.2 Surface water resources availability

The available surface water resources originate from rainfall. The basin as a whole receives an average annual rainfall of about 1,500 mm, and the Pra River carries an average annual runoff of about 4,174 Mm^3. Recorded flow data and information on runoffs are obtained from the Hydrological Services Department, which operates a number of river gauging stations in the Basin. A typical seasonal flow at a river gauging station (Twifo-Praso) is illustrated in Figure 2.5.

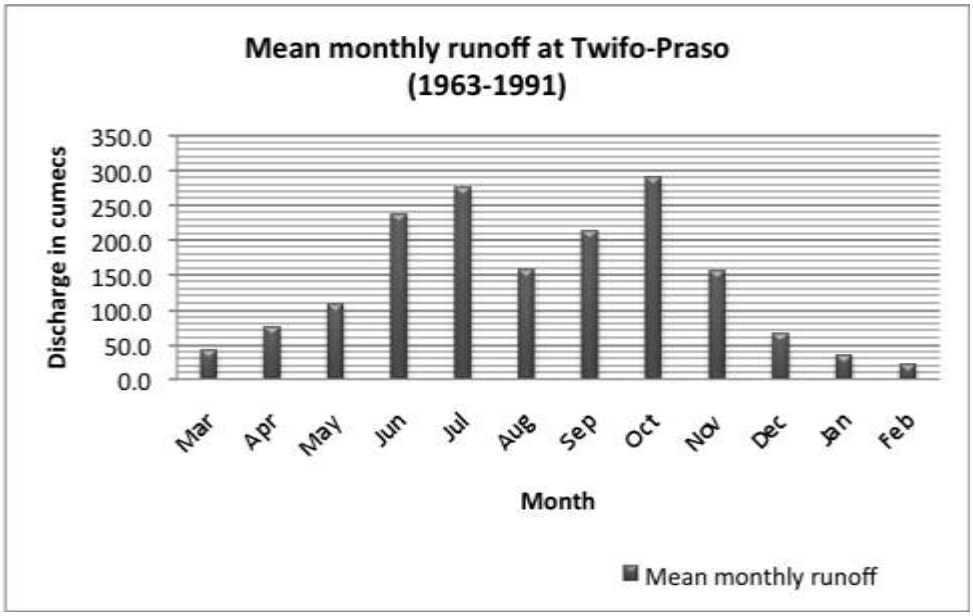

Figure 2.5: Mean monthly runoff at Twifo-Praso gauging station

By using the basin runoff, the annual flow volumes at various points along the Pra River and some of the main tributaries have been estimated and listed in Table 2.3.

Table 2.3: Pra Basin: -Simulated areal runoff for selected gauging stations (1999-2006)

River gauging Station	Basin	Local catchment area	Total catchment	Estimated Areal rainfall (mm)	Local runoff (mm/year)	Runoff coeff	Total runoff (m^3/s)	Total runoff (mm^3/ year)
Daboase	Pra	2054	22820	1600	532	33%	133	4200
Twifo-Praso	Pra	2630	20766	1450	230	16%	98	3100
Assin Praso	Pra	4643	9792	1400	137	10%	45	1420
Dunkwa/Adwumain	Pra / Offin	3858	8344	1375	122	9%	34	1085
Ampunyase	Pra/Jimi	396	396	1375	124	9%	1.6	49

Adiembra	Pra/Offin	2458	3132	1350	146	11%	14	440
Bekwai/Anwia-Nkwanta.	Pra/Oda	958	958	1350	131	10%	4.0	125
Mmuronem	Pra /Anum	1799	1799	1375	159	12%	9.0	285
Offinso	Pra/ Offin	674	674	1350	119	9%	2.5	80
Dadieso	Pra	103	103	1400	159	11%	0.5	16
Akim Oda	Pra/Birim	3039	3247	1400	146	10%	15	480
Osino	Pra/Birim	208	208	1450	170	12%	1.2	39

Data Source: WRC (December 2010): WRC (2010), National Baseline Studies and Institutional Analyses towards the Development of the National IWRM Plan Report

2.4.3 Groundwater occurrence

The hydrogeology of the basin is dominated by aquifers of the crystalline basement rocks and the Birimian Province[8]. Groundwater occurs mainly in the Birimian geological formations, which comprise of the Lower Birimian (metasediment rocks) and the Upper Birimian (metavolcanic rocks). The Lower Birimian underlies over 80% of the total landmass of the basin while the Upper Birimian crops out in the eastern and extreme southern sections of the basin (Figure 2.6).

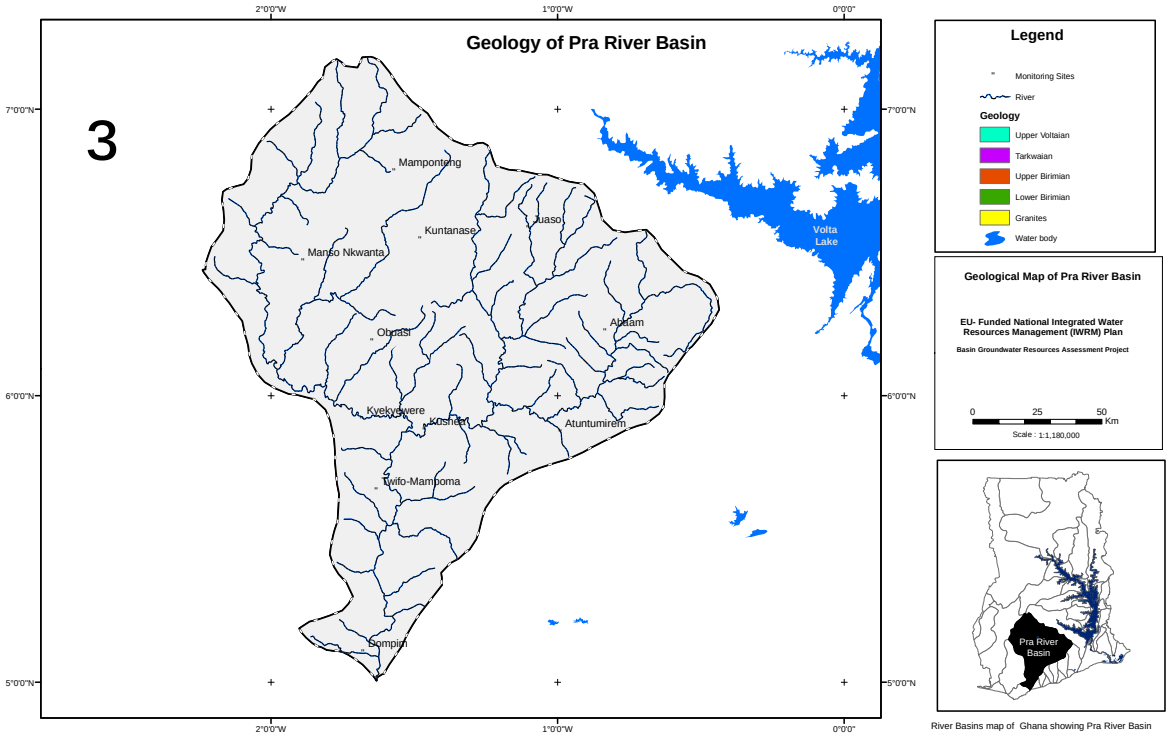

Figure 2.6: Geological map of the Pra Basin

Source: WRC/CSIR-WRI (2010). Catchment-Based Monitoring Project Report (December 2010)

[8]*WRC (December 2010). Baseline Studies and Water Balance Assessment for Pra and Tano basins towards the Development of National IWRM Plan Report.*

Aquifer transmissivity is quite high and ranges between 5.7m^2/day and 799m^2/day. Well yield amongst the crystalline basement aquifers and the Birimian province are amongst the highest in the entire country are therefore very important in the water delivery system of particularly the rural population. Average thicknesses of the weathered zone or overburden ranges between 4.5 m to 40 m in the basin

2.4.4 Water balance for the basin

About 12% of the mean annual rainfall in the Basin contributes to the flow of the Pra and more than 72% of mean annual rainfall evaporates and returns to the earth's atmosphere (Table 2.4).

Table 2.4: Annual water balance for Pra Basin

Water balance component	Annual amount	In percent of rainfall
Rainfall	1,504 mm	
Actual evapo-transpiration	1,083 mm	
Pra Basin area[9]	23,129 km^2	
Rainfall over basin (volume)	34,786 million m^3	100 %
Actual evapo-transpiration (volume)	25,046 million m3	72%
Recharge to groundwater (volume)	5,566 million m^3	16 %
Surface water runoff (total for basin)	4,174 million m^3	12%

Source: WRC (2010). Pra Basin Baseline Study Report

2.5 Water resources utilisation

The main consumptive uses of water in the basin are for domestic, industrial/mining and agricultural (irrigation), while the swimming in Lake Bosomtwe by tourists constitute the main non-consumptive use.

2.5.1 Domestic water supply

Both surface and groundwater supplies are utilized to meet daily domestic and industrial demand of most cities and towns in the basin. The Offin is dammed at Barekese to serve as a source of treated water for the Kumasi Metropolis and surrounding towns. Other impoundments and reservoirs have been constructed in order to mobilise surface water for urban water supply. Table 2.5 gives a summary of major urban supply systems in the basin.

[9] *MINING SECTOR SUPPORT PROGRAM, GHANA: Strategic Environmental Assessment, Assessment of Riverine Material Transport in the Pra, Ankobra and Tano Rivers (April 2007)*

Table 2.5: Key active Urban and non-urban water supply systems in the Pra Basin

Location of Small Dam	Tributary/ River	Basin	Capacity (thousand of m^3)	Annual Abstraction Rate (m^3)
Barekese	Offin	Pra	89,588.52	29,862,840
Owabi	Offin	Pra	15,329.91	5,109,971
Daboase	Pra	Pra	29,880.36	9,960,120
Ofoase	Pra	Pra	236.52	78,840
Osenase	Supong	Pra	236.52	78,840
Kusi	Birim	Pra	236.52	78,840
Kibi	Birim	Pra	236.52	78,840
Osino	Birim	Pra	236.52	78,840
Bunso	Birim	Pra	998.64	332,880

Data Source: Ministry of Water Resources, Works and Housing, 1998c; WRC, 2005

It is estimated that nearly 58%[10] of households in the basin have access to potable water, though pipe-borne water reached only 38% of households. On the average, the coverage for Ashanti, Eastern, Central, and Western Regions stand at 63%, 72%, 45% and 47% respectively. If wells are included in the potable water category, the basin's water supply coverage then becomes 77%, while the coverage by region are 81%, 84%, 68% and 70% for the Ashanti, Central, Eastern and Western Regions in that order.

Rural water supply in the basin is derived mainly from boreholes and hand-dug wells. Most of the boreholes are for domestic purposes and are fitted with hand pumps. There are also communities where boreholes are mechanized with motor-driven pumps. The estimated rural water coverage in 2009 is 63%. Applying the percentage areas of the parts of the four (4) regions in the Pra Basin, rural coverage in the basin are estimated at1,029,127, 228,310, 274,029 and 48,031 persons for Ashanti, Central, Eastern and Western Regions respectively.

2.5.2 Industrial and Mining

Records of water use permits granted by the WRC for mining and other industrial uses in the basin show a total 49.2 million m^3/year for both surface water and groundwater.

Some of companies permitted include:

> AngloGold Ashanti (Gh.); Abore Mining Company Ltd; Resolute Amansie Ltd; Bonte Gold Mines Company Ltd; Narawa Company Limited; Central African Gold Limited; Chirano Gold Mines Ltd; AngloGold Ashanti (Iduaprem); Stratsys Investment Ltd; Xtra Gold Mining Limited; Central Ashanti Gold Limited; Benso Oil Palm Plantation Limited

Within the supply areas of urban pipe-borne schemes the water demand by industries, manufacturing and other commercial activities is included in the schemes production figures. However, a number of industries and institutions rely on their own water supply from both rivers and groundwater from boreholes.

[10] *WRC (2010): Baseline Studies and Water Balance Assessment for Pra and Tano basins towards the Development of National IWRM Plan Report.*

2.5.3 Agricultural Water use

Irrigation

There are three (3) formal irrigation schemes in the Pra Basin, all managed by Ghana Irrigation Development Authority (GIDA). These are the Anum Valley-Bottom Irrigation Project on the Anum River, Adiembra Irrigation Project on the Offin River and the Gyadam Irrigation Project on the Birim River. WRC has granted water use permits to GIDA to abstract various amounts of surface water for irrigation purposes. The combined annual water abstraction permitted for these schemes in 2010 is 17.4 million m^3 or a daily abstraction of 47,671 m^3.

Informal urban and peri-urban irrigation is practiced around some towns in the basin. There is little data on the overall extent of this informal irrigation in the basin. However, it is estimated that there are at least 12,700 smallholders irrigating more than 11,900 ha in the dry season around Kumasi alone, which is more than the area currently functioning under formal irrigation in the whole of the country. The major irrigated crop is rice. Other crops include tomatoes, pepper, okra, cucumber and maize.

The impact of irrigation on water quantity is not significant, due to the limited extent of irrigation. However, many of the water sources used for peri-urban irrigation (around Kumasi) are heavily polluted and therefore both growers and consumers are at risk from bacterial infections.

Livestock water use

Due to the lack of data on livestock population in the Pra Basin, livestock water demand is often estimated as a percentage of the rural population water demand. Assuming a livestock water demand of 6% of the rural demand, livestock water usage in the Pra Basin is estimated to be 3 Mm^3/year (using 100% of rural demand). Therefore, livestock water use in the basin is negligible.

In summary, utilisation of the surface water resources annually through abstractions for urban piped schemes presently amounts to just over 1% of the mean annual runoff of the Pra Basin. The groundwater abstraction for the rural schemes amounts to less than 1% of the mean annual basin recharge. The existing utilisation (abstraction) of the water resources in the Pra Basin is summarized in Table 2.6.

Table 2. 6: Summary of Water Resources Utilization

Category	Million m^3/year	%
Available Runoff	**4,174**	
Recharge to groundwater (volume)	5,566	
Water Resources Use		
- urban water supply	42.3	1.0
- rural water supply	31.7	0.8
- irrigation	17.4	0.4
- livestock	3.0	0.07
Industry (not served by urban piped schemes)	49.2	1.2
Total water use for Pra basin	**143.6**	**3.4**

Adapted from WRC (2010), Pra Basin baseline studies report, December 2010

Undoubtedly, these water resources have the potential for being further utilized. However, the resources are at risk from quality deterioration due to inappropriate human activities (poor land-use practices, mining, and poor waste disposal).

Land-use changes appear to be altering the pattern of stream flows and some supply shortages are occurring in the big cities like Kumasi and Obuasi. Nevertheless, in general there is currently little conflict over water use.

2.5.4 Environmental flow considerations

Generally, it is the low flow characteristics of the river that determine its suitability as source for a year-round water supply, i.e. direct abstraction without a storage reservoir. The flow of the Pra River and its tributaries particularly during the dry season has a significant impact on the flora and fauna associated with the prevailing aquatic system.

Therefore, in addition to the direct abstraction requirements, the minimum amount of flow required to maintain these vulnerable areas of the basin (environmental flow) must be defined downstream of existing and proposed water intake sites (e.g. Barekese dam). Environmental flow is an important requirement (a water demand category in its own right) to be taken into consideration as part of the Pra Basin IWRM planning.

2.6 Water Quality and Pollution

2.6.1 Surface Water quality

Pra River has the densest network of streams as well as mining operations among the south western basins system, and is therefore quite vulnerable to pollution from diverse sources. Water pollution has therefore been identified as the number one water management problem in the basin[11]. This is attributed to pollution arising out of practices such as the discharge of untreated waste into water bodies from domestic and industrial activities, and illegal artisanal mining (‘galamsey’).

In the Pra Basin, pH for the entire basin is generally within the acceptable range of 6.5 to 9.0 units for both high and low flow periods. High levels of conductivity have been detected at some sites located on tributaries passing through urban centres and mining towns. For example, median values of 540µS/cm and 399µS/cm have been detected at Ampunyase on Jimi River and Anwia-Nkwanta on Oda River respectively. The high conductivity at Anwia-Nkwanta, which is downstream of Kumasi may be attributed to discharge of raw domestic waste and industrial effluents into the Oda River from Kumasi Metropolis, while that at Ampunyase is attributed to both raw liquid waste and mining waste from Obuasi town which is about 20 km upstream. The Birim tributary, which is less urbanised, is noticeably soft with low conductivity (less than 100µS/cm) compared to the high levels detected in other tributaries such as Jimi and Oda Rivers.

[11] *Water Resources Commission (2000): Water Resources Management Problems Identification, Analysis and Prioritization Study. CSIR-Water Research Institute (September, 2000).*

The concentration of most metals is at the background level. However, high concentration of Arsenic has been detected at Ampunyase where values of about 1300µg/l[12] were measured in the dry season and 200µg/l during the high flow period. The large source of Arsenic is the Obuasi mining area in the Jimi catchment. Similar concentration level was detected at Mmuronem on the Anum River which drains Konongo, an old mining district where Arsenic was consistently above background levels and the WHO drinking water quality guideline of 10µg/l during the monitoring period. The Arsenic concentration is still high (close to 10µg/l) in the lower reaches of the Pra River, particularly at Daboase and Twifo-Praso, confirming the existence of large sources along the lower Offin and Pra rivers.

The major concern is that some important Ghana Water Company Limited (GWCL) water supply intake facilities to some large towns and cities are located in these reaches, which is a public health concern.

Biological oxygen demand (BOD) levels in the Pra system are on the whole, slightly above average for Ghanaian river background condition (~2mg/l). There is only a trivial correlation with domestic waste input particularly at monitoring stations which are downstream of main towns and cities. However, high levels of faecal coliform counts in the basin have been detected as a result of direct waste discharges into the rivers. Counts ranging between 21 x 10^3counts/100ml and 44 x 10^{11} counts/100ml have been reported[13].

Nitrate levels are relatively low in the upstream reaches of the rivers (<1mg/l) but become momentarily high at sites downstream of cities like Kumasi (5.7mg/l at Anwia-Nkwanta and Obuasi (13.2mg/l at Ampunyase). The levels at the extreme downstream sites (from Twifo-Praso down to the coast) are again low (<1mg/l).

2.6.2 Groundwater quality

It is difficult to make meaningful conclusion with respect to groundwater quality due to the paucity of data. While there are isolated incidents of poor groundwater quality arising from excess salinity, fluoride and iron levels in some boreholes in other basins in Ghana, groundwater in the Pra Basin is generally of satisfactory quality.

2.7 Water Quality Index (WQI)

The WRC, through the National Water Quality Monitoring Programme implemented under the WSSP–II (2004 to 2008), has prepared a Raw Water Quality Index (WQI) that is used to classify the health of rivers, streams, and lakes in a systematic manner. It guides WRC to categorise the quality of each section of a water body as good, fair, poor, or grossly polluted and also enables the comparison of the health of one river or section of a river with that of another.

The WQI is an index that measures the suitability of water resources for domestic purposes based on the weighted concentrations of a set of parameters. The index is used to describe the state of water quality as a whole instead of looking at individual parameters and different weights are assigned to each of the parameters based on their perceived effects on primary health care. The WQI is based on ten water quality parameters comprising: Dissolved Oxygen, Biochemical Oxygen Demand, Ammonia- N, Faecal Coliform, pH, Nitrate-

[12] *MINING SECTOR SUPPORT PROGRAM, GHANA(2007): SEA, Assessment of Riverine Material Transport in the Pra, Ankobra and Tano Rivers (April 2007)*
[13] *WRI/IAB Technical Report, 1994, WRC, 2000*

Nitrogen, Phosphate- Phosphorus, Suspended Solids, Electrical Conductivity and Temperature

The methodology incorporates the selected key physical, chemical and microbiological determinants, and aggregates them to calculate a WQI value at a specific water quality monitoring/sampling site. Based on the WQI value, the index classifies water quality into four categories as presented in Table 2.7, with a descriptive note concerning the pollution level of the water body in question. The aim is to protect natural waters from pollution such that the water falls at least in the upper portion of Class II - and more desirable in Class I.

Table 2.7: Criteria for classification of surface water bodies

Class	WQI - range	Description
I	> 80	Good - unpolluted water
II	50 – 80	Fairly good quality
III	25 – 50	Poor quality
IV	< 25	Grossly polluted water

An example of the results of the WQI computed for the major monitoring sites in the Pra Basin obtained from water quality campaign carried out in July 2010 by CSIR-WRI is presented in Annex 2.

At all the sites, the quality is within the Class II category, which represents fairly clean water[14], except in Barekese reservoir near Kumasi, where the value is lower than 50%, and therefore represents poor quality water. The poor quality of water in the reservoir is attributed partly to low dissolved oxygen content, a condition which discourages any form of aquatic life in the water body.

[14]*The WQI tend to mask site-specific pollutions. How reliable it is as an indicator of health hazard at specific sites cannot be ascertained*

3.0 ANALYSES OF WATER AVAILABILITY AND DEMAND PROJECTIONS

3.1: Generalities of the Water Evaluation and Planning (WEAP) System

The Water Evaluation Planning (WEAP) system as applied to the Pra Basin has been developed to support water resources planning and to inform decision making on water allocation in the basin. A brief about the process to integrate demography, water resource availability, water requirements and allocation of various uses are discussed below.

3.1.1 Schematization

In the schematic part of the WEAP, the Pra Basin is delineated into nine sub-catchments, and reservoirs are also specified. GIS maps based on the river network and the digital elevation model (SRTM) is used to determine the exact location of the streams in WEAP. Each sub-catchment is essentially the area that contributes to river flows as observed at a river gauging station located on the outlet of each catchment. This way, modelling was facilitated.

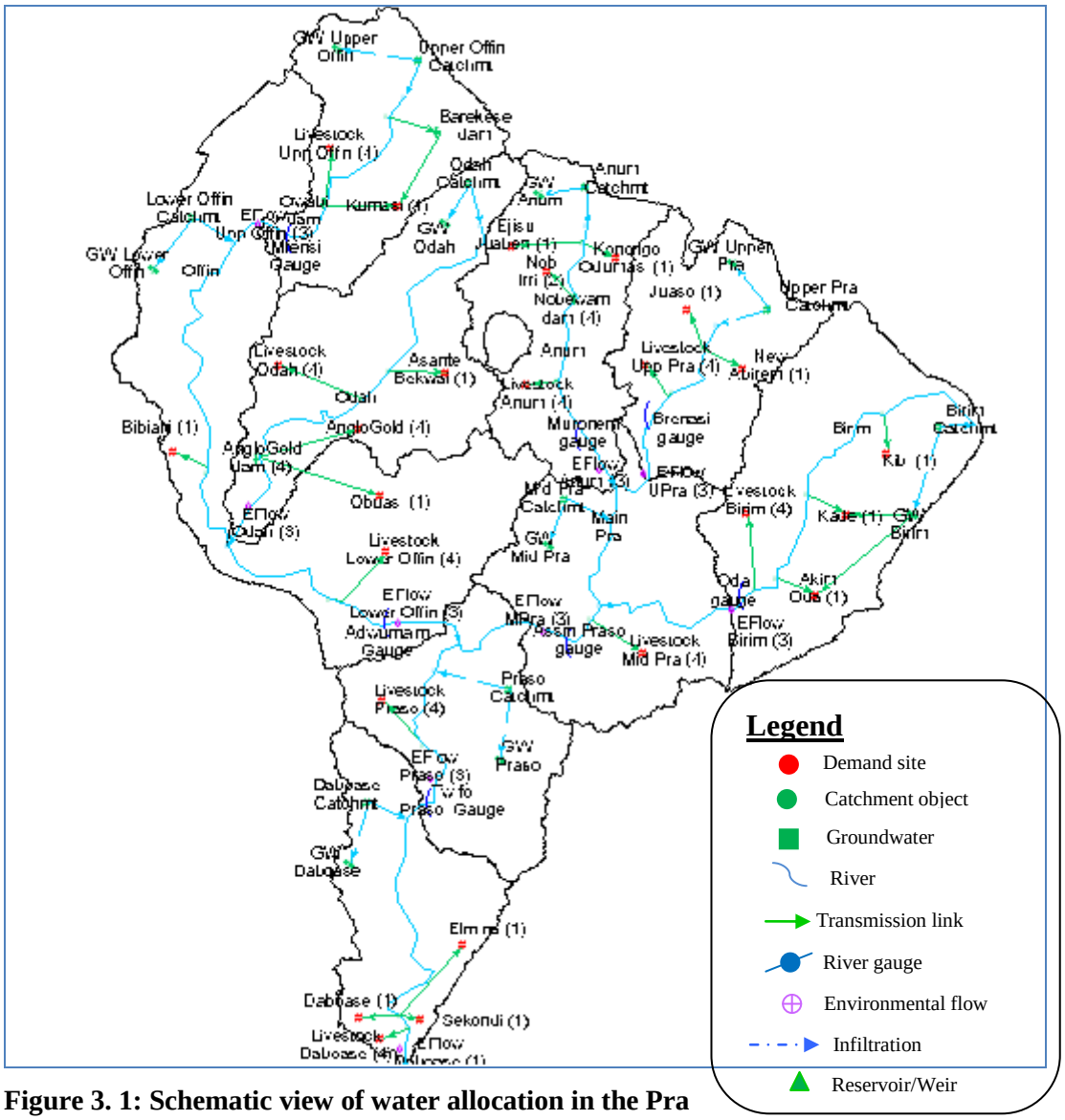

Figure 3. 1: Schematic view of water allocation in the Pra

The schematization of the basin involved collating and entering the following data in the WEAP:

- Water uses (demand site)
- Reservoirs: location, capacity and operation rules
- Flow gauging station
- River head flows
- In-stream flow requirement[15] (environmental flow requirement / ecological reserve)

In the absence of reliable hydrological data, water resource for exploitation was derived from precipitation which is injected into the model through a catchment object[16] represented by a '**green dot**'. This is a simplified hydrologic model (rainfall-runoff), for which satisfying the hydrologic cycle is paramount. Thus the precipitation contributes to runoff, groundwater recharge, evapo-transpiration and storage, where existent while meeting the respective water demands of the various uses.

The WEAP presents water use as "demand site" represented by a '**red dot**'. Thus water use and for that matter, water requirements are assessed for various needs in the basin. Four consumptive uses have been considered for the Pra basin notably:

- Domestic water requirements for key towns and cities;
- Livestock water requirements;
- Irrigation activities and developments; and
- Other demands (e.g. Industrial/Mining water requirement).

In most cases, surface water is abstracted to supply demands. In few cases, groundwater is harnessed to supplement domestic demands.

3.1.2: Prioritization of water demands

Every sub-catchment has a number of demand sites, including domestic, agriculture (irrigation), livestock, environmental flow and other uses. Based on priorities for water allocation set by WRC, domestic water use and environmental flow are the most important and have the highest priority. Second important use is Agricultural (irrigation), third is for livestock and the other uses have least priority (see Table 3.1)

Table 3. 1: Priority for water allocation

Demand	**Priority**
Domestic water demand	1
Environmental flow	1
Irrigation water demand	2
Livestock use	3
Other demands	4

[15] *Environmental flow was assumed in view of lack of data or research in this area*
[16] *This was necessitated by the lack of long-term hydrological data for the basin*

3.2 Data input to the WEAP model

Data and information that characterize the Pra basin was processed and organized into formats usable in WEAP. These included meteorological data, land cover and land-use, demography and water requirements for various uses. The water year in Ghana, which begins in March was assumed.

3.2.1 Hydro-meteorological data

Historical data of river flows as observed at various gauges on the Pra Rivers were unreliable and not readily available, therefore meteorological information (including rainfall and temperature) on monthly time series for the basin obtained from the Water Resources Commission (WRC) were used. Further, data on relative humidity and cloud cover for the basin was extracted from the TS 2.1 dataset of the Climate Research Unit (CRU) of the University of East Anglia (http://www.cru.uea.ac.uk/cru/data/hrg/cru_ts_2.10). The CRU dataset used covered the period 1951 – 2002. There was however, no data on the wind. The default value of 2 as noted in WEAP was used. In the future, this gap should be filled.

3.2.2 Land cover/land use and projections

The total land area for the Pra basin is estimated at 23,210 Km^2. The land use and land cover in the Pra basin is characterized largely by agricultural lands, grassland, forests, and human settlement. A baseline study conducted in the basin indicated that about 20% land use goes for settlement as at 2000. Over the years agricultural land use has increased owing to population expansion. Thus grassland and forest covers have reduced and will continue to experience a decline. It is also expected that proper town planning of settlements would be instituted by the MMDAs to influence/control infrastructure and housing development towards managing environmental sanity. The table below presents estimates of land cover and land use for the basin,

Table 3. 2: Land cover/use in the WEAP

Land Cover/Land use	1960s	2000	2040
	%	%	%
Agriculture	20	30	40
Grassland	20	15	15
Human settlement	10	20	25
Forest	50	35	30
Total	100	**100**	**100**

A decline of forest cover from 50% in 1960 to 30% by 2040 implies that laws governing the exploitation of the basin forests should be enforced and implemented towards maintenance of the ecological integrity. A key assumption in the model was that each of the delineated catchment had the same proportion of land cover/ land use.

3.2.3 Demography and domestic water requirements

A number of key towns and cities were identified and represented in the model to reflect water resources development of the Pra basin. An attempt was made to represent in each sub-catchment at least a town and/or city. Pending the release of the report of the population

census carried out in 2010, population growth rates based on the 2000 census figures were used to project the water demands into the future (till 2025)[17].

3.2.4 Irrigation water requirements

A number of irrigation schemes exist in the basin for which operations are expected to expand in the future. Specific to this is the Anum valley irrigation scheme. However, the volume abstracted as per the water rights granted by WRC in 2010 notably 11 Mm^3 was kept constant over the simulation period.

3.2.5 Mining water requirements

AngloGold Ashanti mining company in Obuasi (the largest mining company) has been represented in the model. Although other companies were granted water rights for 2010, it is yet to integrate these in the model. The value allocated to AngloGold is kept constant over the period of simulation.

3.2.6 Environmental flow

To sustain river flows for environmental 'maintenance', minimum flow requirements have been introduced downstream of the water abstraction points and dam sites. The assessment of the minimum flow requirements were based on a low-flow frequency analysis on the monthly flow data[18] and determined as the 95-percentile flow (i.e. the 20-year minimum flow return period) in each calendar month. The environmental flow requirements for downstream major reservoirs/dams in the basin were estimated to be $0.1 m^3/s$.

3.3 Current accounts and Reference scenario years

The Current Accounts is the dataset from which the scenarios are built. Scenarios explore possible changes to the system on future years after the Current Accounts year. A default scenario, the "Reference scenario" carries forward the Current Accounts data into the entire period specified for the simulation and serves as a point of comparison for the other scenarios in which changes are made to the system data.

The year 2010 is chosen as the "Current Accounts" year, or base year, for this model and the period for simulation is set to 2010 to 2025.

3.4 Climate change scenarios

The climate change scenarios have been developed based on the projections for West African sub-region[19] in the Fourth Assessment Report (AR4) of Intergovernmental Panel on Climate Change (IPCC). It is projected that by 2030, temperature for southern regions will increase by 1.1–1.3°C and up to 1.4°C for northern regions of West Africa. The predictions for precipitation by 2050 indicate a slight decrease in the central regions of Ghana and Cote d'Ivoire while the coastal regions in Ghana will be wetter by 20 mm to 30 mm.

Thus two climate change scenarios have been considered in the WEAP model on the assumption that by 2030, there will be 1°C rise in temperature of the basin.

[17] *Historical data on the populations for most of the towns and cities, with(1960-as reference year) were sourced from* http://www.ghanadistricts.com/districts/?r=7&_=118&sa=3334

[18] *The runoff records for many of the river gauging stations had many gaps, while the rainfall records were of long-term series. Rainfall-runoff analyses were carried out in most cases to fill in gaps and extend the river flow series.*

[19] http://www.ipcc.ch/publications_and_data/publications_and_data_figures_and_tables_gr-climate-changes-2001-syr.htm

The scenarios are as follows:

- Climate change with no change in precipitation trends relative to historical data. This is noted as "reference" or "normal";
- Climate change with a decrease in precipitation relative to historical data and referred to as "drier". A 10% reduction in precipitation relative to the reference situation was applied.
- Climate change with increase in precipitation relative to historical data and referred to as "wetter". In this case, a 10% increase of precipitation relative to the reference situation was applied.

The scenarios took into account increasing trends of water demands for domestic consumption whereas livestock and projected irrigation development were kept constant through the simulation period towards assessing the water resources and existing infrastructure capacity.

3.5 Results from the scenario analyses

In the context of this plan, the results from the scenario analyses are reported on and compared with each other by highlighting the level of coverage (% of requirement met) as calculated at the different demand sites during the planning period.

Water supply system losses and environmental flow requirements are included in all the WEAP model runs presented below.

3.5.1 Assessment of renewable water resources

Simulation of rainfall-runoff in the normal situation (reference scenario) indicates that relative to the amount of water available in the basin (precipitation), the bulk of the available water will be used to satisfy water supply demands - consumption (Figure 3.2). The unused supplies go as runoff that will be available for other future use (e.g. groundwater recharge).

There are variations however with water available which need to be well managed to offset any unforeseen issues that will reduce the water availability.

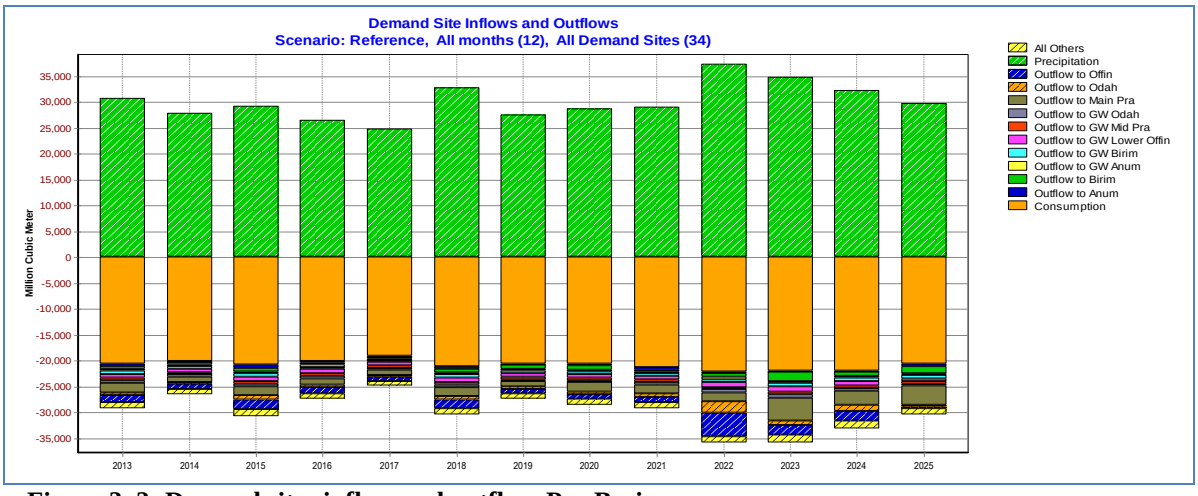

Figure 3. 2: Demand sites inflow and outflow-Pra Basin

3.5.2 Water Demand in the basin

Projected water demand for major use sites is illustrated in Figure 3.3. Kumasi being the most urbanised, the largest share of the future surface water demand falls within the metropolis. This is followed by Agricultural demand (Nobewam Irrigation Scheme). Water demand for mining and other industrial use are quite negligible compared to water demand for domestic and agricultural use.

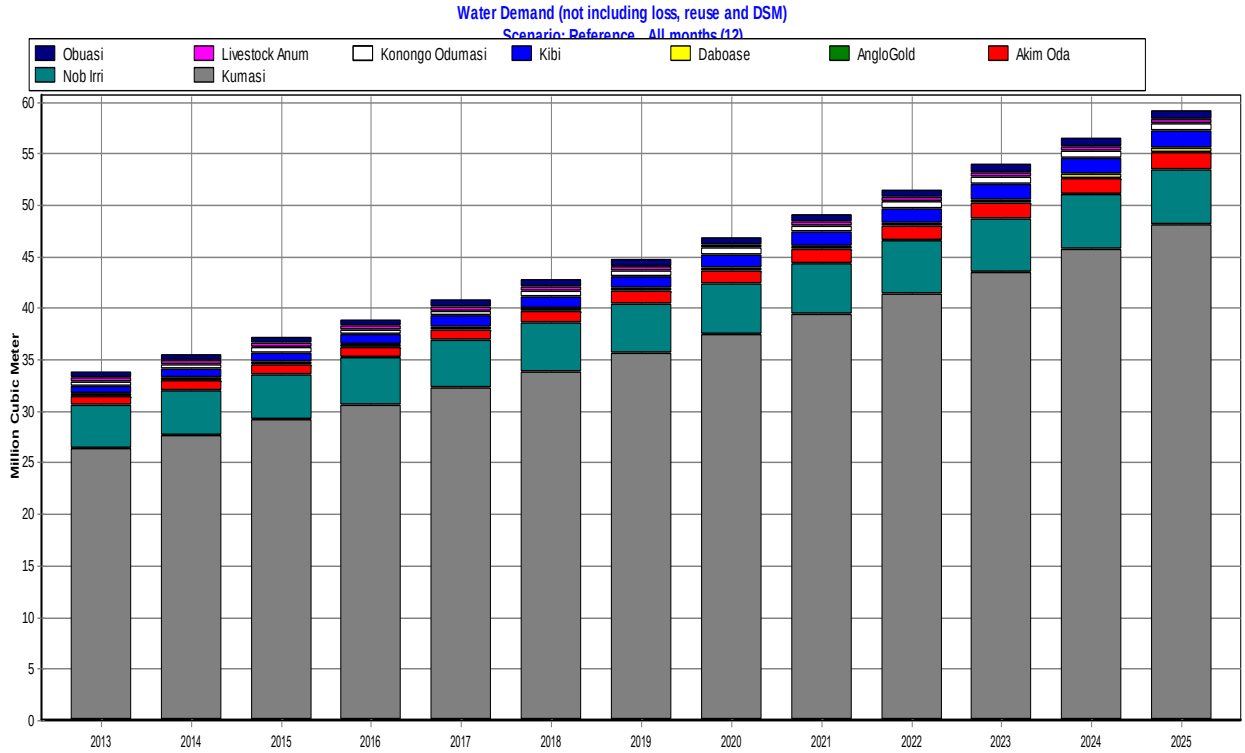

Figure 3. 3: Water demand projections

3.5.3 Unmet demand under wet and dry conditions

Simulation results shown in Figure 3.4 indicate that the water demand at all sites in the basin (including demand for irrigated agriculture at Nobewam) will be met except for water supply to Akim Oda and Kibi in the Birim sub-basin, and Konongo in the Anum sub-basin.

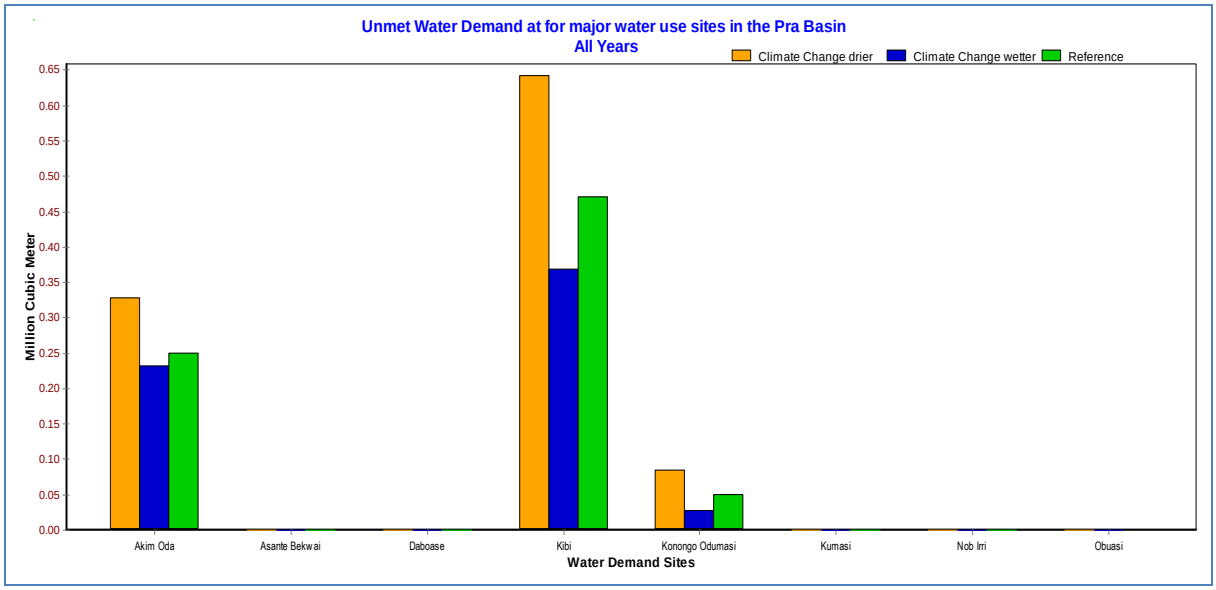

Figure 3. 4: Water shortages for all demand sites under all climate change scenarios

The implications are that water resources in the basin are sufficient to meet most demands, and that climate change would reduce the reliability of supply to only the three towns.

Under dry climatic conditions, the unmet demand at Akim Oda and Kibi are projected to be 0.04 and 0.12 million m^3 per year respectively by 2017 (Figure 3.5). The unmet demands are projected to reoccur in 2020 at Kibi. The risks of water shortages are expected to be higher in 2022 and 2024 at Akim Oda, Kibi and Konongo even under wet climatic conditions (Figures 3.4 and 3.5).

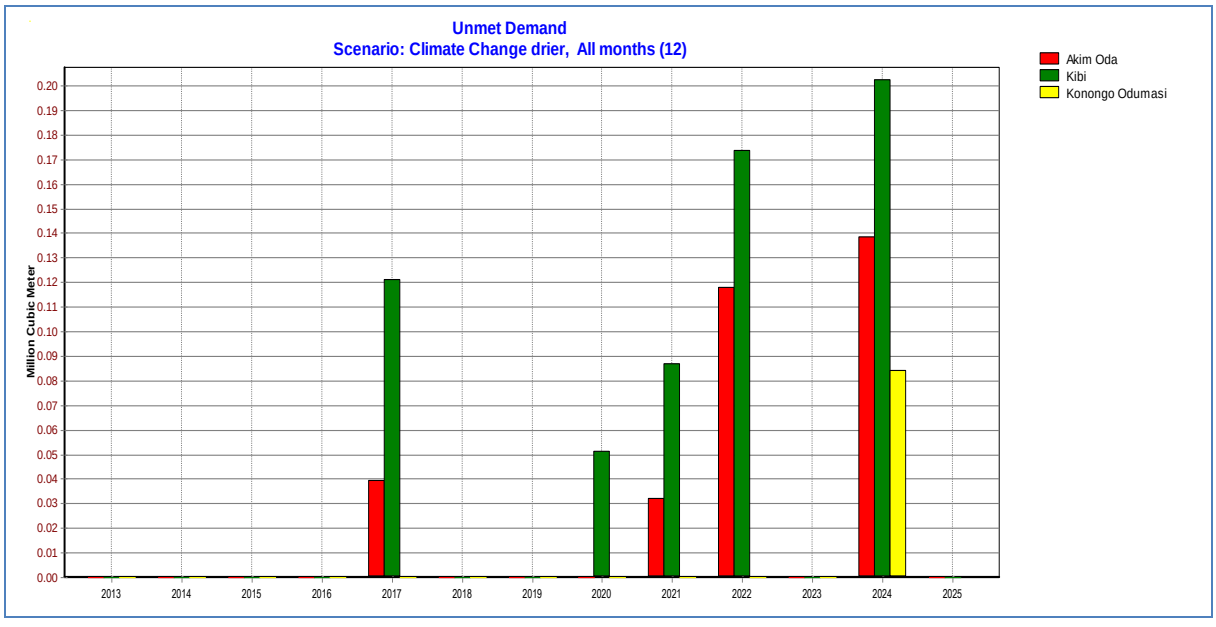

Figure 3. 5: Local impact of drier climate

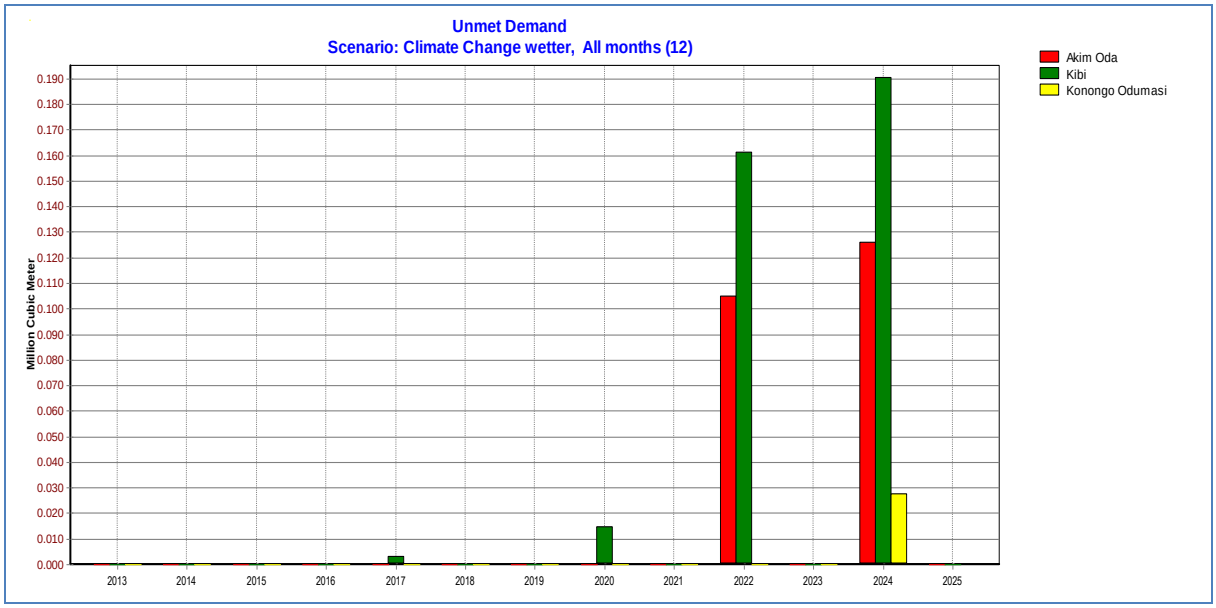

Figure 3. 6: Local impact of wetter climate

3.5.4 Water demand coverage (% of requirement met)

The water supply coverage under wet and dry climatic scenarios for Kibi, Akim Oda and Konongo are shown in Figures 3.6 and 3.7. In the dry season, coverage for the demand sites varies from 25% to 100% and from 30% to 100% in the wet season. The situation is likely to deteriorate in the long term if no measures are taken to address the shortages. At Kibi for instance, only 25% of water demand will be available in January 2024 (Figure 3.7).

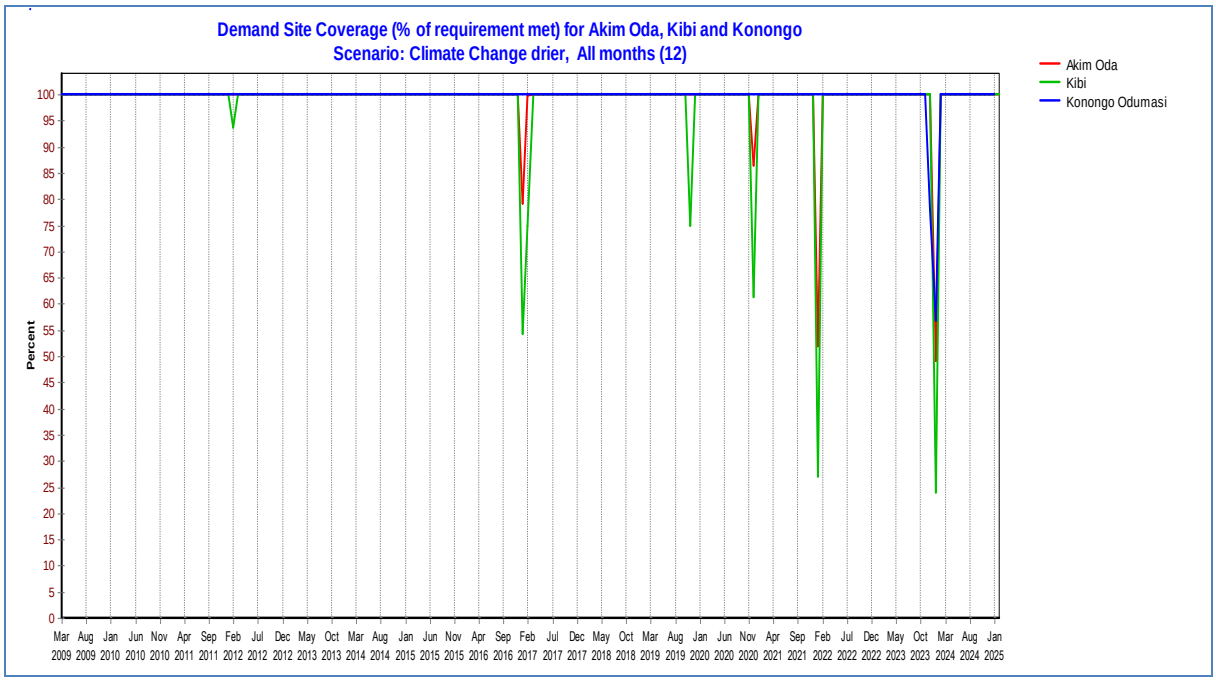

Figure 3. 7: Demand coverage in dry season

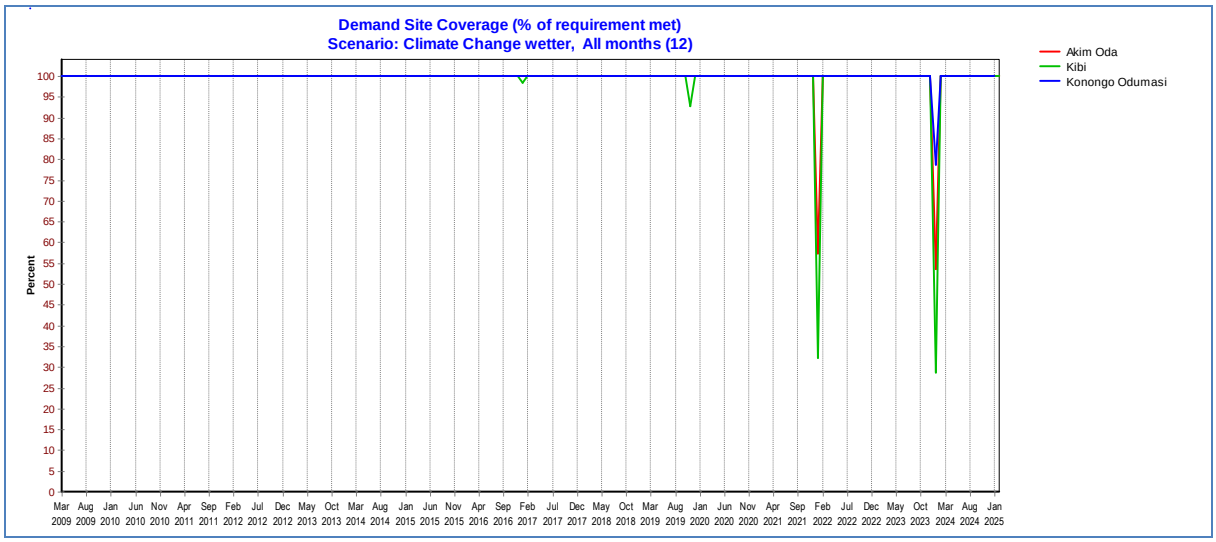

Figure 3. 8: Demand coverage in wet season

Some suggested strategies to avoid the projected shortages will include:

- Supplement the existing systems with groundwater (especially at Kibi, which is one of the most upstream towns in the Birim Basin.
- Promote rainwater harvesting at all sites to supplement urban water supply.

4.0 CONSULTATIVE PROCESS

4.1 Application of SEA in the IWRM planning process

Following from the technical assessments and description of the water resource-related challenges as presented in the previous chapters, a consultative process was carried out to involve basin-based stakeholders with the aim of capturing the local knowledge on water resources problems and actions required in addressing the identified water management issues and problems.

In the Ghanaian context, well established procedures exist where plans and programmes are elaborated and vetted following a participatory approach allowing for thorough public discussions – often in workshop settings – guided by principles which form part of the concept of Strategic Environmental Assessment (SEA). Thus, the SEA procedures and tools[20] have been applied in the process of developing the Pra Basin IWRM plan.

A SEA approach for planning is defined as:

"*A systematic process of evaluating the environmental effects of a policy, plan or programme and its alternatives, including documentation of findings to be used in publicly accountable decision-making".*

Furthermore, the application of SEA procedures in IWRM planning means that the evaluation of environmental effects has an additional social dimension, viz.:

"…to safeguard the future sustainable use of water resources aimed at maintaining the economic and social welfare within a basin without compromising the preservation of vital aquatic ecosystems".

The district-based planning by District Assemblies is the cornerstone of the decentralised governmental approach for which the overall legal framework and institutional delegation of responsibilities are proven and understood - although gaps in legislation, overlapping responsibilities, lack of capacity/resources and enforcement still exist.

An IWRM plan for a basin addresses the basin-wide water management problems to achieve future sustainable management of the basin's water resources, and as such provide a framework for local water management planning at the district level.

Consequently, the effects of the IWRM plan should not be restricted to a description of broad existing and projected future environmental and social impacts, but should also try to describe the effects of the IWRM plan on other existing plans and programmes.

The IWRM plan may entail legal and institutional consequences that may cause conflicting management structures, which then need to be coordinated and adjusted to ensure an efficient implementation of the plan.

In adherence with the SEA principles of embracing a participatory approach, stakeholders with specific interest/knowledge of the basin, including planners from District Assemblies, Governmental Departments, representatives from the mining industries, NGOs and water user organisations were gathered at three occasions in workshop settings convened by WRC at Kumasi.

[20] *WRC (October 2006), Support and Capacity Building to apply SEA Principles and Tools in preparing IWRM Plans at River Basin Level*

At a follow-up workshop, the identified problems were ranked and the proposed actions prioritised using pre-designed scoring tables.

At the third and last workshop the action programme was subjected to a test aimed at assessing the overall sustainability of the IWRM plan by the concerned decision-makers and other stakeholders.

4.2 Water resources management issues as identified by stakeholders

Guided by SEA procedures, the wide range of issues and problems in the basins perceived by the stakeholder were analyzed and grouped under five (5) problem areas namely:

a) Inadequate water supply to meet demand for domestic, commercial, agricultural, and industrial purposes (including mining);

b) Land degradation from deforestation, agriculture, mining settlements, etc.;

c) Water quality deterioration from household, commercial, industrial (including mining) and agricultural wastes;

d) Insufficient response to climate variability and change;

e) Weak institutional capacity in terms of human, financial, logistic, data, information, etc.

The key challenges in the Pra Basin and priority actions for addressing those are summarized in Table 4.1.

Table 4. 1: Problems, root causes and actions proposed by stakeholders

Problems	1. INADEQUATE WATER SUPPLY	2. LAND DEGRADATION AND WATER QUALITY DETERIORATION	3 INADEQUATE ADAPTATION TO CLIMATE CHANGE AND VARIABILITY	4. WEAK INSTITUTIONAL CAPACITY
Causes	• Increasing urbanization due to rapid population growth • High percentage of non-revenue water (over 50%) in urban water supply system due to poor physical infrastructure and pilferages • Inadequate financial resources and logistics for water supply and sanitation (WSS) delivery • Poor maintenance of irrigation infrastructure leading to low water use efficiency	• Land degradation from poor agricultural practices, forest excision for settlements and illegal mining • Deforestation for agricultural land and fuel wood • Fragmented buffer zone policies • Farming along the river banks • Point pollution from discharges of waste from mining, industrial and urban centres • Poor urban sanitation practices • Use of chemicals in fishing • Inability to enforce regulations and permit conditions • Limited awareness and knowledge on environmental hygiene • Unregulated peri-urban irrigation practices	• Lack of integrated flood management in development planning • Inadequate coping mechanisms for climate change • Inadequate financing of water resources development and management	• Inadequate data and information for planning • Limited awareness and knowledge • Inadequately trained and motivated man power • Inadequate financial resources and logistics • Weak capacity of decentralized institutions and civil society groups, (MMDAs, CBOs, NGOs) to perform river basin management tasks • Fragmented responsibilities and inadequate coordination of stakeholders' roles • Inadequate effective stakeholder participation in water resources planning, development and management

Actions to address the issues	➢ Improve Operation and Maintenance of existing water infrastructures ➢ Improve efficiency of water use ➢ Build new surface and groundwater infrastructure to meet projected demand up to year 2025 ➢ Increase institutional capacity to increase water supply ➢ Promote rainwater harvesting and use of underground dams ➢ Initially recover cost for O&M and later attain full cost recovery	➢ Create awareness and sensitise stakeholders about negative impacts of land degradation ➢ Provide incentives to change behaviour and alternatives to lost livelihoods ➢ Implement Buffer Zone Policy ➢ Strengthen institutional capacity to enforce compliance with Regulations ➢ Support MMDAs to enact Bye-Laws for enforcement of environmental laws ➢ Support MMDAs to rehabilitate, expand and build new waste treatment facilities to meet increasing demand ➢ Enforce Regulations on waste management and pollution control of surface and groundwater resources ➢ Strengthen institutional capacity at all levels for waste management ➢ Implement the Polluter Pays Principle and recover costs	➢ Monitor climate elements and create early warning systems ➢ Promote Community to National level approach to adapting to Climate Change (Adapts) ➢ Develop scenarios for extreme water availability, their impacts and develop corresponding strategies to adapt, cope and achieve water security ➢ Strengthen institutional capacity for adaptation	➢ Create and sustain awareness and sensitize stakeholders on WRM problems, issues and solutions ➢ Intensify education and training at all levels ➢ Set up Inter-sectoral collaboration and co-ordination committees at District level ➢ Provide logistics to enforce Regulations ➢ Develop GIS-driven data and information databases on the ecosystems, socio-culture, economics, water cycle, water supply systems, etc. ➢ Carry out research into technology development, adaptation, Etc. ➢ Monitor and evaluate

Source: WRC/Nii Consult (August 2011), Strategic Environmental Assessment of the Pra Basin IWRM Plan

5.0 OBJECTIVES AND STRATEGIC ACTIONS FOR THE PRA BASIN PLAN

5.1 Management objectives for the Pra Basin IWRM Plan:

Taking into account the prioritized problems identified through the stakeholder consultative processes (section 4.2) and their impacts on the freshwater and coastal resources, and on the health of the ecosystem, the following IWRM objectives for the Pra Basin are envisaged:

1) To secure the availability of water resources through efficient water use;

2) To improve water conservation and ecosystem health through effective protection and regulation of land and water resources;

3) To mitigate the suffering and economic loss of communities through adaptation to climate variability and change;

4) To strengthen Human and Institutional capacities to carry out key IWRM mandates.

5.2 Strategic Actions

Each objective is supported by a number of actions, which form the basis for the basin plan. The strategies, which are distilled from the actions identified by the stakeholders (Table 4.1) will ensure delivery of above objectives. It is expected that the basin board (PBB) will lead in the elaboration of targeted action programs for implementation in collaboration with the communities and other key stakeholders (NGOs and CBOs).

Objective 1: *To secure availability of water resources through efficient water use*

Water use efficiency in the sense of optimizing the benefits per unit water use is related to domestic water supply and agricultural production under irrigated condition. There should also be sufficient flow in rivers for ecosystem to flourish (Environmental Flow).

To secure water availability will involve reducing losses (non-revenue water) and encouraging more efficient practices on the part of water users. Efficiency of water use should minimize water losses during treatment, transport, storage and use. Reducing water loss involves aspects related to design, construction and operation and maintenance of systems, as well as user attitudinal change.

To facilitate the achievement of water use efficiency, the implementation of the water use regulation needs to be enforced and well monitored. Large commercial users who require permit to use water will be required to develop and submit to the PBB/WRC a Water Management Plan in accordance with permit conditions. Large industrial or commercial users who draw their water from urban supply systems and do not have to obtain a water use permits will have to submit a Water Management Plan as part of their Environmental Management Plan.

The Pra Basin has a potential for the installation of rainwater harvesting systems as option for water conservation and flood moderation. Flow or roof-water harvesting can be a means of increasing local water supply and groundwater recharge whilst simultaneously alleviating flooding problems in some areas. Construction of rainwater harvesting system could be made mandatory for all schools, government buildings, new industries, etc. Clear guidelines for roof water collection tanks and other cisterns, which can provide some initial retention of storm water, should be considered.

The key actions to achieve this objective may be summarized as follows:

- Support the development and enforcement of targets and benchmarks for efficient water delivery by water use institutions (GWCL, CWSA and GIDA);
- Ensure effective implementation and monitoring of the water permitting regulations;
- Promote Rainwater Harvesting for water conservation.

The main responsibility for implementing actions that secure sustainable use and availability of water falls on a number of different sectors, including GWCL (Urban Water supply), CWSA (Rural Water supply), and MMDAs (improved sanitation), and GIDA (Irrigation efficiency). Some initiatives by GWCL to minimize non-revenue water (NRW) and to gain on the efficiency are being implemented through the installation of meters at government institutions in certain municipalities. The key role of the Pra Basin Board is to secure water sources through management of water use regulations and promoting water use efficiency.

Objective 2: *To improve water conservation and ecosystem health through effective protection and regulation of land and water resources;*

The WRC has formulated a Buffer Zone Policy, which emphasizes on water quality conservation. Effective management of riparian buffer and adjourning landscapes will encourage the restoration of natural habitats, species and natural sediment transport processes, which will ensure that freshwater sources are protected. This will also help prevent and reduce nutrient enrichment, where the excessive growth of algae and other plants reduces overall biodiversity.

Improved sanitation in its various forms could also play an important role in keeping the integrity of both water and the environment. Unless the provision of sanitation services is improved, water sources and the environment will in some cases suffer damage that is almost impossible to reverse.

The key actions to deliver this objective include the following:

- Create and sustain awareness on threats to water and other natural resources;
- Implement the Buffer Zone Policy so as to retard silting of streams and pollution of water bodies;
- Support MMDAs to enact Bye-Laws for enforcement of regulations on environmental management;
- Set up effective water quality monitoring program;
- Promote integration of Tourism Development in the basin IWRM plans.

The main responsibility for implementing the strategies to improve land management rest with Forestry Commission, with greater collaboration from MOFA, MMDAs, EPA, Tourist Board, NGOs and CBOs.

Objective 3: *To mitigate the suffering and economic loss of communities through adaptation to climate variability and change.*

Climate Change and variability impacts are multi-sectoral issues. Promoting increased resilience to climate change will demand measures to ensure that policies on housing, energy,

landscape, water services, agriculture and waste management are aligned and contribute to optimal use of water resources, and ultimately water security.

For resilience against expected floods and sea level rise, it could mean building protective infrastructure (flood retention structures, sea defence walls, etc.) and towns' planning that restricts settlement in flood prone areas in the basin.

In terms of land use, this could mean developing green belts (buffer zones) along rivers and storm drains to replenish aquifers, improve water quality, minimize flood risks and enhance the habitat. For wastewater, it could mean re-designing treatment plants that can produce methane to be used as a fuel source or fertilizers to be used in agriculture.

Key actions to achieve this objective include the following:

- Raise public awareness on climate impacts (including dangers of settling in flood prone areas)
- Improve flood management through catchment conservation and protection so as to retard surface run-off (Buffer Zone Policy implementation)
- Support development of participatory disaster preparedness and management plans

Responsibility for implementing the strategies rest with WRC/PBB, with greater collaboration from Chiefs and Community Leaders, EPA, NADMO, MMDAs and other NGOs and CBOs.

Objective 4*:* *To strengthen Human and Institutional Capacities to carry out key IWRM mandates*

The institutional and human responsibilities envisaged under the Basin-IWRM Plan will require extensive and long-term capacity building to ensure its effective implementation. In particular, decentralisation entails the devolution of many governance responsibilities to the PBB and the MMDAs. The PBB and their secretariat will have delegated responsibilities, which imply the need for logistics and expertise (such as investigation of water use permit applications, environmental data and pollution control, and implementation of actions on river basin protection). There is the need therefore, to strengthen the managerial and technical capacities at those levels.

Stakeholder participation is also very important for effective governance of the basin. The communities know the environment in which they live and by sharing information, the PBB can both be better informed, and take account of differing interests and perspectives. Stakeholder participation can be initiated by distributing information to create awareness. The PBB will establish a representative forum (Forum of Actors) to help to develop constructive and trusting relationships between water resource managers and the public and civil society groups, with the aim of forming a common vision and understanding of the PBB's role and functions.

The actions are intended to provide the basis for public engagement in the various aspects of IWRM in the basin through co-operation, collaboration and agreement. They will target (a) appropriate capacity needs, (b) the provision of opportunities for collaborative actions, and (c) communication and access to information.

The key actions include the following:

- Set-up effective basin institutions (Pra Basin Board, sub-basin committees, water users associations, etc.);
- Provide logistics (office, vehicles, computers, etc.) for efficient running of the basin institutions (secretariat of PBB) and enforcement of Regulations;
- Support Education and Training in IWRM at all levels;
- Facilitate the preparation of annual basin and community action programmes for implementation;
- Set up Inter-sectoral collaboration mechanism and Forum of local actors;
- Coordinate the development of a detailed basin-level data and information management system;
- Monitor and Evaluate annual action programmes

The key actions are structured under the thematic areas and the respective objectives and presented in Table 5.1

Table 5. 1: Overview of the Pra Basin IWRM Planning framework

ID	Thematic Area	Strategic Objective	Key Actions	Implementing Entities (Lead Agency + Collaborators)
1.	Water use efficiency and conservation	*To secure availability of water resources through efficient water use*	**1.1**Support the development and implementation of targets and benchmarks for efficient water delivery by water use institutions (e.g. GWCL, CWSA and GIDA). **1.2**: Enforce and monitor the water permitting regulations **1.3:**Promote Rainwater Harvesting and use of Underground Dams for water conservation	**PBB/WRC +** MWRWH**,** GWCL, CWSA, GIDA, NGOs
2.	Catchment Protection and Water Quality Conservation	*To improve water conservation and ecosystem health through effective protection and regulation of land and water resources*	**2.1:** Create and sustain awareness on the value of water as a scarce resource, and threats to water and other natural resources **2.2:** Implement the Buffer Zone Policy so as to retard silting of streams and pollution of water bodies **2.3:** Support MMDAs to enact Bye-Laws for enforcement of regulations on water and environmental management **2.4:**Set up effective monitoring and assessment of water resource availability and use, and resource quality **2.5:** Promote integration of Tourism Development in the basin IWRM work programmes to boost local economies;	**PBB +** MMDAs, Chiefs and Communities' Leaders, Forestry, EPA, HSD, WRI, Media, Tourist Authority, MOFA, Chamber of Mines, NGOs
3.	Adaptation to Climate Change impacts;	*To mitigate the suffering and economic loss of communities through adaptation to climate variability and change*	**3.1:** Create public awareness on climate impacts (including dangers of settling in flood prone areas) **3.2:** Improve flood management through catchment conservation and protection so as to retard surface run-off (part of 2.2) **3.3:** Support development of participatory disaster preparedness and management programmes **3.4**: Strengthen basin-level information dissemination to facilitate adaptation (e.g. Early Warning Systems).	**PBB/WRC +** NADMO, EPA, HSD, WRI, MMDAs, Forestry, MOFA, NGOs, Chiefs and Communities' Leaders.

4.	Institutional and Human Resources Capacity Development	*To strengthen Human and Institutional capacities to carry out key IWRM mandates*	**4.1:** Set-up effective basin institutions (Pra basin Board, water users associations, forum of Chiefs, etc.) **4.2:** Provide logistics for efficient running of the basin institutions (secretariat of PBB) and enforcement of Regulations; **4.3**: Support Education and Training in IWRM at all Levels **4.4**. Facilitate the preparation of annual basin and community work programmes for implementation **4.5:** Set up Inter-sectoral collaboration mechanism and Forum of local actors **4.6:** Coordinate the development of a detailed basin-level data and information management system (e.g. functioning website for PBB). **4.7:** Monitor and Evaluate annual basin work programmes	**WRC/PBB +** MMDAs, GES, KNUST, NGOs, Chiefs and Communities' Leaders

6: MECHANISMS FOR IMPLEMENTING THE IWRM BASIN PLAN

6.1 Operational Structure:

The Pra Basin has a complex configuration, which is such that the hydro-environmental stakes tend to be circumscribed around the major sub-basins (the main Pra, Birim, Offin and Lake Bosomtwe) rather than at the basin as a whole. For example, the management of the Offin River will interest the districts in the Offin sub-basin and will have little to do with other districts in the Birim sub-basin. Similarly, Lake Bosomtwe is a closed hydrological basin (four streams flow into it but has no outlet) with a rich biological diversity of global significance and several sacred groves, which requires unique care and management.

Considering the complexity of the basin, a three-tier operational structure will be established for the management of the Pra, and will be composed as follows:

i. An Upper Pra sub-Committee to manage the Offin (including Oda), Lake Bosomtwe, and other sub-basins in the upper reaches (e.g. the Anum);

ii. The Birim sub-Committee to be in charge of the Birim sub-basin,

iii. The Lower Pra sub-Committee to manage the sub-basin between Twifo-Praso and the Coast.

Each of the sub-committee will be constituted as follows:

a) Representatives of MMDAs

b) A Representative of Regional Coordinating Councils (Ashanti for Upper Pra, Eastern for Birim and Central for Lower Pra)

c) A Representative each of Regulatory Institutions in charge of Mining, Forest, Environment, etc

d) A Representative each of major water users (Domestic water supply, Agriculture and Mining)

e) A Representative of Traditional Rulers

f) A Representative of Civil Society Groups that is active in the sub-basin.

g) A Representative of Women/Youth groups

- An Assistant Basin Officer each will be appointed to provide technical and secretarial support to the sub-Committees.
- The Pra-Offin Basin office in Kumasi will host the secretariat of the Upper Pra sub-Committee.
- The secretariat of the Birim sub-Committee will be hosted by Densu Basin Office in Koforidua.
- The Shama Municipal Assembly will host the secretariat of the Lower Pra sub-Committee.

For starters, WRC has already established the Pra/Offin Basin Board (PBB) to play consultative and advisory roles as it relates to the planning and management of the Upper Pra River sub-basin's water resources, and represents a wide sphere of interest groups within the Basin, including the traditional authorities. Its work is facilitated by a secretariat as a decentralised entity of the WRC. The PBB membership is constituted as follows:

(a) A chairperson appointed by the WRC,

(b) A representative of the WRC,

(c) One person representing each of the following organizations and institutions within the basin:

1. Minerals Commission
2. Environmental Protection Agency
3. Town and Country Planning Department
4. Kumasi Metropolitan Assembly
5. Ashanti Regional House of Chiefs
6. Ministry of Women and Children's Affairs
7. Ministry of Food and Agriculture
8. Ashanti Regional Coordinating Council
9. Forestry Commission
10. Ghana Water Company Limited
11. Friends of Rivers and Water Bodies
12. Upper Denkyira East Municipal Assembly
13. Obuasi Municipal Assembly
14. Asante Akim South District Assembly
15. Atwima Nwabiagya District Assembly
16. Bosomtwe District Assembly
17. Water Research Institute (WRC's representative)

(d) The Basin Officer serves as ex-officio member appointed by the WRC in charge of the Board's Secretariat. The Pra Basin Officer will also coordinate the activities of the three sub-committees (Figure 6.1).

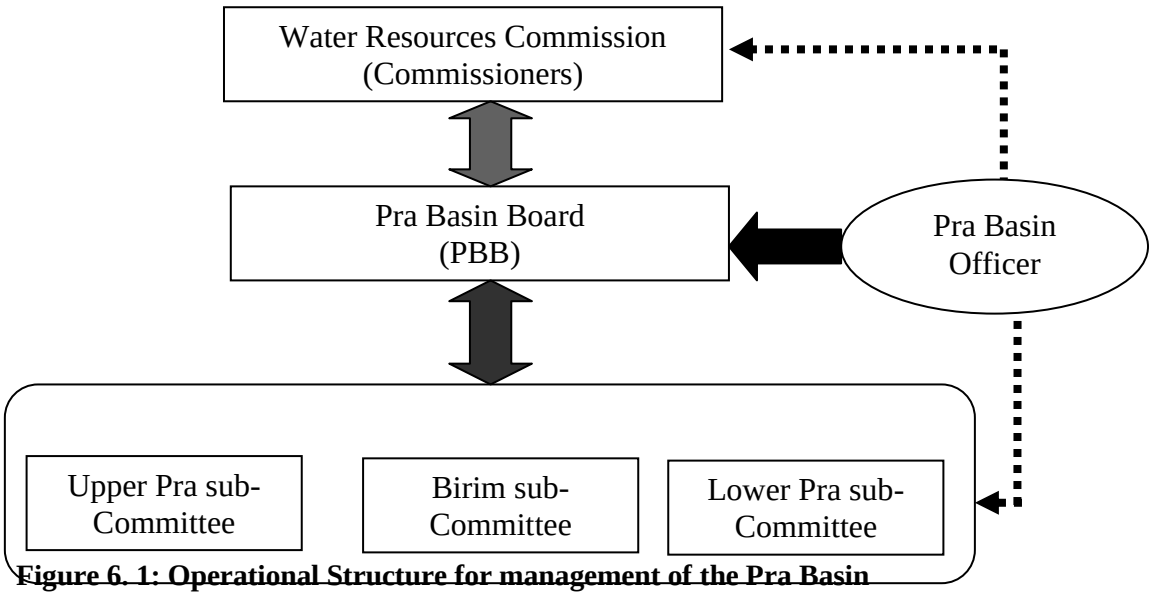

Figure 6. 1: Operational Structure for management of the Pra Basin

6.2: Gender Mainstreaming

Women play a key role in local water management – they have considerable knowledge of water sources, availability, quality, and conservation techniques. Water management schemes in the past that have excluded women or have not empowered women to actively participate, have often failed. Reasons for this include cultural dictates, lack of awareness on the part of authorities and development agencies, and lack of communication skills and confidence on the part of the women in the community to express their needs.

Fortunately, WRC has elaborated a plan for mainstreaming gender in IWRM in Ghana. Due cognisance will be given to recommendations in the plan to ensure that both men and women will be active participants, and women will not be viewed as passive recipients or as a vulnerable group along with children and the handicapped. Women will therefore be encouraged to take up leadership positions in the implementation of the Pra Basin Plan.

6.3: Monitoring the progress of implementation

Monitoring and evaluation (M&E) are key elements in the implementation of any basin plan. Through M&E, progress towards goals and objectives can be tracked and lessons captured to improve performance. To assist in monitoring, evaluation and reporting on progress in the implementation of the Pra Basin plan, the PBB secretariat will be supported to prepare a comprehensive monitoring and evaluation (M&E) plan as a deliverable (4.7) of this IWRM plan.

The general internal progress monitoring tools for this plan will be the half-yearly progress reports and annual reports to be compiled by the PBB secretariat and presented at the regular PBB and WRC Commissioners' meetings.

ANNEX 1: EMPLOYMENT PROFILE OF DISTRICTS IN THE PRA BASIN

Table AN 1: Occupation (in %) of the economically active population

DISTRICT	REGION	Agric& Forestry	Fishing	Mining& Quarrying	Manufacturing	Electricity, Gas & Water	Construction	Wholesale	Hotels &Restaurants	Transport, Storage& Comm.	Financial Intermediation	Real Estate	Public Admin	Education	Other
Adansi East	Ashanti	80.50%	0.30%	0.30%	4.70%	0.10%	1.20%	5.70%	1.50%	1.00%	0.20%	0.20%	0.30%	1.90%	2%
Afigya Sekyere	Ashanti	64.80%	0.30%	0.50%	9.80%	0.10%	2.10%	8.50%	1.90%	1.90%	0.30%	0.30%	0.40%	3.70%	5.20%
Ahafo Ano South	Ashanti	69.20%	0.80%	3.50%	8.10%	0.30%	1.20%	3.60%	1.70%	1.40%	1.50%	1%	0.50%	3.80%	3.30%
Amansie West	Ashanti	83.50%	0.20%	2.40%	3.50%	0.10%	1.20%	3.10%	1.10%	0.60%	0.10%	0.10%	0.30%	1.50%	2.40%
Asante-Akyem North	Ashanti	58.90%	0.80%	2.20%	9.60%	0.20%	2.70%	10.50%	2.20%	2.20%	0.60%	0.50%	0.70%	3.70%	5.20%
Asante Akim South	Ashanti	74.40%	0.30%	0.30%	6.40%	0.10%	1.70%	6.60%	1.80%	1.50%	0.10%	0.20%	0.60%	3.10%	2.80%
Ejisu/Juabeng	Ashanti	52.40%	0.30%	0.60%	13.20%	0.20%	3.80%	13.30%	2.90%	3.30%	0.20%	0.50%	0.70%	3.40%	5%
Ejura Sekyidumasi	Ashanti	68.60%	0.40%	1.60%	6%	0.10%	1.50%	11.60%	1.90%	2.70%	0.50%	0.30%	0.60%	2%	3%
Kwabre	Ashanti	31.30%	0.90%	3.30%	18.20%	0.20%	4.80%	20.50%	4.20%	5.20%	0.80%	0.90%	0.70%	3.10%	5.70%
Offinso	Ashanti	73.80%	0.30%	0.30%	5.80%	0.10%	1.20%	7.70%	1.70%	1.80%	0.10%	0.10%	0.50%	3.10%	3.40%
Sekyere West	Ashanti	66.80%	0.50%	1.90%	7%	0.20%	2.60%	8.50%	1.60%	2.40%	0.60%	0.40%	0.70%	3.60%	4.50%
Bosomtwe/ Atwima/ Kwanwoma	Ashanti	54.60%	1%	2.60%	10.30%	0.10%	3.90%	13.70%	1.70%	3.50%	0.50%	0.50%	0.40%	3.20%	4%
Kumasi Metro	Ashanti	7.10%	0.90%	2.40%	19.20%	0.40%	5.70%	35.90%	3.90%	6.70%	1%	1.70%	1.60%	4.20%	9.20%
Sekyere East	Ashanti	64.50%	0.70%	2.40%	9.60%	0.20%	2.20%	7.80%	1.40%	1.80%	0.70%	0.70%	0.50%	3.50%	3.90%
Atwima Mponua	Ashanti	64.90%	0.60%	1%	8.40%	0.30%	3.20%	9%	2.10%	2.20%	0.50%	0.50%	0.50%	2.70%	3.80%
Atwima Nwabiagya	Ashanti	64.90%	0.60%	1%	8.40%	0.30%	3.20%	9%	2.10%	2.20%	0.50%	0.50%	0.50%	2.70%	3.80%
Amansie Central	Ashanti	83.50%	0.20%	2.40%	3.50%	0.10%	1.20%	3.10%	1.10%	0.60%	0.10%	0.10%	0.30%	1.80%	2.20%
Amansie East	Ashanti	74%	0.70%	1.30%	5.70%	0.10%	1.60%	6.20%	1.30%	1.50%	0.40%	0.30	0%	4%	2.70%

Obuasi Municipal	Ashanti														
Adansi North	Ashanti														
Asikuma/ Odoben/Brakwa	Central	70.40%	1%	0.60%	7.60%	0.40%	1.50%	7.70%	1.90%	1.30%	0.20%	0.60%	0.70%	3.10%	2.8
Komenda/ Edna Eguafo/Ebire	Central	45.50%	12.70%	1.30%	10.20%	0.40%	2.90%	10.70%	3.50%	2.20%	0.40%	0.90%	1.30%	3.20%	4.5
Twifo-Heman/ Lower Denkyira	Central	70.20%	0.60%	0.90%	8.70%	0.40%	1.80%	6.90%	1.30%	1.80%	0.20%	0.80%	0.70%	2.80%	2.8
Upper Denkyira	Central	65.30%	0.90%	2.90%	7.40%	0.30%	1.90%	8.90%	1.30%	2.20%	0.30%	0.60%	0.90%	3.70%	3.30%
Assin North	Central	71.10%	0.70%	1.10%	7.70%	0.30%	2.50%	4.40%	0.40%	3.10%	0.30%	0.80%	0.80%	4.40%	2.50%
Assin South	Central	71.10%	0.70%	1.10%	7.70%	0.30%	2.50%	4.40%	0.40%	3.10%	0.30%	0.80%	0.80%	4.40%	2.50%
Birim North	Eastern	75.60%	0.80%	0.70%	6.10%	0.60%	1.30%	6.20%	0.90%	1.30%	0.10%	0.30%	0.40%	3.10%	2.60%
Birim South	Eastern	54.10%	1.20%	1.80%	10.90%	0.40%	2.40%	13.20%	1.80%	3.30%	0.30%	0.80%	0.90%	3.30%	5.70%
Fanteakwa	Eastern	67.60%	2.40%	0.50%	8.10%	0.20%	1.70%	7.70%	1.80%	1.80%	0.20%	0.60%	0.50%	3%	3.70%
Kwaebibirem	Eastern	57.50%	1%	7.60%	8.40%	0.30%	1.80%	10.30%	1.40%	2%	0.50%	0.50%	0.40%	3.50%	5%
Suhum/ Kraboa/Coaltar	Eastern	59.90%	0.80%	0.40%	10.60%	0.10%	1.70%	13.40%	2.80%	2.60%	0.20%	0.40%	0.50%	3.10%	3.50%
West Akim	Eastern	59.80%	1.20%	1.20%	8.80%	0.70%	1.40%	13.60%	2.70%	2.50%	0.20%	0.70%	0.60%	3%	3.70%
Yilo Krobo	Eastern	58.90%	1.20%	1.20%	9%	0.30%	1.90%	14.10%	2.70%	2.60%	0.10%	0.30%	0.70%	3.70%	3.20%
Kwahu West Municipal	Eastern														
Kwahu South	Eastern	51.10%	6.80%	1%	7.80%	0.20%	2%	1.60%	2%	2.90%	0.30%	0.60%	0.70%	4.40%	4.50%
Atiwa	Eastern														
East Akim Municipal	Eastern	57.70%	0.90%	1.10%	8.80%	0.20%	1.70%	11.50%	2.80%	2.20%	0.30%	0.60%	0.70%	4.30%	6.20%
Bibiani/ Anwiaso/Bekwai	Western	-	-	-	-	-	-								
Mpohor Wassa East	Western	-	-	-	-	-	-								
Shama Ahanta East	Western	-	-	-	-	-	-								
Wassa Amenfi East	Western	79.20%	0.30%	1.60%	6.60%	0.10%	1.70%	2.70%	0.30%	1.60%	0.30%	0.30%	0.60%	3%	1.4

Sources: Pra Basin Baseline Study Report-2010

ANNEX.2: CALCULATION OF WQI AT MONITORING SITES, PRA BASIN (JULY 2010)

Table AN 2: Calculation of WQI at monitoring sites in the Pra Basin

Parameter	Monitoring Stations								
	Adiembra	Barekese Reservoir	Osino	Lake Bosomtwe	Dunkwa-On-Offin	Daboase	Twifo-Praso	Akim-Oda	Akim-Brenase
Dissolved oxygen (DO) (% saturation)	69	48	82.7	101	84	103	97	93	92
BOD (mg/l)	3.10	3.50	4.10	4.80	3.74	3.40	3.10	3.8	4
Ammonia-nitrogen (mg/l)	0.214	0.884	0.366	0.344	0.202	0.801	1.62	1.64	1
pH	7.78	7.35	7.99	9.09	7.96	8.10	7.72	7.66	7.62
NO_3-N (mg/l as N)	0.245	0.251	0.402	0.080	0.434	0.484	0.476	0.441	0.299
Faecal coliform (counts/100 ml)	2	0	32	30	16	40	9	14	80
PO_4-P (mg/l as P)	0.094	0.049	0.298	0.097	0.255	0.206	0.237	0.15	0.118
Suspended solids (mg/l)	17	5	95	6	116	225	224	115	24
Elec conductivity (µS/cm)	164	126	108	1508	164	133	130	98.6	152
Temperature (°C)	29.1	33.7	24.9	26.2	24.3	30.6	26.6	29.3	29.3
Total Score - S (%)	77	69	73	76	76	75	76	76	77
WQI = S^2/100	**59.3**	**47.6**	**53.3**	**57.8**	**57.8**	**56.3**	**53.3**	**57.8**	**59.3**

ANNEX 3: NATIONAL LEGAL AND REGULATORY FRAMEWORK FOR IWRM

Within the overall framework of the 1992 Constitution, the policy framework for water resources management and development in Ghana is anchored on two very important documents: i.e. the WRC Act 522 of 1996 and the National Water Policy (NWP) of 2007. These documents promote an integrated approach to the management of the water resources in ways that are sustainable and most beneficial to the country, and are based on the continuing recognition of the social value of water, while at the same time giving much more attention to its economic value.

The WRC Act clearly defines the WRC as the overall responsible body for water resources management in Ghana and is specifically mandated to:

- regulate and manage the country's water resources; and
- co-ordinate government policies in relation to them

Other documents that complement the WRC Act and the NWP are legislative instruments, regulations and guidelines that address specific areas and issues of the entire water sector. Some of the specific areas and issues and their relevant laws are:

- ***Ownership and Riparian Rights:*** it falls within the provisions of Article 269 of Ghana's Constitution, which seeks to protect water resources by setting up a Commission to regulate, manage and coordinate Government policies in relation to it.
- ***Water Abstraction, Diversion and Damming:*** This is under the Water Use Regulations 2001 (L.I. 1692) and provides procedures for allocating permits for various water uses including domestic, commercial, municipal, industrial, agricultural, power generation, water transportation, fisheries (aquaculture), environmental, recreational and under water wood harvesting.
- ***Drinking Water Tariffs and Efficiency:*** The Public Utilities Regulatory Commission (PURC) Act 538 of 1997 set up the PURC and conferred on it the mandate to regulate standards of utility services including the tariffs set by the Ghana Water Company Limited (GWCL) for urban water supply, the quality of drinking water provided by the company, ensure proper water industry practices, and protect the interests of consumers.
- ***Drinking Water Quality Standards:*** The Ghana Standards Board (GSB) issues Drinking Water Quality Standards and sampling procedures covering the quality of water supplied by public water utilities.
- ***Effluents and Waste Discharges:*** The WRC and Environmental Protection Agency (EPA) control the pollution and effluent discharges into water bodies. EPA, through its Environmental Assessment Regulations of 1999 (L.I. 1652) defines procedures for acquiring environmental permits and conducting Environmental Impacts Assessments (EIA) for development projects that have or are likely to have adverse effects on the environment including water resources.