WATER RESOURCES COMMISSION, GHANA

DENSU RIVER BASIN -

Integrated Water Resources Management Plan

May 2007

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. The Densu River Basin was chosen as the first pilot area for various reasons such as rampant land and water quality degradation, and occasional water shortages in an otherwise perennial river system caused, among other factors, by the rapid population increase of the Accra metropolitan area and other urban centres within the basin.

The Densu River Basin is a classic case of an area in need of a basin-wide planning approach involving stakeholder participation, awareness raising, public meetings, 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 and watershed management, protection of buffer zones along the river banks as well as improved management of liquid and solid wastes 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 Densu River Basin. The decentralised 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 Densu Basin Board, respective planning officers of the District Assemblies and WRC's Densu Basin office in Koforidua (serving as secretariat for the Board).

In parallel to the organisational arrangements, activities of a more technical nature have been ongoing, which eventually resulted in the present Densu River Basin 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 utilisation, conservation, development and improvement of water resources" in adherence with the overall National Water Policy.

The document constitutes the first version of the IWRM Plan. 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.

It is WRC's sincere hope that this plan can be a useful catalyst towards accelerating concrete IWRM activities in the Densu Basin, and importantly – since it is the first of its kind in Ghana – also can serve as a source of inspiration to facilitate similar planning efforts in other vulnerable river basins in Ghana.

Prof. Clement Dorm-Adzobu
Chairman, Water Resources Commission
Accra, May 2007

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ABBREVIATIONS

CBO	Community-Based Organisation
CWSA	Community Water and Sanitation Agency
DA	District Assembly
DBB	Densu Basin Board
EPA	Environmental Protection Agency
GES	Ghana Education Service
GMA	Ghana Meteorological Agency
GoG	Government of Ghana
GPRS	Ghana Poverty Reduction Strategy
GWCL	Ghana Water Company Limited
GWP	Global Water Partnership
ha	hectare
HSD	Hydrological Services Department
IDA	Irrigation Development Authority
IWRM	Integrated Water Resources Management
l/c/d	litre per capita per day
LI	legislative instrument (regulations)
mm	millimetre
m^3/s	cubic metre per second
MDA	ministries/departments/agencies
MDG	Millennium Development Goals
MOFEP	Ministry of Finance and Economic Planning
MOFA	Ministry of Food and Agriculture
MWRWH	Ministry of Water Resources, Works and Housing
NDPC	National Development Planning Commission
NGO	Non-Governmental Organisation
p.a.	per annum
PURC	Public Utilities Regulatory Commission
SEA	Strategic Environmental Assessment
UN-Habitat	United Nations Centre for Human Settlements
VRA	Volta River Authority
WEAP	Water evaluation and planning computer-based model application
WRC	Water Resources Commission
WRI	CSIR-Water Research Institute
WSSD	World Summit on Sustainable Development (August 2002)
WQI	Water Quality Index

1. INTRODUCTION

1.1 IWRM in an international context

At the World Summit on Sustainable Development (WSSD) held in Johannesburg in 2002, 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 plan.

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

> *"... a process which promotes the coordinated development and management of water, land and related resources in order to maximise economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems …"*

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 process is intended to facilitate broad stakeholder input in order to build compromise and equitable access. This is particularly the case for developing countries like Ghana, which allocates much effort in addressing poverty reduction and in implementing the UN Millennium Development Goals.

IWRM is a comprehensive approach to the development and management of water, addressing its management both as a resource and within the framework of providing water services.

The Global Water Partnership models the IWRM process as a cycle of the following activities:

- establishing the status and overall goals;
- building commitment to the reform process;
- analysing gaps;
- preparing a strategy and action plan;
- improving the legal and institutional management framework; and
- monitoring and evaluating progress.

The goal of preparing IWRM plans as called for at the WSSD has set the tone for a world wide initiative, which Ghana has adopted with the purpose "to promote an ef-

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

ficient 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

In Ghana, IWRM plans are thought initially to be prepared at the river basin level starting with the most "water stressed" basins of the country. At a later stage, this exercise can provide input to preparation of an IWRM strategy/plan at national level 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 to water use, and the social and economic implications of implementing an IWRM plan. Actions to be taken as a consequence of 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 with a participatory approach guided by principles which are imbedded in the concept of Strategic Environmental Assessment (SEA).

Generally, SEA is applied with two purposes:

- 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 in Ghana been applied during 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 sector, 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

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[2] *Ghana National Water Policy (final draft, August 2005).*

[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).*

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.

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. Thus, the IWRM plan should be considered a "blueprint", that describes steps to be taken towards realising the visions.

1.3 Purpose and institutional setting of the IWRM plan

The target group of the basin-based IWRM plans is 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.

IWRM is a cyclic and long-term process. Hence, the IWRM plan can be seen as a milestone in this process, where the status of the process is documented, and the plan inevitably will need to be kept up-to-date when new knowledge surfaces, e.g. related to changes in the hydrological regime and projections of future water requirements.

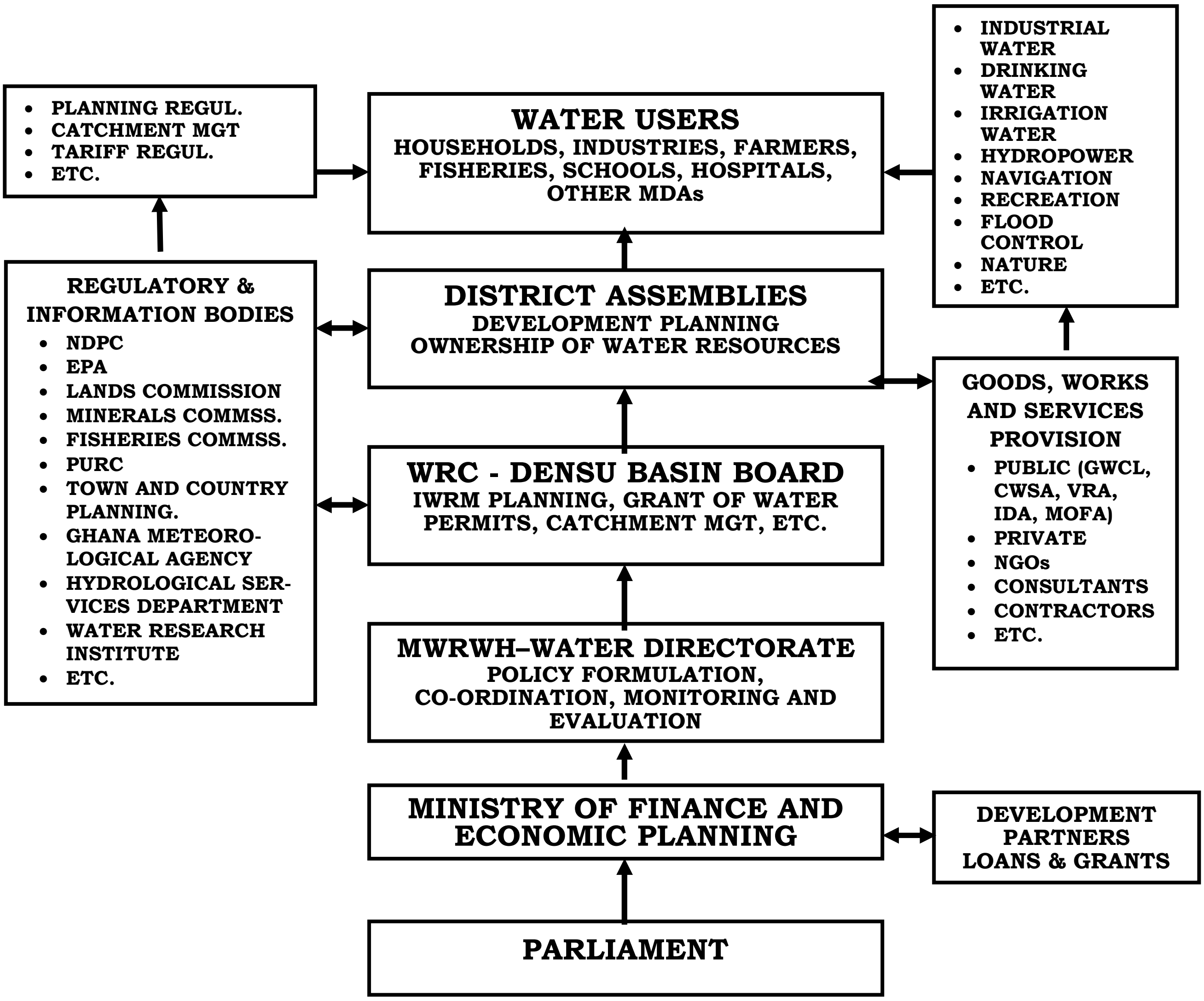
For the IWRM plan to be successfully implemented, it is imparative that the WRC collaborates with institutions affected by the plan. This is because the plan impacts on a variety of societal aspects, viz. utilisation and protection of natural resources, social and cultural situations, economics and production, and the legal, administrative and institutional frameworks. It is evident that there must be effective collaboration with planning efforts in these areas.

For instance, WRC has to collaborate with –

- MDAs, CWSA and GWCL in water demand projections;
- MDAs, Lands Commission, Minerals Commission, EPA, MOFA and traditional authorities in catchment management;
- MDAs and EPA in controlling various wastes into water bodies; and
- EPA, Forestry Commission, Fisheries Department, Water Research Institute and HSD in assessing environmental flow requirements.

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

Figure 1.1: Institutional framework for IWRM planning



1.4 Status of IWRM activities in the Densu River Basin

For quite many years Ghana has been planning for and engaged in the introduction of IWRM at various levels of society, and as such has advanced in the IWRM process resulting in a new national water policy and legislation facilitating water resources management and development based on IWRM principles. Furthermore, an enabling institutional framework has been introduced at national level, i.e. establishment of the Water Resources Commission (WRC) and the Water Directorate under the Ministry of Water Resources, Works and Housing, and at local river basin level in the form of creation of river basin boards.

The Densu Basin Board (DBB) was the first created and officially inaugurated in March 2004. DBB has a consultative and advisory role as it relates to the management of the the Densu 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 DBB membership combines the following:

(a) A chairperson appointed by the WRC,

(b) A representative of the WRC,

(c) One person representing each of the following within the basin.

- East Akim District Assembly
- Suhum/Kraboa/Coaltar District Assembly
- New Juaben Municipal Assembly
- Ga West District Assembly
- Akwapim South District Assembly
- Eastern Regional Coordinating Council
- Greater Accra Regional Coordinating Council
- Ministry of Health
- Ministry of Food and Agriculture
- Ministry of Women and Children's Affairs
- Environmental Protection Agency
- Ghana Water Company Limited
- Forestry Commission
- National Commission on Culture
- Orthodox Church
- Prominent Chief within the basin
- Non-Governmental Organisations

(d) The Basin Officer as ex-officio member appointed by the WRC in charge of the Board's Secretariat.

Over the past few years quite many specifically targeted studies and related activities have been completed aimed at providing data and new information of relevance for the IWRM planning. In the following chapter "Baseline Description" these various sources of information and reports are acknowledged as and when used.

Furthermore, in the Densu Basin a number of IWRM activities have also been initiated by the Densu Basin Board and WRC as well as NGOs and other partners, all with the purpose of addressing the reduced water availability and the water quality degradation facing the Basin. Some of these activities are:

- Holding of four Board meetings annually for the formulation of strategies to enhance coordination of the management and utilisation of the water resources of the basin;
- Organisation of sub-committee meetings of the Densu Basin Board to draw-up and review work programmes for implementation;
- Promotion and support for target groups' awareness creation and education within the basin (in communities and schools) and development of educational materials;

- Collaboration with agencies/organisations and communities working towards the recovery of the ecological health of the Basin, including activities such as tree-planting, clean-up exercises, river channel clearance and river bank protection;
- Identification of raw water users (to assist in the process of registering and granting water rights/issuance of permits);
- Establishment of links with the Basin's District Assemblies, traditional authorities/landowners to tackle specific issues relating to pollution and degradation of the catchment area, e.g. relocation of waste dump sites away from the river banks;
- Preparation of a "buffer" zone policy; and
- Provision of information services for students during preparation of their special studies and theses works, consultants, NGOs, CBOs and concerned individuals.

1.5 Preparation and structure of the IWRM plan

The WRC has elaborated the present IWRM plan for the Densu River Basin as part of WRC's mandate to "*propose comprehensive plans for utilisation, conservation, development and improvement of water resources*" [4] with due consideration to stipulations in the National Water Policy.

The IWRM plan is based on a number of dedicated assessment studies and information reviews all unveiling implications relevant for decisions made during the process of prioritising measures forming the IWRM plan. Guided by the newly introduced SEA procedures, consultative meetings and workshops have taken place during the course of preparation, specifically targeting the Densu Basin Board members, and District Assemblies and their planning officers.

Following the present introductory chapter, Chapter 2 presents the baseline description, which provides the background against which the planning and identification of actions can be made. In Chapter 3 water demand projections are presented based on district development plans and other information notably the 2000 census results. 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.

Chapter 4 describes the process followed towards identification and ranking of water resource management problems and issues as perceived by local stakeholders and planners of the basin, and documents the result of the SEA consultations. The final Chapter 5 concludes the IWRM planning process by presenting an action plan comprising of a number of prioritised activities and measures for implementation required to meet the IWRM challenges of the Densu River Basin.

[4] *Water Resources Commission (WRC) Act No. 522 of 1996*

2. BASELINE DESCRIPTION

2.1 Physical, demographic and socio-economic features

The Densu River traverses a highly densely populated part of Ghana and it is one of the most exploited rivers in the country considering its size. The basin is characterised by an accelerating land and water quality degradation, and is marked by occasional water shortages in an otherwise perennial river system caused, among other factors, by the rapid population increase due to proximity to the Accra metropolitan area.

2.1.1 Location, topography and river network

The Densu River Basin is located between latitude 5°30’N - 6°17’N and longitude 0°10’W - 0°37’W. The basin is bounded to the east and north by the Odaw and Volta basins, respectively. The boundary to the northwest is shared with the Birim basin and to the west with the Ayensu and Okrudu basins.

The topography of the Basin is diversified. The Basin is characterised by steeply dissected landscapes with hilly and rolling lands to the north, and flat coastal plains to the south with slopes and erosion surfaces that vary from 30% in the upper sections of the basin to less than 2% at the coast. The Basin is bordered to the east by the Akwapim hills and the Kwahu-Mampong scarps. The highest part of the basin reaches about 750 m above sea level and occurs along the north-western basin boundary. The topography of the Basin is depicted in Map 2.1 (inserted at the end of chapter).

The Densu River belongs to the Coastal River System group and the basin encompasses an area of about 2,600 km^2. The river takes its source from the Atewa range and flows from its upstream sections in an easterly direction towards the Akwadum - Koforidua area, from where the river gradually changes its course and flows in a southerly direction into the Weija reservoir - one of the two main sources of water supply for the Accra metropolitan area. When the Weija reservoir is full excess flow discharges into the Densu delta (Sakumo) lagoon and salt pans complex, which constitutes one of Ghana’s internationally recognised protected areas (Ramsar sites), before discharging into the Bay of Guinea (Atlantic Ocean) some 10 km west of Accra. The total length of the Densu river is about 120 km, and its main tributaries are the Pompon, Kuia, Adaiso, Dobro and Nsaki rivers. The river network is shown on Map 2.4 (inserted at the end of chapter).

2.1.2 Administrative structure, population and settlement pattern

The administrative fabric of the relatively small Densu River Basin can be characterised as rather complex in the sense that 3 administrative regions and 13 districts are represented within the basin, including part of the Accra metropolitan area. Approximately 72% of the basin (the northern portion) lies within the Eastern Region, 23 % within the Greater Accra Region and the remaining 5% within the Central Region. Among the 13 administrative districts, the portions of the five districts of East Akim, New Juabeng, Suhum/Kraboa/Coaltar, Akwapim South and Ga West constitute together close to 85% of the basin area. Contrary, the portions of Fanteakwa, Yilo Krobo and Kwaebibirem districts in the north of the basin constitute only about 1% of the basin area. Likewise, only a small part of the Ga East district is located within the basin boundary. These features are depicted in Map 2.2 (inserted at the end of chapter) with figures given in Table 2.1 below.

Applying the 2000 Census[5] results, the population size within the Densu River Basin is shown in Table 2.1 listed for each district and in accordance with the settlement classification, i.e. whether people live in rural or urban settings. Per definition, the urban population combines all settlements larger than 5,000 people. The portion of a district's rural population living within the Basin is estimated by matching the proportion of the area of the respective district, which is located in the Basin, and using this percentage to calculate the rural population. The population density is also indicated in Table 2.1.

The population increases recorded in the latest inter-censal period (i.e. between the censuses of 1984 and 2000) show not surprisingly heavy growth rates in the areas of the Basin close to the Accra metropolis, i.e. the Ga West and Ga East districts as well as the Accra Metro area itself. Generally, in these areas annual growth rates of close to 10% have been recorded. This characteristic is also evident from the settlement pattern (split between rural and urban population) as well as the population density figures given in Table 2.1.

Internal migration is the most important determinant of this marked population growth in these parts of the Densu Basin. As the localities are becoming relatively attractive for migrants, new waves of migrants are likely to gravitate to the localities to swell up the existing population. The driving force behind this vibrant development is the urban sprawl phenomenon of Accra. This "urbanisation" trend is expected to continue unabated in the foreseeable future, and hence, will gradually affect larger and larger areas in the Basin, particularly of the Ga West District.

As an average for the entire Densu Basin, the population density (year 2000) is 387 pop/km^2, five times bigger than the national average of 77 pop/km^2. The location of a number of the major settlements/towns within the Basin is also indicated on Map 2.2.

[5] *Ghana Statistical Service: 2000 Population and Housing Census (official results on DC-ROM, January 2002)*

Table 2.1: Population in the Densu River Basin (2000 Census)

<table>
<tr><th rowspan="2">Region</th><th rowspan="2">District</th><th rowspan="2">Settlement category</th><th rowspan="2">Population (2000)</th><th colspan="2">Area in basin</th><th rowspan="2">Density (pop/km²)</th></tr>
<tr><th>(km²)</th><th>(%)</th></tr>
<tr><td rowspan="18">Eastern</td><td rowspan="2">Fanteakwa</td><td>rural</td><td>800</td><td rowspan="2">10</td><td rowspan="2">0.4</td><td rowspan="2">80</td></tr>
<tr><td>urban</td><td>0</td></tr>
<tr><td rowspan="2">Yilo Krobo</td><td>rural</td><td>1,200</td><td rowspan="2">18</td><td rowspan="2">0.7</td><td rowspan="2">67</td></tr>
<tr><td>urban</td><td>0</td></tr>
<tr><td rowspan="2">East Akim</td><td>rural</td><td>27,500</td><td rowspan="2">334</td><td rowspan="2">12.8</td><td rowspan="2">223</td></tr>
<tr><td>urban</td><td>47,000</td></tr>
<tr><td rowspan="2">Kwaebibirem</td><td>rural</td><td>~ 0</td><td rowspan="2">2</td><td rowspan="2">0.1</td><td rowspan="2">-</td></tr>
<tr><td>urban</td><td>0</td></tr>
<tr><td rowspan="2">New Juabeng</td><td>rural</td><td>22,000</td><td rowspan="2">209</td><td rowspan="2">8.0</td><td rowspan="2">651</td></tr>
<tr><td>urban</td><td>114,100</td></tr>
<tr><td rowspan="2">Suhum/ Kraboa/Coaltar</td><td>rural</td><td>101,700</td><td rowspan="2">763</td><td rowspan="2">29.3</td><td rowspan="2">174</td></tr>
<tr><td>urban</td><td>31,000</td></tr>
<tr><td rowspan="2">Akwapim North</td><td>rural</td><td>19,700</td><td rowspan="2">146</td><td rowspan="2">5.6</td><td rowspan="2">169</td></tr>
<tr><td>urban</td><td>5,000</td></tr>
<tr><td rowspan="2">Akwapim South</td><td>rural</td><td>53,100</td><td rowspan="2">322</td><td rowspan="2">12.4</td><td rowspan="2">298</td></tr>
<tr><td>urban</td><td>43,000</td></tr>
<tr><td rowspan="2">West Akim</td><td>rural</td><td>10,500</td><td rowspan="2">88</td><td rowspan="2">3.4</td><td rowspan="2">212</td></tr>
<tr><td>urban</td><td>8,200</td></tr>
<tr><td rowspan="6">Greater Accra</td><td rowspan="2">Ga West</td><td>rural</td><td>125,500</td><td rowspan="2">546</td><td rowspan="2">21.0</td><td rowspan="2">854</td></tr>
<tr><td>urban</td><td>341,100</td></tr>
<tr><td rowspan="2">Ga East</td><td>rural</td><td>2,300</td><td rowspan="2">10</td><td rowspan="2">0.4</td><td rowspan="2">870</td></tr>
<tr><td>urban</td><td>6,400</td></tr>
<tr><td rowspan="2">Accra Metro</td><td>rural</td><td>2,100</td><td rowspan="2">30</td><td rowspan="2">1.2</td><td rowspan="2">927</td></tr>
<tr><td>urban</td><td>25,700</td></tr>
<tr><td rowspan="2">Central</td><td rowspan="2">Awutu/ Efutu/Senya</td><td>rural</td><td>8,800</td><td rowspan="2">122</td><td rowspan="2">4.7</td><td rowspan="2">154</td></tr>
<tr><td>urban</td><td>10,000</td></tr>
<tr><td colspan="2" rowspan="2">Densu Basin, total</td><td>rural</td><td>375,200</td><td rowspan="2">2,600</td><td rowspan="2">100.0</td><td rowspan="2">387</td></tr>
<tr><td>urban</td><td>631,500</td></tr>
</table>

2.1.3 Socio-economic profile[6]

The water resources of the Densu Basin contribute substantially to the economic livelihood of the people living in the basin. Water is used for a variety of purposes in the domestic, agriculture and industrial sectors.

Agriculture is the main economic activity in the rural areas and it provides employment for majority of the people. The agricultural activities are practiced both commercially and as subsistence farming which together provide the food needs and financial income of the people. The impact of agriculture activities on the natural resources (land and water) can be attributed to the system of farming adopted by the

[6] *Water Resources Commission: Identification of Major Trends in the Socio-economic Development in the Densu Basin of relevance for Integrated Water Resources Management. ISSER (February 2003)*

farmers. Majority of the farmers practice the traditional bush fallowing with its attendant slash-and-burn method, which contributes significantly to deforestation in the basin. The cultivation of crops along the river bank is a common practice, which results in the removal of the top soil and exposes the land to erosion.

Irrigation systems in the Densu Basin can be found in the Weija, Mangoase, Suhum, Koforidua and Nsawam localities. The Weija irrigation system – although not operational at present – supplies water primarily for the cultivation of vegetables. The Nsawam irrigation scheme abstracts water from the Dobro tributary for the cultivation of ornamental flowers. There are also a number of individual small scale irrigation systems either from groundwater or surface water sources for growing of vegetables and other crops.

Logging which was originally predominant in the northern part of the basin is once again being pursued in the basin with a number of timber concessions being granted by the Forestry Commission to larger timber operators. Harvesting of fuel wood has also become an important economic activity, particularly for the rural residents within the basin.

Fishing activities are practiced in the basin especially in the upper reaches of the river system, but also in the southern section. Apart from the traditional methods of draw-net and hook-and-line fishing, some fishermen use illegal methods such as chemicals and explosives with adverse effects on the water quality.

Small-scale gold mining activities and stone quarrying are also common in some parts of the Basin. The mining activities are restricted to the Birimian formation in the East Akim district, whereas the stone quarrying and sand winning activities are carried out especially in Koforidua, Nsawam and many localities in the Ga district.

In the urban areas, the economic activities are more diversified and the prominent occupations include wholesale and retail trading, manufacturing and other commercial activities. The major industries in the basin are mainly fruit processing and bottle water production industries. The small scale industries include auto servicing shops, saw milling, carpentry, block making, local soap manufacturing, black-smithing and metal work. In addition, there are large commercial shops where manufactured goods are sold, and large markets which form points of contact between rural and urban residents.

The above outlined socio-economic pattern with its noticeable differences between rural and urban settings is highlighted in Table 2.2. The figures in the table are derived from the 2000 Census data, and are given as percentages of the economically active population (above 15 years of age).

The employment situation generally in the basin is such that about 25% are unemployed, 60% are self-employed and 15% are in full-time formal employment. People who work on their own farms are considered self-employed. This also shows that the majority of the economically active part of the population is in the informal sector.

Table 2.2: Occupation (in %) of the economically active population [1]

Economic activity (industry)	District								
	East Akim	New Jua-beng	Suhum Kraboa Coaltar	Akwa-pim North	Akwa-pim South	West Akim	Awutu Efutu Senya	Ga East/ West	Accra Metro
Agriculture and forestry	57.7	15.9	59.9	50.1	46.9	59.8	36.8	13.9	3.7
Fishing	0.9	1.4	0.8	0.3	2.1	1.2	10.5	1.9	2.5
Mining and quarrying	1.1	0.7	0.4	0.5	1.4	1.2	0.9	1.9	1.4
Manufacturing	8.8	15.2	10.6	9.3	10.5	8.8	13.6	14.9	17.4
Wholesale and retail sale	11.5	28.6	13.4	16.7	17.1	13.6	16.0	27.2	33.9
Construction	2.6	6.0	1.7	3.0	2.7	1.4	4.4	10.1	5.5
Hotel and restaurants	2.8	4.0	2.8	2.9	3.5	2.7	2.4	3.5	4.6
Transport and communication	2.2	5.3	2.6	3.6	3.7	2.5	3.8	6.8	6.6
Education	4.3	6.8	3.1	4.9	4.2	3.0	3.7	8.0	8.0
Other (unspeci-fied) activity	8.1	16.1	4.7	8.7	7.9	5.8	7.9	11.8	16.4
	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

[1] *Only districts with a sizeable population within the basin are included in this table*

2.1.4 Land use pattern and ecological trends

The original ecology of the Densu Basin was moist semi-deciduous forest with thick undergrowth featuring rich flora and fauna. The human activities through time, however, have greatly modified this forest ecology – and at an accelerating rate. Within the past 10-20 years, the ecological perspective of the Densu Basin has changed dramatically. The thinning of the forest has intensified, and at the same time the marked shift in land use caused by the "urbanisation" in the eastern corridor of the basin from Weija area through Nsawam to Koforidua has its ecological impacts.

At present the Densu Basin is characterized by three different types of vegetation zones. The north-eastern section of the basin is forested land, but with intensive devegetation activities ongoing to allow agricultural activities to take hold. In this zone, cocoa farming was predominant until recently when the swollen shoot disease caused land use evolution in the forested area. Cocoa farming has now been replaced by extensive bush fallow food cropping. The main food crops that are cultivated here include plantain, cassava, yam, cocoyam and cereals such as maize. Large estate and peasant-scale oil palm plantations have also become important in the recent past, which also contribute to deforestation in the Basin.

The traditional forest zone in large part of the Basin's middle sections are gradually giving way for areas - the second zone - characterised by scattered trees developing into areas of shrub and grassland. These parts of the Basin are characterized by extensive cultivation of cassava, maize, pineapple and vegetables, and host much livestock grazing. The coastal savannah zone in the extreme southern section of the basin makes up the third vegetation zone.

From various perspectives, the Densu Basin and its water resources are under siege. The main determinants of this situation are the arable food crop farming and logging in the upstream reaches of the Basin, arable food crops and pineapple farming in the midstream sections of the Basin, and sand winning and stone quarrying in the downstream areas caused by the urbanisation phenomenon emanating from Accra.

Map 2.3 (inserted at the end of chapter) provides a simplified overview of the land use/cover situation as derived from satellite image maps produced in year 2000. From similar image maps representing year 1990, Table 2.3 summarises the development in area coverage of the forested land and other zones described above as it has occurred during this ten-year period.

Table 2.3: Development in land use/cover of the Densu Basin (1990-2000)

Year	Forested area (dense tree cover)	Semi-forested area, scattered trees and shrub/grassland	Settlements and build-up (bare) areas
1990	40%	50%	10%
2000	20%	65%	15%

2.1.5 Protected areas

Forest reserves

Protected areas in the basin include two forest reserves located in the East Akim district, and two small reserves in the Fanteakwa and Yilo Krobo districts. The largest of these reserves is the Atewa Range Reserve, which provides the headwaters (the source) of the main branch of the Densu River. The forest reserves are also indicated on Map 2.3.

Densu delta Ramsar site

The Densu delta and salt pans complex - also known as the Sakumo I Lagoon and Panbros Salt Pans - constitutes one of Ghana's internationally declared protected wetland areas (Ramsar site). It is recognised for its role as a sanctuary for migrating seashore bird species utilising the lagoon as roosting and nesting grounds. The Densu delta Ramsar site covers an area of around 50 km^2 and comprises the salt pans, sand dunes, the flood plains and lowest part of the Densu river catchment south of the Accra-Winneba road.

Protection activities in the area are undertaken by the Wildlife Division of the Forestry Commission, in close consultation with Panbros Salt Company, who owns part of the Ramsar site. In the Ramsar declaration it is stated that existing land use could be allowed to continue, but future developments were to be strictly assessed in terms of their compatibility with the Ramsar concept. At that time it was further recommended that the catchment area of the Densu River immediately north of the Accra-Winneba road, including the Weija dam and reservoir area, should be demarcated as a Land Use Management Zone, which, however, never materialised.

The water regime of the Densu delta, as determined by the operational strategy of the Ghana Water Company Limited (GWCL) in managing the Weija Water Works, can be a source of conflict between the GWCL, the owners of the salt industry and the fishing communities. As it is, the flow of water into the wetlands is fully controlled by the damming of the river and the releases of water from it. During the rainy season water is released to maintain the right reservoir level and for protection of the stability of the dam.

Peak salt production takes place when conditions are dry and the fishermen's catch declines when water levels are too high in the delta. Flooding of the wetlands interferes with the birds' roosting and nesting sites, and often washes away nests and eggs. Contrary, during the dry season no water is released from the dam and the lack of freshwater inflow to the wetlands impairs the flora and fauna, and the other activities in the delta. Hence, there is a need to develop a water management strategy which would be satisfactory to all interested parties and also would enhance the wetland's habitat for birds as stipulated in the Ramsar conditions.

2.2 Water resources

2.2.1 Meteorological characteristics and impact of climate change

Data concerning the meteorological conditions are obtained from the Ghana Meteorological Agency, which operates a number of synoptic and rainfall stations in the Basin. The location of these monitoring stations is indicated on Map 2.4 (inserted at the end of chapter).

The Densu Basin falls under two distinct climatic zones, i.e. the relatively dry equatorial climate of the south-eastern coastal plains and the wet semi-equatorial climate further north in the basin. Both climatic zones are characterized by a bi-modal rainfall regime with different intensities. The main rainy season extends from April to July and attains a peak in June, whereas the second - less intense – rainy season occurs between September and November. These features can be detected from the figures in Table 2.4, which presents rainfall data from the Nsawam meteorological station used as an example.

Table 2.4: Mean monthly rainfall (mm), Nsawam (1950-2005)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
27	56	110	115	168	221	95	58	98	146	101	36	1,231

The rainfall pattern over the year can be classified as erratic in its occurrence. The meteorological statistics show that in average about 12% of the rainy days produce 50% of the total annual rainfall. The annual rainfall of the coastal plains averages about 800-900 mm and approaches 1,600-1,700 mm in the higher ranges in the northern part of the Basin, where the Densu river system has its headwaters. Generally, it can be stated that the rainfall to the north in the basin is more reliable than that of the southern part. The mean annual rainfall distribution is also shown on Map 2.4.

The relative air humidity ranges from an average of 50-60% in the driest months to 80-90% in the rainy season. The mean annual potential evapo-transpiration varies from 1,700 mm in the southern part of the basin to about 1,500 mm in the north.

The Densu Basin is characterised by uniformly high temperatures throughout the year with a mean annual temperature of about 27°C. The months of March and April are the hottest periods with a temperature of about 32°C. August is the coolest month with a temperature of about 23°C.

In a study by the Environmental Protection Agency[7] the impacts of likely climatic changes on river discharges (runoffs) were analysed for the country. One of the basins included in the study was Ayensu, which borders the Densu basin to the west. It is imperative that the impacts and consequences cited in that study report are duly recognised in future water resource planning activities for the Densu Basin. The main findings of relevance for the Densu IWRM plan are:

- There was an observed increase in temperatures of about 1°C over a 30-year period, and reductions in rainfall and runoff in the historical data sets.
- Simulations using realistic climate change scenarios (10-20% change in rainfall and a 1-2°C rise in temperature) indicated reduction in runoffs of 15-20% over the coming 20-year period.
- The climate change scenarios also cause reduction in groundwater recharge at a rate of 10-15% during the same period.
- Irrigation water demand would be affected considerably by the simulated climate change adding some 50% to the base period water demand.

2.2.2 Surface water availability

The Densu River and its tributaries constitute the surface water system, which for its size is one of the most exploited in the country.

Water (hydrological) balance

Taking the Densu Basin as a whole, the water (hydrological) balance representing a full year has been calculated based on the following criteria:

- monthly data series used;
- average basin rainfall based on rainfall distribution (Map 2.4) weighted according to representative size of basin area;
- actual evapo-transpiration rates derived from results of field research carried out in the Pompon sub-catchment[8] of the Densu Basin;
- average groundwater recharge rate derived from (ref.[7]) and other sources, and set at 14% of rainfall; and
- contribution from groundwater to river flow (base-flow) and vice-versa has not been incorporated.

[7] *Environmental Protection Agency (EPA): Climate Change Vulnerability and Adaptation Assessment on Water Resources in Ghana (February 2000)*

[8] *A Study of Water Balance in the Pompon Sub-catchment of the Densu River Basin. PhD Dissertation by Jacob Waako Tumbulto, Department of Geology, University of Ghana, Legon (January 2005)*

Table 2.5 provides a summary of the water balance. It should be noted that the outcome of the water balance calculations - in this case the amount of surface water available - has high sensitivity to the actual evapo-transpiration values used in the water balance equation. The annual figure of 950 mm indicated in the table below, is arrived at as the sum of monthly values, which in turn are calculated based on estimated rates of daily actual evapo-transpiration (ref.[8]) varying from 1.3 mm/day during the driest months to 4.0 mm/day during the wettest months.

Table 2.5: Annual water balance for Densu Basin

Water balance component	Annual amount	In percent of rainfall
Rainfall	1,230 mm	
Actual evapo-transpiration	950 mm	
Densu basin area	2,600 km^2	
Rainfall over basin (volume)	3,198 million m^3	100 %
Actual evapo-transpiration (volume)	2,470 million m^3	77 %
Recharge to groundwater (volume)	448 million m^3	14 %
Surface water runoff (total for basin)	280 million m^3	9 %

From Table 2.5 it can be concluded that on an annual basis - and taken as an average for the entire basin - 77% of the rainfall goes back to the atmosphere as evapo-transpiration, 14% infiltrates down to the groundwater or remains as soil moisture, and the remaining 9% ends up as surface water runoff. It must be emphasised, though, that this water balance calculation presents a simplified situation incorporating assumptions which can be refined, but nevertheless, is judged to provide a realistic measure as to the relative size of the elements of the Basin's hydrological cycle.

On an annual basis, the average "yield" of the Densu Basin (surface water availability) amounts to 280 million m^3. By using this basin runoff, the annual flow volume at various points along the Densu River and for some of the main tributaries have been estimated (calculated on the basis of sub-basin area) as listed in Table 2.6.

Table 2.6: Mean annual flow volume, Densu River system

River/locality	Area of sub-basin (km^2)	Mean annual runoff (million m^3)
Densu at Koforidua	510	55
Densu at Nsawam	1,440	155
Densu at Manhea (Weija Lake)	2,300	248
Kuia sub-basin	408	44
Adeiso sub-basin	338	36
Nsaki sub-basin	152	16
Total Densu basin	2,600	280

Runoff statistics

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. The locations of these monitoring stations are indicated on Map 2.4 (inserted at the end of chapter). However, the available data records comprise in general short time series with many gaps. Unbroken records of more than five years are not available from the Densu basin gauging stations. Nevertheless, analyses carried out on the available data series[9] indicate in many instances clearly detectable correlation between the recorded runoffs at the different gauging sites in the Densu River system as well as between rainfall and runoff. These regression methods have then be used to some extent to fill in gaps and expand on the hydrological data records.

The flow regime of the Densu River exhibits a marked variability in the seasonal runoff within the year as well as in the annual flows. These features are highlighted in Table 2.7 and Figure 2.1, respectively, which have utilised the measured/generated runoff data[9] representing the Nsawam gauging site.

Table 2.7: Densu River mean monthly flow (1970-2000), Nsawam (m^3/sec)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
Mean	0.77	0.62	1.70	1.42	3.96	9.89	10.47	5.42	5.38	5.59	3.79	1.62	4.22
Max.	1.86	1.03	2.68	3.47	6.40	17.80	20.66	11.62	11.22	12.03	7.50	2.49	8.23
Min.	0.25	0.32	0.97	0.49	2.20	5.29	3.12	0.75	0.92	2.46	1.85	0.86	1.62

The average annual runoff of 4.22 m^3/sec is equivalent to an annual flow of 133 million m^3. A comparison of this figure with the value of 155 million m^3 given in Table 2.6, which was calculated based on another (the water balance) method, shows a reasonable match within a margin of ± 8 %. It can be noted that in the measured/generated annual flow volume of 133 million m^3 the volume of water abstracted at Nsawam and upstream is not included, whereas the value from the water balance calculation incorporates all abstractions.

[9] *Water Resources Commission: Water Resources Assessment Tools, Elements of a Decision Support System, the Case of the Densu River Basin (November 2003)*

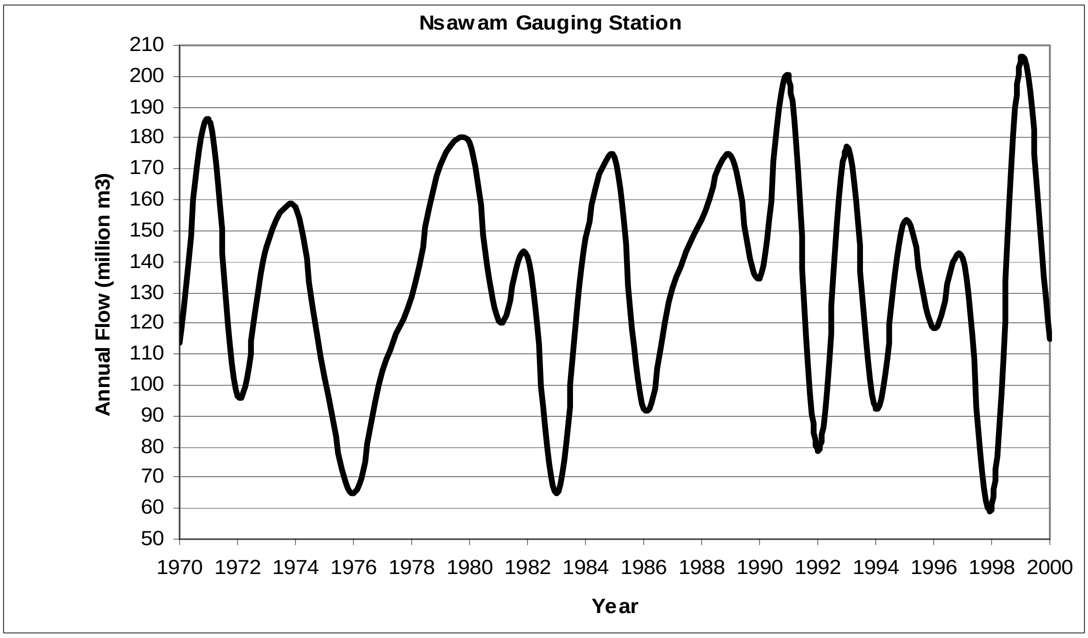


Figure 2.1: Densu River annual runoff (1970-2000), Nsawam (in million m^3)

The erratic flow pattern of the daily flows is visualised in Figure 2.2 using the most recent measured flow data at the Pakro gauging site some 10 km upstream of Nsawam used as an example.

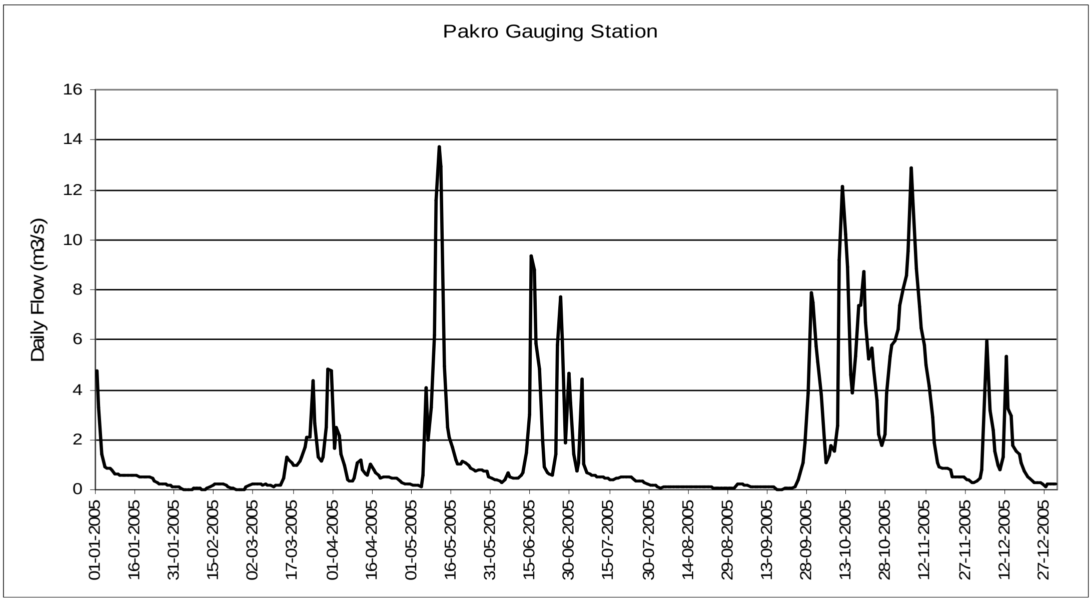


Figure 2.2: Densu River daily flows (2005), Pakro gauging station (in m^3/sec)

Minimum/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. Furthermore, the flow of the Densu River and its tributaries particularly during the dry season has a significant impact on the flora and fauna associated with the prevailing aquatic system.

Undoubtedly, the aquatic ecosystems of the Densu Basin are under a significant pressure due to the increasingly high population density, the poor wastewater and solid waste infrastructure, and lack of environmental awareness. Therefore, in addition to the direct abstraction requirements, the minimum amount of flow required to maintain these vulnerable areas of the basin must be defined downstream of existing and proposed water intake sites as well as downstream of the Weija dam. Environmental flow is an important requirement (a water demand category in its own right) to take into consideration as part of the Densu Basin IWRM planning.

In this regard, the environmental flow consideration is not only a matter of maintaining a minimum flow regime, but as importantly also to safeguard that this flow maintains a certain acceptable water quality for the aquatic ecosystems to prevail.

2.2.3 Groundwater resources

Geology and aquifer systems

The geology of the Densu Basin comprises mainly of the Granitoids, the Upper Birimian formation and the Togo series rocks, which are characterised by little or no primary porosity. Groundwater occurrence, therefore, is associated with the development of secondary porosities caused by fracturing, faulting, jointing and weathering. Map 2.5 (inserted at the end of chapter) depicts the geology of the Densu Basin.

The Birimian rocks to the extreme northwest of the Basin are generally well folded, fissured and deeply weathered, and hence groundwater occurrence in the areas underlain by the upper Birimian rocks is rated as high. The granites are less fractured and weathered, and subsequently groundwater occurrence in general terms is rated moderate to low, though locally, particularly in the northern part of the granitic area, relatively productive groundwater zones exist. The highly folded, jointed and fractured rocks of the Togo series to the southeast of the basin, coupled with the contact zone to the granite rocks, provide favourable conditions for groundwater accumulation as well as the occurrence of springs.

The development of secondary porosity has given rise to two distinct types of aquifers in the Densu Basin, viz. the weathered zone aquifers and the fractured zone aquifers. The weathered zone aquifers usually occur at the base of the thick weathered layer. The thickness of the weathered zones varies greatly depending on the climatic conditions and the type of rocks. The thickest weathered layers are common in the forested area of the Basin.

The fractured zone aquifers tend to be more localized in nature, and groundwater occurrences are controlled by the degree of fracturing and the nature of groundwater recharge. Borehole yields within the fractured zone are determined by the extent and degree of fracturing. A formation which combines a thick weathered zone with a well fractured bedrock zone provides the most productive aquifer situation.

Hydrogeological data from existing boreholes

Based on data and information available from the existing boreholes in the Basin, Table 2.8 summarises the statistical evidence related to the occurrence and rate of groundwater abstraction in the Basin.

Table 2.8: Borehole characteristics in Densu Basin[10]

Geological zone	Depth of borehole (m)	Thickness weathered zone (m)	Depth to aquifer top (m)	Static water level (m)	Borehole yield (m^3/hour)
Granites	9.1 - 103.0	1.0 - 32.0	1.9 - 72.0	0.1 - 13.5	0.1 - 30.0
Birimian rocks	25.0 - 40.0	5.0 - 27.0	10.0 - 31.0	0.8 - 16.9	0.7 - 9.0
Togo series	28.0 - 97.0	3.0 - 36.0	4.5 - 59.0	1.1 - 17.9	0.6 - 6.0

For the three geological zones, the average yield is found to be as follows:

- Granitic zone: 2.0 m^3/hour;
- Birimian rocks: 3.7 m^3/hour; and
- Togo series: 2.8 m^3/hour.

It should be reiterated that the yield values given in this section are derived from the records and performance of existing boreholes – old as well as new ones. In this connection it can also be mentioned that the success rates of drilling in the granite, Birimian rocks and Togo series have been 50%, 85% and 60 %, respectively.

As stated earlier, relatively productive groundwater zones occur within the northern part of the granitic area, mainly in the Suhum-Kraboa-Coaltar and New Juabeng districts. These areas are associated with extensive fracturing and weathering that favour the formation of thick overburden. The yield of boreholes in these areas can be expected to be in the range of 8-12 m^3/hour or higher depending on the siting techniques used, borehole design (depth and diameter), etc.

Another notable groundwater zone in the Basin is the area that lies west of the contact zone between the granite formation and the Togo series. Prominent areas include the Nsawam and Medie localities with yields of 10-15 m^3/hour and higher.

In general, the groundwater assessment study[10] indicates that considerable reserves are available and if well developed can produce large volume of water. To obtain optimal utilization of the Basin's groundwater resources, it is imperative, therefore, that groundwater schemes are based on state-of-the-art hydrogeological assessment methods, efficient borehole siting techniques as well as proper design, construction and development of the boreholes.

[10] *Water Resources Commission: Groundwater Assessment, an Element of Integrated Water Resources Management - the Case of Densu River Basin. CSIR-Water Research Institute (July 2003)*

2.3 Utilisation of water resources

2.3.1 General overview of water supply situation

The Densu River serves as the main source of water supply for a number of fast growing communities within and outside the Basin. The groundwater resources of the Basin also serve as an important source of supply for the basin's population, particularly in the rural areas, but also some piped urban water supply schemes rely on groundwater.

Table 2.9 provides an overview of the existing water supply situation and shows for each district within the basin, the main source of drinking water as derived from the 2000 Census, i.e. with the quoted percentages representing the entire district.

However, to assess the existing water supply situation for the Densu Basin as a whole by means of a weighted average figure for each water source category (last row in Table 2.9), the percentages for the districts have been applied against the proportion of the respective district population living within the Basin boundary.

Table 2.9: Main source of drinking water (in % of households)

District	Pipe-borne supply	Borehole and well	Tanker supply	Spring and rain water harvesting	River, stream, pond and dugout
East Akim	19.5	43.9	0.4	5.7	30.5
New Juabeng	66.6	20.9	0.8	2.2	9.5
Suhum/Kraboa/Coaltar	14.2	46.7	0.5	3.1	35.5
Akwapim North	39.7	24.2	1.3	6.8	28.0
Akwapim South	37.3	34.4	1.7	7.2	19.4
West Akim	11.0	48.2	0.3	4.0	36.5
Awutu/Efutu/Senya	43.2	20.6	20.9	1.3	14.0
Ga East/West	57.6	9.8	19.2	2.8	10.6
Accra Metro	90.5	4.7	3.1	1.0	0.7
Densu Basin (average)	47.6	22.2	10.0	3.4	16.8

The figures in Table 2.9 reveal the prevalent differences between predominantly rural districts and more urbanised districts concerning pipe-borne water supply versus the traditional sources (borehole/well and stream/pond). Taken in its entirety, it appears that close to half of all households in the Densu Basin receive water from a piped supply - either in the form of direct house connections or from public standpipes.

2.3.2 Urban water supply

Presently, in the Densu Basin a total of 8 pipe-borne water supply schemes are in operation serving mainly urban communities. 5 of these schemes rely on the Densu river system as the source, whereas 3 schemes are groundwater based. Table 2.10 provides a list of these schemes including information about source, intake, treatment capacity and abstraction rates as obtained from the individual water plants' statistics. The water supplied is used for domestic, industrial, commercial and institutional purposes. The figures in Table 2.10 reveal that presently as much as 95% of the total abstraction of water for the urban supply schemes is for the Weija water treatment plant alone, and it is also seen that reliance on groundwater is only a small fraction compared to the surface water abstractions.

By comparing the figures in Table 2.6 and Table 2.10, it can be concluded that on an annual basis utilisation of the water resources through abstractions for urban schemes presently amounts to less than 3% of the mean annual runoff of the basin at Nsawam. Likewise, the abstraction from the Weija dam alone amounts to about 30% of the mean annual inflow to the reservoir.

Table 2.10: Piped water supply schemes in Densu Basin (2005)

Water supply scheme	Source	Intake	Treatment capacity m^3/day	Abstraction	
				m^3/day	million m^3/year
Weija	surface water	dam	206,000	200,000	73.00
Other schemes:					
Adeiso	groundwater	3 boreholes	-	15	0.01
Apedwa/Asafo	surface water	weir	436	20	0.01
Old/New Tafo	surface water	dam	1,080	760	0.28
Koforidua	surface water	weir	4,545	5,570	2.03
Akwadum/Nankese (1)	groundwater	1 borehole	-	25	0.01
Suhum	groundwater	4 boreholes	-	380	0.14
Nsawam	surface water	weir	4,320	4,050	1.48
Total, other schemes				10,820	3.96

(1) *Originally surface water based, now converted into a groundwater scheme*

Population served by pipe-borne schemes (excluding Weija)

By applying the normally used criteria for unit consumption figures, which are differentiated according to settlement sizes, i.e. 55 l/capita/day for settlements less than 15,000, 85 l/capita/day for settlements between 15,000 and 50,000, and 105 l/capita/day for a population larger than 50,000, the number of people served by the schemes can be estimated. Pooled together the urban water supply schemes in the Densu Basin (other than the Weija dam water works) are calculated to serve a population of about 110,000, equivalent to 43% of the urban population in the basin (ref. Table 2.1), i.e. people living in settlements larger than 5,000 (excluding Accra Metro and Ga West/East districts).

It should be noted, though, that in the above estimation of the number of people being served, the un-accounted water, i.e. leakage and other distribution losses, has not been duly incorporated in the figures. This would imply that the proportion of the population served as given here is somewhat over-estimated.

The "unmet" demand combines the part of urban dwellers living in settlements not yet provided with piped water and people living within existing supply areas, but not reached by the water scheme's supply. The reasons for not being able to cater for this "unmet" demand are attributed to various factors, e.g. technical-economic and financial aspects in expanding the systems' treatment capacity as well as the distribution network (the outreach) of the scheme.

However, a limiting factor is also the capacity of the surface water source, which is subject to a decline in the low-flow regime (EPA: Climate Change Vulnerability Study, ref [7]) resulting in a reduction of abstraction or even a total cease in water production during the dry season. This situation is particularly prevalent in the case of the water supplies for Tafo and Koforidua. There is, therefore, a need to provide storage in order to have access to the resource throughout the year, to augment with groundwater and/or to import water from a neighbouring basin as envisaged in the expansion plans for the Koforidua water supply in which a pumping scheme providing water across from the Volta Lake at a design rate of 13,600 m^3/day is being implemented. These aspects are further elaborated on the scenario analysis presented in Chapter 3.

Weija Dam Water Works

The Weija dam, brought back into operation after its reconstruction was completed in 1978, is an earth/rockfill structure with an embankment height above the river bed of close to 17 m and with an inundated area (surface area of reservoir) at about 30 km^2 at maximum water level. The effective storage capacity is approximately 133 million m^3, calculated as reservoir volume at maximum design level (143 million m^3) minus volume at the intake's lowest draw-off point (10 million m^3).

Due to the overwhelming increase in water demand for the Accra metropolitan population now expanding up through the Ga West and Ga East districts, the Weija Water Works has regularly been subject to expansion with a marked increase in the abstraction of water from the reservoir as a result. Currently yet another expansion is under construction, which will bring the abstraction rate from the present 200,000 m^3/day up to 268,000 m^3/day.

Most of the water produced at the Weija Water Works is "exported" out of the Densu Basin as an integral part of the Accra-Tema water supply scheme. From Table 2.1 the size of urban population (2000 Census) residing in the Accra Metro, Ga West and Ga East districts located within the Basin is found to be 373,200. Recent statistics[11] indicate that some 61% of this population (i.e. about 227,000 people) has access to the water supply services. With an assumed consumption rate of 105 l/capita/day, it implies that around 24,000 m^3/day of the 200,000 m^3/day presently abstracted from Weija reservoir is used within the Densu Basin itself.

[11] *GWCL, Planning Department for Urban Investment Requirements (2004)*

Overall urban water supply coverage

In conclusion it can be stated, that as an overall estimate for the whole Densu Basin, the size of the urban population (settlements larger than 5,000 people) served by pipe-borne schemes amounts to about 337,000 people, i.e. 227,000 (Weija) plus 110,000 (other urban schemes), equivalent to about 53% (ref Table 2.1) of the total urban population within the Basin.

Finally, it should be reiterated that the calculation of number of people served based on abstraction rates and per capita consumption figures as presented above is a simplistic way of depicting the actual situation since factors like production losses, distribution pipe network leakages, certain industrial and commercial activities etc have not fully been taken into account. In any case, it is evident that a sizeable “unmet” demand exists in the urban areas and that the water-stressed situation becomes more and more pronounced. Prudent water demand management measures need also to be introduced to be able to utilise the existing water sources and supply facilities more effectively.

2.3.3 Rural water supply

As can be seen in Table 2.9, the Densu River system with its tributaries and many seasonal streams still serves directly as the water source for a sizeable part of the rural population. Increasingly, however, in step with the accelerated programmes to improve their water supply situation, rural communities are giving up this source in favour of water supplied through boreholes and protected shallow (hand dug) wells.

Boreholes numbering about 600 as well as a number of hand-dug wells (estimated at 200) are the means by which the groundwater resources of the Basin are exploited. Most of the boreholes are for domestic purposes and fitted with hand pumps. There are, however, also places where boreholes are mechanized with motor-driven pumps for provision of water in the rural communities.

Based on the CWSA borehole design of 200 persons per water point and an average abstraction rate of 4.8 m^3/day (i.e. 8 hours pumping per day at 10 l/min), it can be found that the 800 water points imply a total groundwater abstraction of 3,840 m^3/day (or 1.4 million m^3/year) serving 160,000 people at present. This calculation indicates that about 43% of the basin’s rural population of 375,200 (ref. Table 2.1) is served through improved water points.

It is worth noting, that the groundwater abstraction within the Basin only constitutes a small fraction of the estimated annual groundwater recharge as given in Table 2.5, which - needless to say - is no consolation in the search for satisfactory yielding boreholes as and when required at specific localities (ref. Section 2.2.3 above).

2.3.4 Water for agriculture

Irrigation

The Densu Basin is not used intensively for irrigation, except at Weija, where about 220 ha of irrigable land exist, operated and managed by the Weija Irrigation Project[12]. Originally, 1,200 ha was envisaged for irrigation in this area, but the unregulated growth of Accra metropolis has now created a situation whereby it is not possible to expand the existing irrigable land further. Water is abstracted directly from the Weija reservoir, although it can be mentioned that the whole scheme is under rehabilitation with the result that no abstractions are being realised for the time being.

In general terms, irrigation water requirements are reported in the WARM study[13] to vary from an annual amount of about 10,000 m^3/ha for vegetable produce to around 25,000 m^3/ha for rice fields. An average value of 15,000 m^3/ha/year is adopted for the irrigation water demand in the Densu Basin (equivalent to approximately 1.5 l/sec/ha in average per year assuming a 4-month irrigation season). It can be mentioned that this amount matches well with a similar figure which can be derived from the State of Environment Report 2004[14], indicating an amount of 14,300 m^3/ha/year as representative for the whole country.

When the Weija irrigation scheme starts operating again, it can be assumed that the 220 ha would require a maximum abstraction from the Weija reservoir of about 3.3 million m^3 per year.

Another established irrigation scheme which utilises the Dobro tributary is producing ornamental flowers drawing water from the Medie dam situated southeast of Nsawam. The irrigated area is 23 ha with an estimated water consumption 0.35 million m^3 per year.

Furthermore, a number of commercial farms practicing irrigation specifically for vegetable fields and pineapple farming have been introduced over the recent past in the Densu basin. However, information is rather scanty about these schemes concerning areas under irrigation, irrigation practices, water consumption etc.

By adding the irrigation water demand covering these other commercial farms in the basin, a total water demand of 4.0 million m^3 per year is estimated to represent the present utilisation of water for irrigation in the Basin. The potential irrigable area in the Densu basin is assessed to be 1,500 ha (verbal communication, Ghana Irrigation Development Authority, 2006).

Livestock

As generally done for the purpose of estimating livestock water demand, a percentage figure of the rural population water demand is applied. From the WARM study[13] it can be derived that a figure of about 15% of the rural water demand can be adopted to calculate livestock water demand. That means the present livestock water usage in the Densu basin is 15% of 1.4 million m^3/year (ref. section 2.3.3), i.e. 210,000 m^3/year or about 600 m^3/day.

[12] *The Weija Irrigation Project took over from the then Weija Irrigation Company some years back, and it is now run as a community-based activity with input and management support provided by the Ghana Irrigation Development Authority.*

[13] *Ministry of Works and Housing: Water Resources Management (WARM) Study, Information " Building Block" Study, Part II, Vol. 4: Information on the Coastal Basin System. Nii Consult (May 1998)*

[14] *Environmental Protection Agency: State of Environment Report 2004. EPA (April 2005)*

2.3.5 Industrial water use

Within the supply areas of the urban pipe-borne schemes the water demand by industries, manufacturing and other commercial activities is included in the schemes' production figures and hence, in future expansion plans. However, quite a number of industries and some institutions rely on their own water supply, mainly from boreholes, which locally can have a sizeable rate of abstraction. These main industries include:

- Voltic (Gh) Ltd (Medie);
- Blue Skies Products (Gh) Ltd (Medie);
- Akwaaba Mineral Water (Medie);
- Still Pure Water (Medie);
- Astek Fruit Processing Company Ltd. (Nsawam);
- Cocoa Research Station (Tafo);
- Intravenous Infusions Ltd. (Koforidua); and
- Brick/tile factory (Weija).

Based on granted water abstraction licences and field inspections (WRC), it is judged that the current groundwater abstractions for these industries amount to 1,000,000 m^3/year, equivalent to 2,740 m^3/day.

2.3.6 Summary of water resources utilisation

Table 2.11 provides an overview of the existing utilisation (abstraction) of the water resources located within the Densu Basin as derived from the above description.

Table 2.11: Water resources utilisation (2005), Densu Basin

Category	Present (actual) Abstraction		Source
	m^3/day	million m^3/year	
Potable (domestic, industrial and institutional):			
- urban water supply	210,820 [(1)]	76.96	mainly surface water
- rural water supply	3,840	1.40	mainly groundwater
Agriculture:			
- irrigation	11,000 [(2)]	4.00	mainly surface water
- livestock	600	0.22	mainly surface water
Industry (not served by urban piped schemes)	2,740	1.00	mainly groundwater
Total for Densu basin	229,000	83.58	

(1) *Out of this amount 176,000 m^3/day (84%) is "exported" and used outside the Densu basin*
(2) *Current abstraction is only about 20% of this amount due to rehabilitation of the Weija irrigation works*

Groundwater as a source constitutes only a small fraction of the total abstraction - a resource which undoubtedly has the potential for being further utilised. Contrary, the Densu basin surface water resources is under stress with a current annual rate of utilisation approaching one-third of the basin's total mean annual runoff calculated where the river enters the Weija reservoir (ref. Table 2.6).

2.4 Water quality and pollution

2.4.1 Water quality monitoring

The first water quality monitoring programme in the Densu River system dates back to the early 1960's carried out by the then Public Works Department, but was rather short lived due to scarcity of resources. Results from that time showed high level of dissolved oxygen for most parts of the year – a situation which persisted also in the early years after construction of the Weija reservoir. However, by the early 1990's the dissolved oxygen values in the Densu River system were found to have been reduced by almost half. A special Weija lake water quality survey was conducted in 1996 (ref.[13]), which - among other objectives - aimed at generating data to determine whether stratification had developed in the lake, and also for determining requirements related to the water treatment process in light of the degrading water quality situation.

As part of a Rapid Environmental Assessment Study covering the Densu Basin under the Water for African Cities Programme[15] a water sampling exercise, which included 14 locations in the river system, was carried out in 2001. The sampling sites were visited once and thus, the exercise could only provide a "snapshot" picture of the water quality situation in the basin as it prevailed at that time.

Furthermore, the previous water quality monitoring activities related mostly to the physico-chemical parameters, and the data records were scarce with considerable gaps in time and space. However, a revived water quality monitoring programme, which includes the Densu Basin, targeting both surface water and groundwater sources, was initiated by WRC in late 2004. This programme also includes monitoring of trace metals, pesticides and biological parameters as well as phytoplankton and micro-pollutants as may be detected in bio-tissue (fish).

The surface water monitoring in the Densu Basin incorporates four sampling stations along the river, i.e. at Potroase (representing the upstream section of the river), Mangoase and Nsawam (representing the mid-stream conditions) and the Weija reservoir at its downstream end. The stations are visited and water samples collected for laboratory analyses five times per year representing the hydrological regime, i.e. samples taken during the low flow and the high flow seasons.

2.4.2 Surface water quality

General overview

The Densu river system has experienced a gradual, but persistent, degradation in water quality over the past years, particularly during the last decade or so. This has amply been demonstrated in the previous water quality monitoring programmes and studies. The decrease in the water quality has been more pronounced in the stretches of the river along and close to urban areas.

[15] *UNEP-UN Habitat: Water for African Cities Programme, Rapid Environmental Assessment and Action Planning of Densu River Basin. Nii Consult (July 2001)*

The absence of proper land use practices in the Basin, which has led to accelerated erosion of top soil with increased turbidity of the water as a result, has changed the physical appearance of the water. Chemically, the surface water resource shows a trend towards increased eutrophication.

Although industrial activities and factories in the basin locally have significant impact on the environment, for the time being the main threat to the ecological character of the river is the numerous and diffuse pollution sources, such as free-range defecation, poor disposal of household refuse and other solid waste, and rudimentary agricultural practices, including un-checked use of agro-chemicals (fertilizers and pesticides). Industrial and domestic wastewater is in many instances discharged directly into open drainage systems that empty into the river system.

The human activities have impacted overwhelmingly on the ecosystem and diversity of species prevailing in the Basin. There is now a nearly total loss of riverine forest, and where still existing it is much fragmented. The high rate of timber logging (albeit it was practiced more commonly in the past than at present) as well as fuel wood extraction has also exacerbated deforestation and, hence, vulnerability of the surface water resource.

These factors, coupled with over-abstraction and climate (rainfall) variability, have resulted in dwindling environmental (minimum) flows. Most of the species in the ecosystems found nowadays are those that can tolerate eutrophication.

Water Quality Index

The Water Quality Index (WQI), adopted by WRC in 2003, is used to facilitate comparison and to classify to which extent the natural water quality is affected by human activities. The index is used to describe the state of water quality as a whole instead of looking at individual parameters, and can provide indications as to the suitability of the water for various purposes. The methodology incorporates 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 2.12, 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 2.12: Criteria for classification of surface waters

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

Table 2.13 and Figure 2.3 present the result of the WQI calculations for the four monitoring sites along the Densu river as sampled and analysed during the two years of 2005 and 2006[16]. For each year, the parameter values given are calculated as an average of the 5 sampling rounds/analyses carried out per year for each monitoring station.

Table 2.13: Calculation of WQI at 4 monitoring sites, Densu River (2005-2006)

Parameter	Value (lab. analysis) 2005				Value (lab. analysis) 2006			
	Potro-ase	Man-goase	Nsa-wam	Weija lake	Potro-ase	Man-goase	Nsa-wam	Weija lake
Dissolved oxygen (% saturation)	93.3	80.3	80.8	85.6	96.0	85.1	74.1	112.0
BOD (mg/l)	3.04	2.66	6.50	3.94	3.14	3.62	4.24	5.42
Ammonia-nitrogen (mg/l)	0.615	0.676	5.67	1.03	0.186	1.04	0.641	0.381
pH	7.70	8.05	7.41	8.50	6.95	7.00	6.93	8.03
NO_3-N (mg/l as N)	1.63	3.13	3.00	0.840	0.973	0.772	0.471	0.431
Faecal coliform (counts/100 ml)	308	68	464	48	323	541	1732	250
PO_4-P (mg/l as P)	0.001	0.057	0.656	0.020	0.024	0.211	0.357	0.043
Suspended solids (mg/l)	5.5	17.2	19.2	8.4	4.5	21.0	19.0	9.3
Elec conductivity (µS/cm)	218	487	590	421	174	256	276	339
Temperature (°C)	24.3	26.0	27.0	27.9	24.5	26.1	27.8	28.4
Total Score - S (%)	83	74	57	77	91	80	67	80
WQI = S^2/100	**69**	**55**	**33**	**59**	**83**	**64**	**45**	**64**

The WQI values calculated for the sites along the Densu River clearly reflect the prevailing situation of the water quality of the river from its upstream end towards its mid- and downstream sections and impacts of pollution, particularly where the river traverses urban settlements. The 2005 and 2006 values portray the same situation, namely that the upstream Potroase monitoring station has the highest WQI value with a WQI value in 2006 in the lower end of Class I, which indicates a good, almost unpolluted water. The WOI values then decrease progressively from Mangoase to Nsawam, the latter location with 2005 and 2006 values in the Class III range, indicating a water source of poor quality.

Furthermore, it is interesting to note that the water quality after entering the Weija reservoir once again is to be found in the Class II category. Apparently, the water

[16] *CSIR Water Research Institute: Water Quality Monitoring of the South-Western and Coastal River Basin Systems – 2005 and 2006 Annual Water Quality Monitoring and Assessment Reports. Prepared for the Water Resources Commission (January 2006 and February 2007, respectively).*

source manages to "recuperate" and to some extent recover from the heavy pollution load found at Nsawam. This phenomenon is most likely attributed to the effect of the large water body created by the dam with its wind action and resulting in some water circulation, which may facilitate a self-purifying effect.

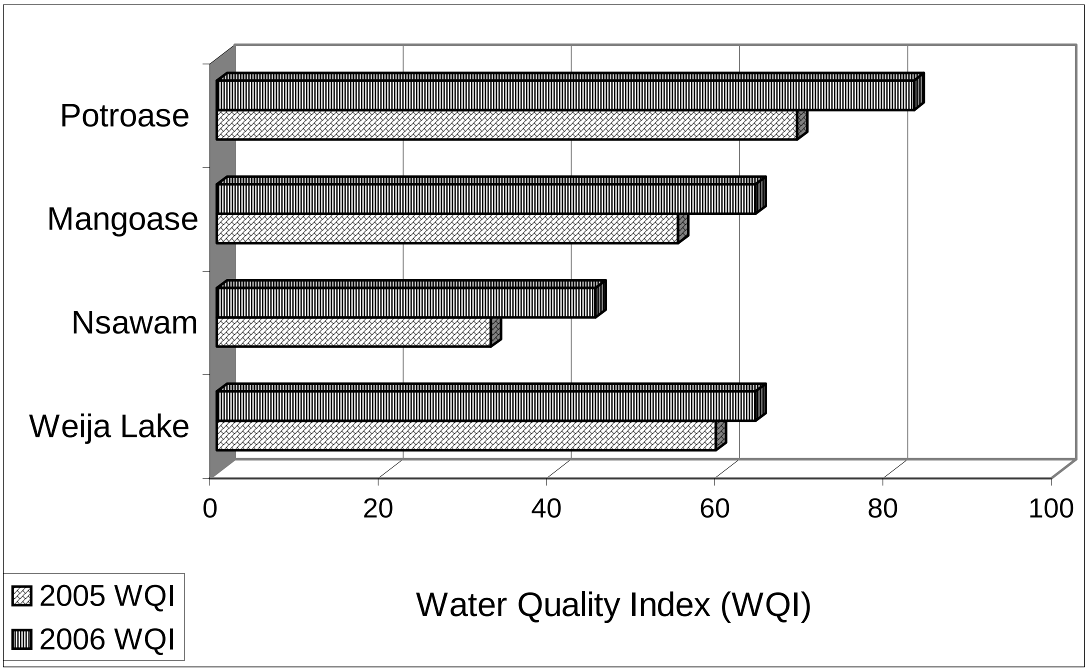


Figure 2.3: Improvement of water quality in the Densu Basin

It is also worthwhile to note as visualised in Figure 2.3 that the water quality at all four stations has improved from 2005 (with an average WQI value of 54) to 2006 (with an average WQI value of 64). This is a sign that the various IWRM activities initiated during the past few years, e.g. relocation of solid waste dump sites, river bank protection, tree-planting and public awareness raising activities, begin to have an impact on the state of the Densu River.

Trace metals and micro-organic pollutants

The screening of trace metals at the four stations along the Densu River in 2005 and 2006 indicates that most of the metals are found in concentrations close to the expected levels normally seen in freshwater without heavy pollution loads, particularly from industrial activities. Furthermore, the trace metals concentrations in Weija Lake comply with the National Target Water Quality Range for Drinking Water[17] and the WHO Drinking Water Guidelines[18].

A screening for micro-organic pollutants was also carried out with focus on pesticides and derivatives of DDT. Values higher than expected were observed. However,

[17] *CSIR, Water Research Institute, Ghana Raw Water Criteria and Guidelines, Volume 1: Domestic Water Use. Report for the WRC, August 2003.*

[18] *World Health Organisation: Guidelines for Drinking Water Quality, Volume 1: Recommendations. Third Edition. 2004.*

no specific conclusions can be drawn related to micro-pollutant level at this juncture, and hence the monitoring will be continued and expanded also to include detection of these compounds in sediments and biota.

2.4.3 Groundwater quality

As mentioned in Section 2.4.1 above a revived water quality monitoring programme was initiated by WRC in late 2004. As part of this programme, the groundwater monitoring incorporates sampling from a total of ten boreholes well distributed over the Densu Basin. All monitoring boreholes are visited twice a year to download water level data from the electronic divers and to collect water samples for laboratory analysis[19]. In general, the quality of the groundwater resources is rated as good with some exceptions as described in the following:

- On the whole, the pH level of the groundwater falls within acceptable limits except for parts of the northern area of the basin where the pH is approaching slight acidity levels.
- There is a distinct delineation in the occurrence of chloride: to the north of Nsawam the groundwater is associated with relatively low concentrations and for areas to the south chloride concentrations increases to about 500 mg/l, and even higher at certain localities. The salinity undoubtedly is caused by seawater intrusion due to lowering of the groundwater table as result of locally over-pumping from certain boreholes.
- In general, turbidity, taste and discolouration due to iron in the water is not a problem, except in the northern part of the Basin, where locally relatively high iron concentrations are found, which facilitate growth of iron-bacteria in pump-parts and pipes.
- The concentration of nitrate is often used as an indicator of groundwater pollution. The nitrate levels in most parts of the basin fall within the recommended guideline value. A noticeable departure from this trend is the area between Mangoase and Tinkong in the Akwapim North district, where concentration of nitrate in general is higher, although not excessive.
- The concentration of fluoride and arsenic in the groundwater does not seem to be a concern as both parameters fall well below the recommended guideline values.

In conclusion it can be said that the groundwater in the Densu Basin is generally of acceptable quality and hence suitable for most purposes including domestic, industrial and agricultural uses. There are, however, few areas particularly within the Ga West and Ga East districts where the levels of dissolved solid material (mineralization) exceed the recommended value, thus making the water less potable. The same thing can be stated concerning the chloride contents in areas of the southern part of the Basin.

[19] *CSIR Water Research Institute: Annual Reports (2005, 2006) on Groundwater Monitoring in the Densu River Basin for the Water Resources Commission (March 2006)*

2.4.4 Sources of pollution and sanitary condition

Causes of water pollution

Degradation of the water quality of the Densu river poses a range of threats, including eutrophication, algal toxicity with related health hazards, resulting from indiscriminate disposal of waste, flooding, improper use of agro-chemicals, illegal fishing methods, leaching from waste dumps, effluent discharge and accidental spills from industries. A potential risk related to further contamination of the surface water system would be the impact of a likely exploitation (mining) of bauxite in the Atewa range where the Densu takes its source. Lumbering activities in the Densu Basin causes sheet and gully erosion as well as leaching of soil nutrients - all of which end up contaminating the water sources.

The Densu Basin is generally suitable for vegetable and pineapple farming, hence the river is getting increasingly polluted due to un-checked use of agro-chemicals. It is evident from the ongoing water quality monitoring programme that agro-chemicals indeed are present in the river system and may be found in concentration levels of concern.

In recent times, the Densu Basin has increased in the number of industries within its boundaries. Though there seems to be no immediate impacts of concern, occasional reports from GWCL indicate some industrial pollution. Of importance is the growing number of food processing companies and how their waste is treated and discharged.

The collective impacts of these adverse effects result in:

- high water treatment cost;
- loss of biodiversity;
- loss of livelihoods and income;
- high disease prevalence rate and associated high medical cost;
- diminishing water availability; and
- water use conflicts.

Overview of the sanitary situation at basin level

Generally, the sanitary and waste disposal facilities are inadequate leading to disposal of domestic sewage and garbage into the river system. At Nsawam, for example, an estimated 30-40 metric tons of waste are generated annually much of which are disposed of in farms sited on the fringes of the town and close to the river.

Furthermore, toilet facilities are inadequate for inhabitants living close to the river in Nsawam, Koforidua and other communities, hence there is open defecation along the river banks and directly in the river. Most of the excreta collected from pan latrines are dumped directly into the river. However, these pan latrines are being phased out. Some schools and small communities within the basin have been provided with KVIPs by CWSA.

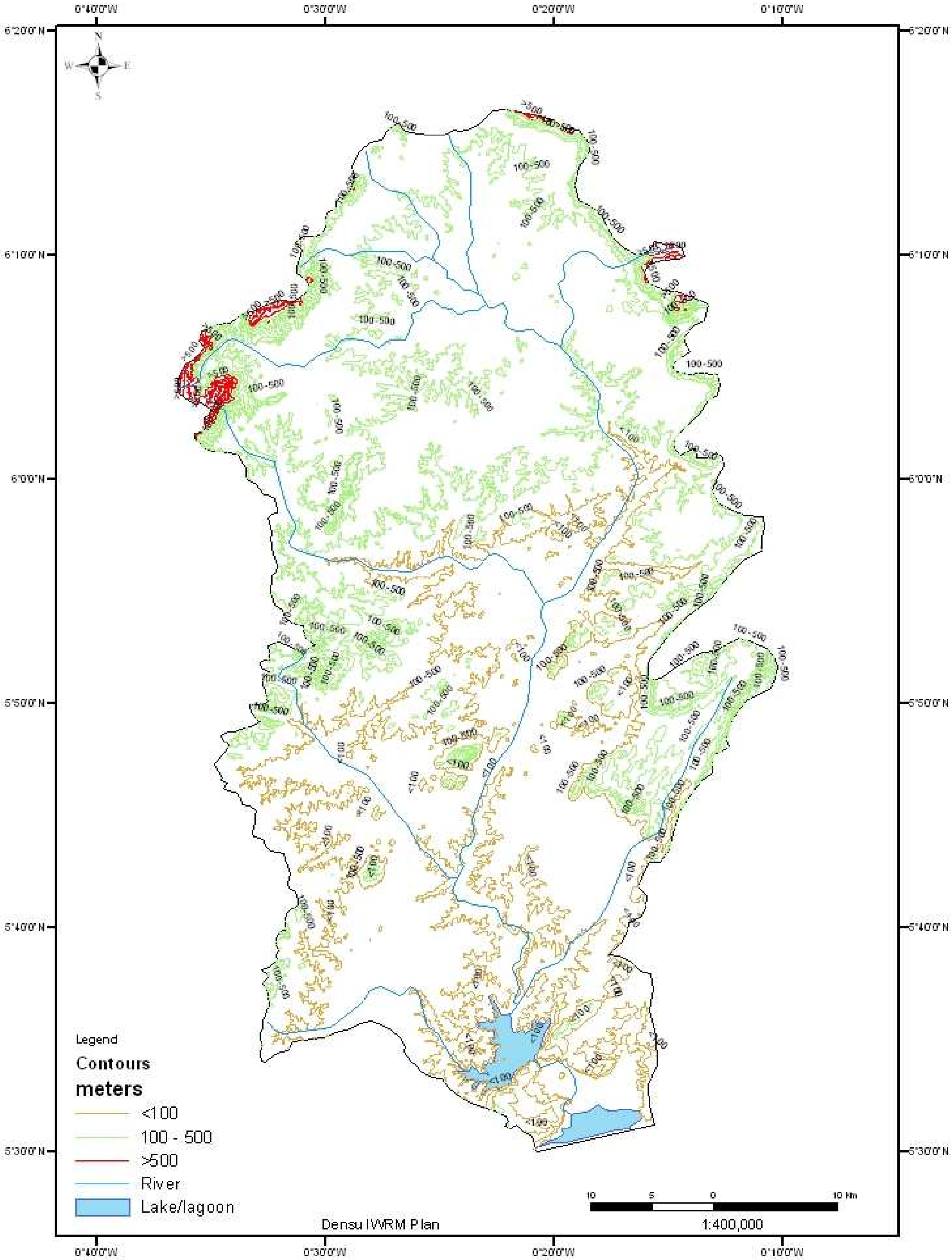
The waste water treatment plant serving Koforidua is located close to the river. For lack of proper operation and maintenance, untreated effluents from the sedimentation tanks find their way directly into the river. Likewise, the old waste treatment facility at Nsawam Prisons is out of order.

Some health facilities in the basin have septic tanks that are emptied from time to time. Incinerators are also used for other waste generated. The regional hospital in Koforidua has a biogas treatment plant, which is not working properly at present. The Blue Skies Company Limited, a fruit processing company, has a waste treatment facility on site at Nsawam.

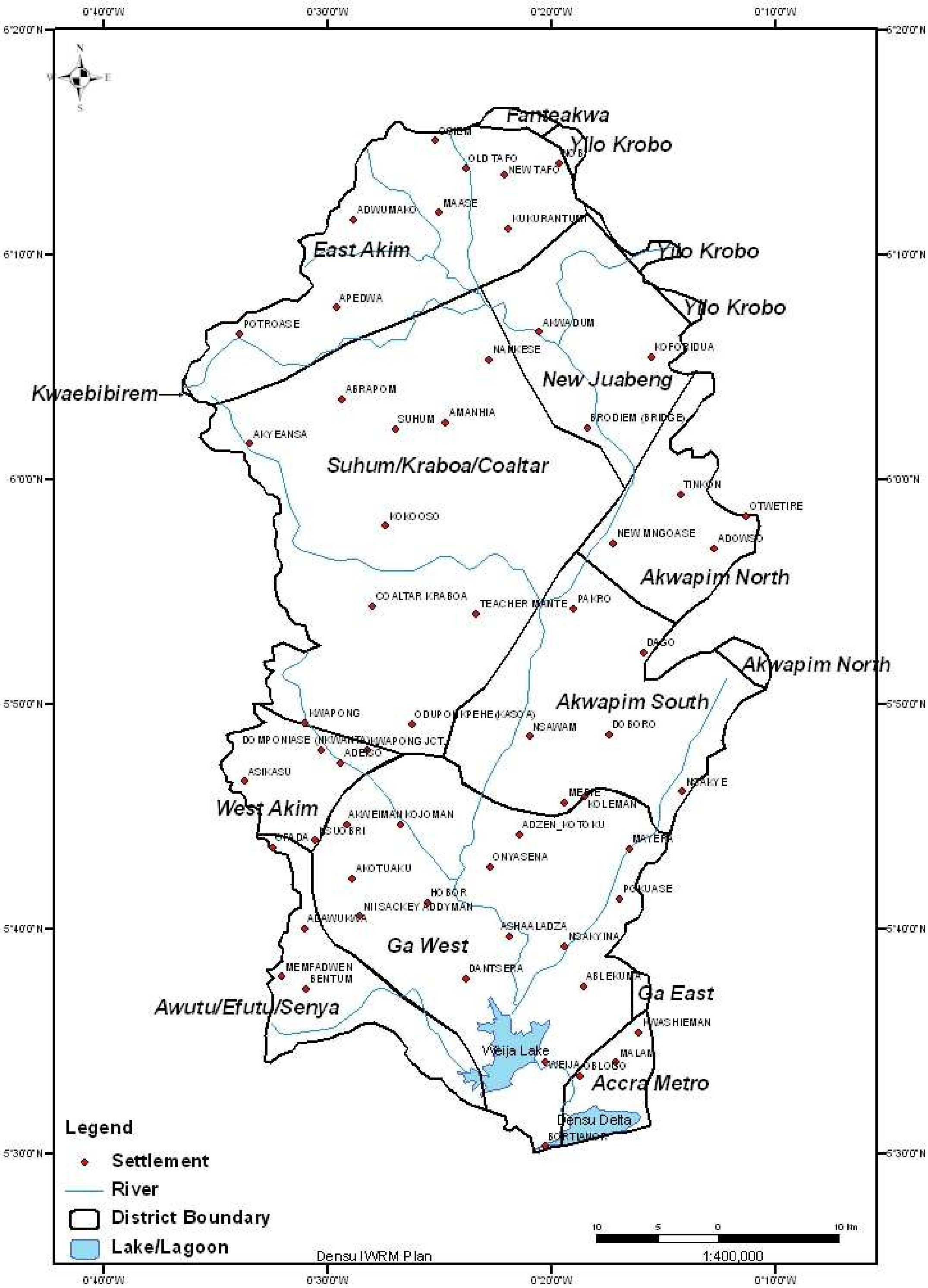
Garbage collection and disposal is very poor and pile up in huge heaps and as such leaching from the heaps drains into the river or groundwater aquifers. Landfill sites are most often not managed properly and pose a threat to the river, as garbage and leach end up in it.

2.4.5 Trends in pollution load

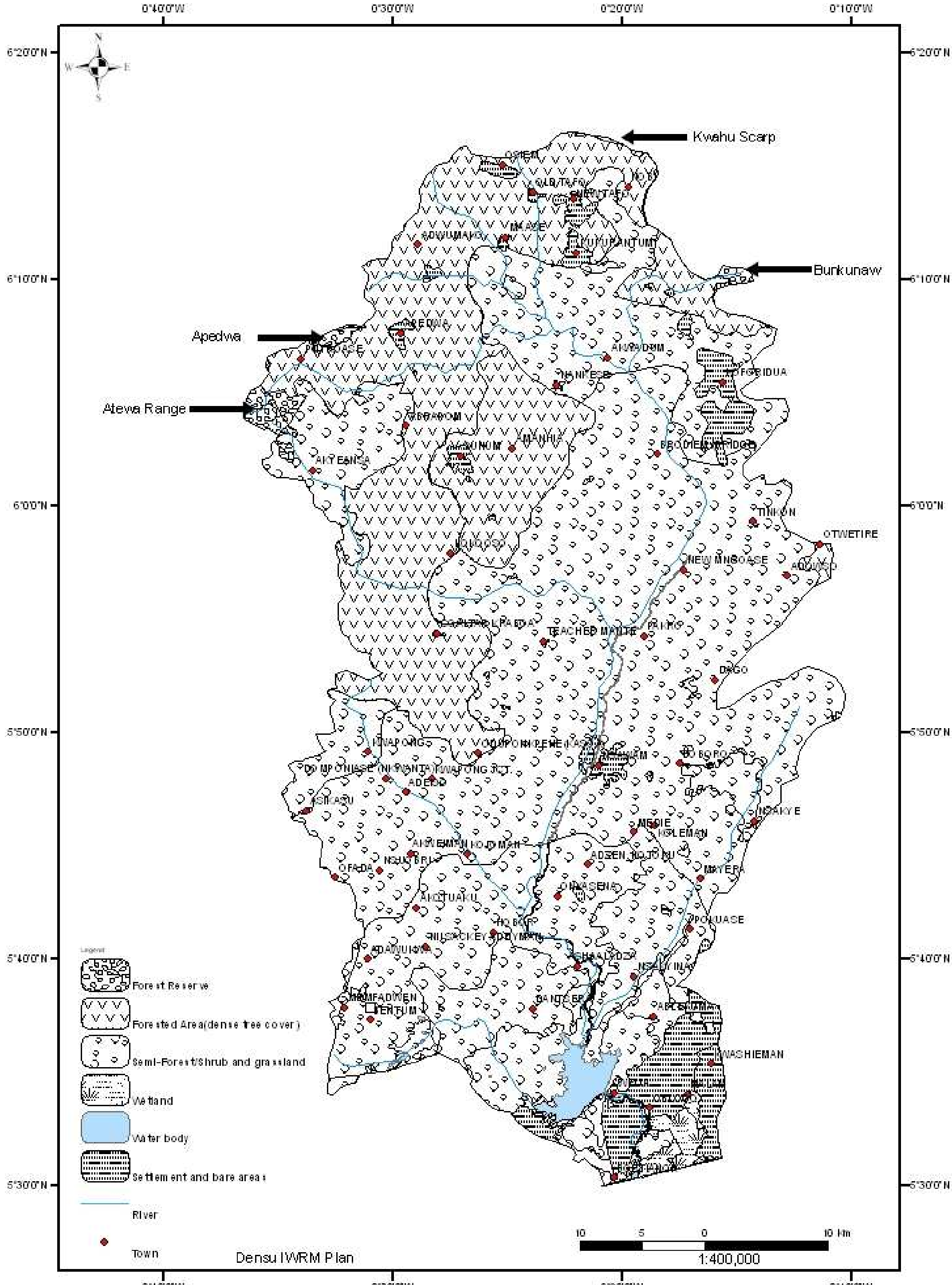
In step with further urbanisation and industrialisation, coupled with an increase in water supply coverage in the basin, the likely pollution load and its impact on the water quality is bound to increase markedly. In this connection it can be mentioned that an increase in the total water abstraction of two to three times during the plan period from the present abstraction rate (ref. Table 3.3 in Chapter 3) could imply an increase in waste water discharge to the river system of up to 10 times the present load. Undoubtedly, introduction of waste water treatment schemes on a broader scale will be required in parallel with further improvement and expansion of the water supply infrastructure.



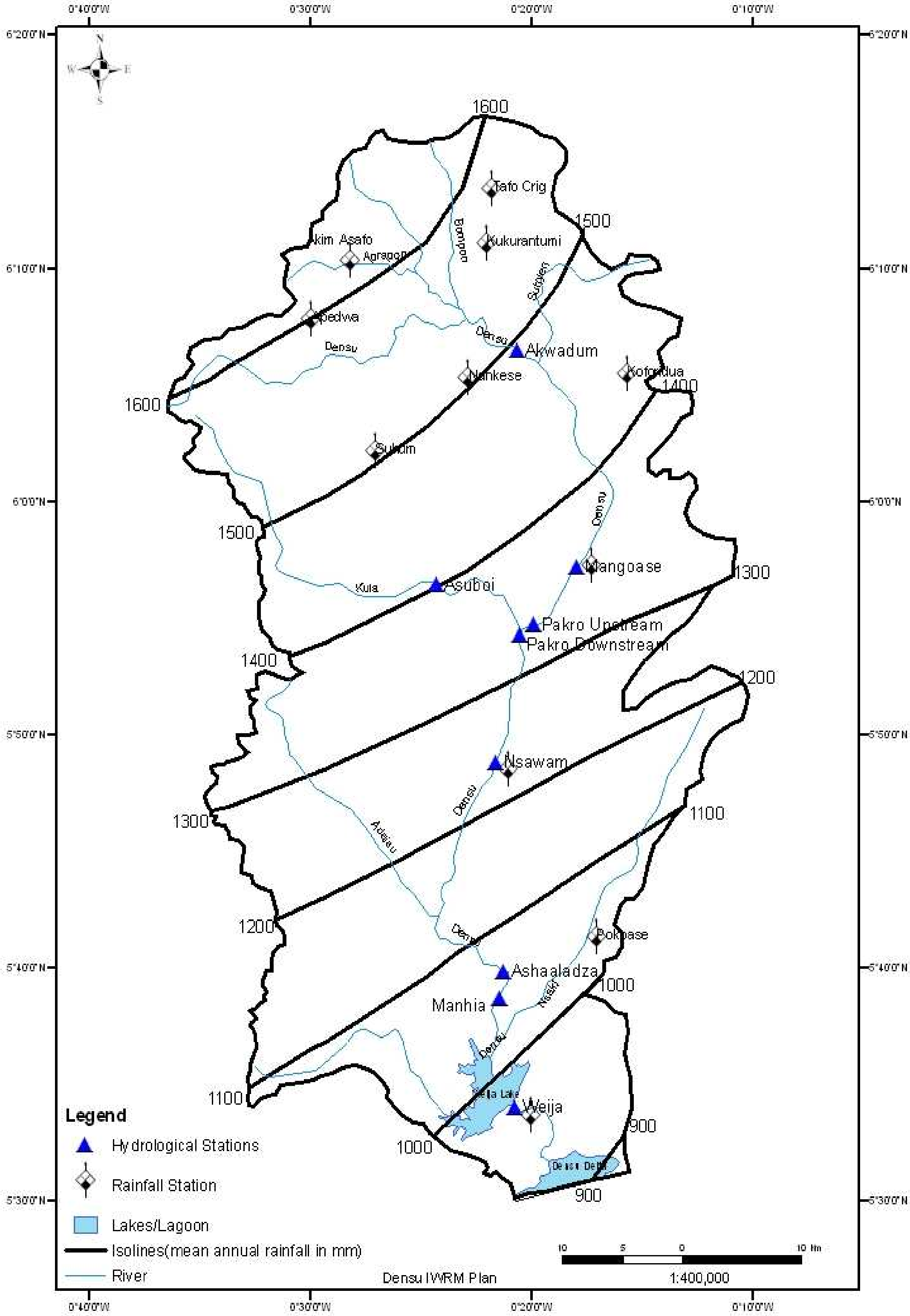
Map 2.1: Topography of the Densu Basin



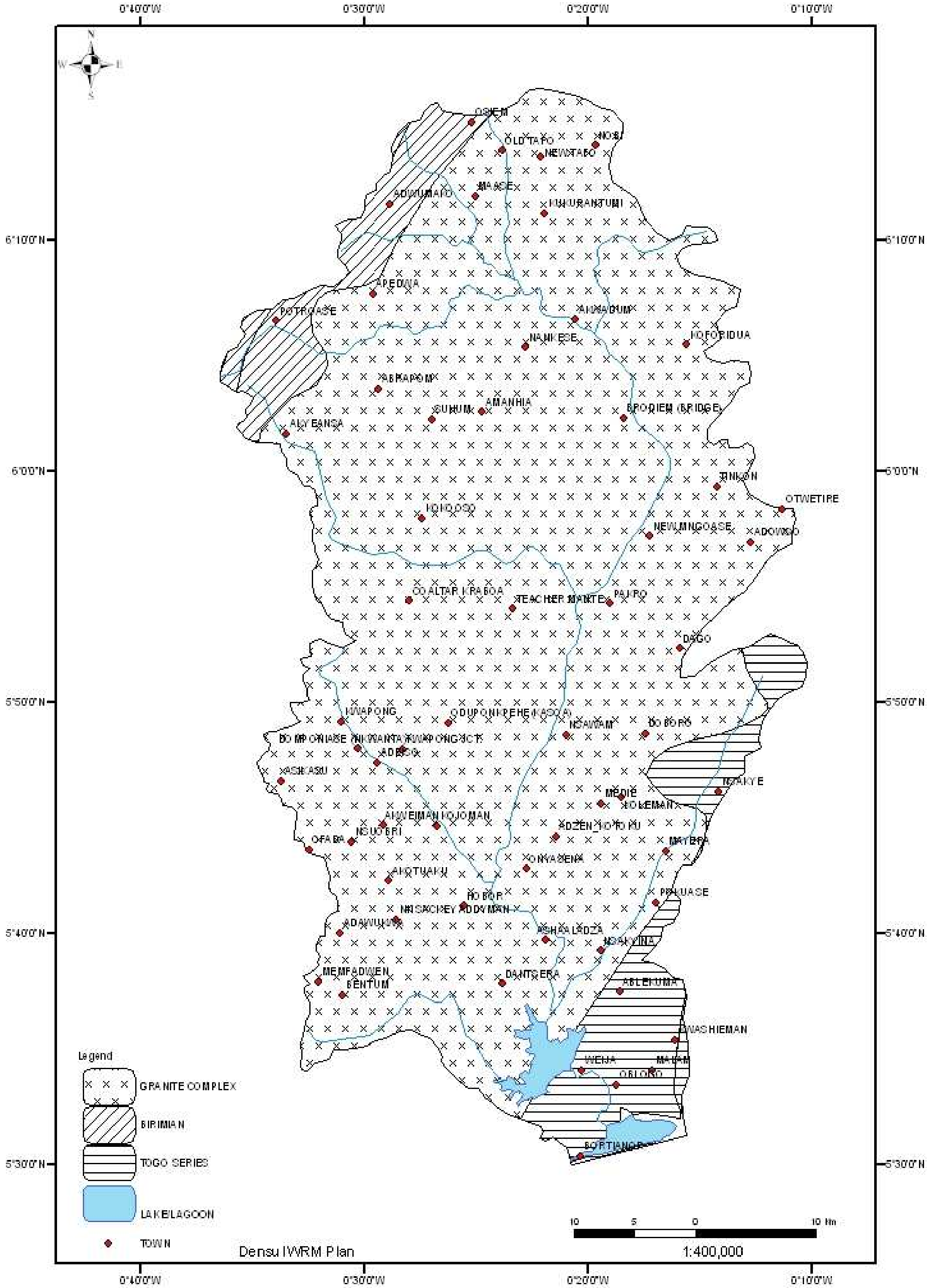
Map 2.2: Administrative Districts and Settlements in the Densu Basin



Map 2.3 : Land Use/Cover (2000) of the Densu Basin



Map 2.4 : River Network, Hydrological and Rainfall Monitoring Stations, Densu Basin



Map 2.5 : Geological Map of Densu Basin

3. WATER DEMAND PROJECTIONS AND WATER AVAILABILITY

Based on the demographic/socio-economic figures and other information given in the Baseline Description, this part of the IWRM plan provides information on projected water demands and assesses the balance between future requirements and water availability.

The demand projections versus water availability is addressed in a two-pronged manner in this chapter, i.e. firstly, an assessment of the overall basin situation is made (ref. sub-chapter 3.3 below), and secondly, scenario analyses are presented, which highlight various options related to utilisation and management of the available water resources (ref. sub-chapter 3.4 below). The water demand projections are made covering a plan period ending by year 2020.

The scenario analyses capture some of the key ‘quantitative’ water resource planning issues associated with the Densu Basin, namely supply options for the major demand centres including Koforidua and Nsawam, and import and export of water to/from the basin, including continued and increased supply to Accra from the Weija dam. Also the impacts of any likely climate change, environmental flow requirements and groundwater abstractions are included in the scenario calculations.

3.1 Demographic and socio-economic development trends

The assumptions used in calculating water demand for the supply of potable (municipal/domestic) water and to meet water requirements for the main socio-economic activities, notably agriculture (irrigation) and industry, are outlined below.

3.1.1 Assumptions for projection of potable water demand

The requirement for potable (municipal/domestic) water is determined based on estimates of per capita water demand and future population growth. The unit water demand (daily per capita demand) figures applied are adapted from the design values commonly used in Ghana (GWCL), which are differentiated according to settlement size and time horizon as depicted in Table 3.1.

Table 3.1: Unit water demand (litres/capita/day)

Settlement size	2005	2010	2015	2020
< 2,000)	200 persons per water point			
2,000-5,000	30	30	35	35
5,000-15,000	55	65	75	85
15,000-50,000	85	85	90	95
> 50,000	105	110	115	120
Densu Basin, rural	35	35	35	35
Densu Basin, urban	95	100	110	120

For the purpose of projecting water demand for the whole basin as a unit, an average set of unit demand figures have been defined for rural and urban settlements as also shown in Table 3.1. The daily per capita demand of 35 l/c/d indicated for the rural communities is set relatively high to reflect the fact that some water from the point sources (boreholes/wells) also is used for subsistence farming purposes.

With departure point in the 2000 Census population figures presented in Table 2.1, annual population growth rates as given in the individual District Poverty Profile reports[20] have been used to arrive at the 2005 population sizes for each district represented within the Densu Basin. The same annual growth rates have been applied throughout the plan period to estimate the future population except for a few adjustments as explained below.

In the case of Ga West and Ga East districts, the reported growth rate of 8.7% annually has been lowered during the plan period to end with a 5% rate. This is done in recognition of the fact that it is anticipated that these districts in 10-15 years will have achieved a certain level (saturation) of "urbanisation" built-up. In this regard it can be noted that the Accra Metro area by now shows an annual growth rate of around 4%. Likewise, the Akwapim South district is given an increasing growth rate during the plan period to reflect the anticipated trend that the Accra metropolis urbanisation phenomenon gradually will reach this district also as witnessed in the Ga West and Ga East districts in the recent past.

Against this background, Table 3.2 presents the population forecasts per district and accumulated for the entire Densu basin. In the table, growth rates are given for each five-year period. It can be noted that the various District Poverty Profile reports provide one growth rate only, which means (it must be assumed) that the indicated growth rates represent "average" values combining both the rural and the urban settlements of the respective district.

From the figures in Table 3.2 it can be seen that the total population of the Densu Basin is expected to increase from the 2000 Census figure of about 1.0 million to some 2.7 million twenty years later in 2020, equivalent to an average annual growth rate of around 5% (with a decreasing trend during the plan period). In year 2000 approximately 50% of the basin's population was residing in the Ga West, Ga East and Accra Metro districts. In year 2020 this proportion is anticipated to increase to about 70% of the basin population. It can be noted that these three districts together area-wise occupy less than one-quarter of the total basin area.

[20] *As part of the second generation Ghana Poverty Reduction Strategy (GPRS II) activities, the National Development Planning Commission (NDPC) directed each District Assembly to prepare poverty profiling, mapping and pro-poor programming reports. These became available during the latter part of 2004.*

Table 3.2: Population projections per part of districts within Densu Basin (2005-2020) [(1)]

District	Settle-ment type	2000 popula-tion	2005		2010		2015		2020	
			p.a. %	Popula-tion	p.a. %	Popula-tion	p.a. %	Popula-tion	p.a. %	Popula-tion
Fanteakwa	rural	800	1.4	858	1.4	920	1.4	986	1.4	1,057
	urban	0	1.4	0	1.4	0	1.4	0	1.4	0
Yilo Krobo	rural	1,200	1.4	1,286	1.4	1,379	1.4	1,478	1.4	1,584
	urban	0	1.4	0	1.4	0	1.4	0	1.4	0
East Akim	rural	27,500	1.4	29,480	1.4	31,602	1.4	33,877	1.4	36,316
	urban	47,000	1.4	50,383	1.4	54,010	1.4	57,898	1.4	62,067
New Juabeng	rural	22,000	2.6	25,013	2.6	28,438	2.6	32,332	2.6	36,759
	urban	114,100	2.6	129,725	2.6	147,489	2.6	167,686	2.6	190,649
Suhum/ Kraboa/ Coaltar	rural	101,700	1.4	109,022	1.4	116,872	1.4	125,287	1.4	134,307
	urban	31,000	1.4	33,232	1.4	35,624	1.4	38,190	1.4	40,939
Akwapim North	rural	19,700	1.8	21,538	1.8	23,547	1.8	25,744	1.8	28,146
	urban	5,000	1.8	5,466	1.8	5,976	1.8	6,534	1.8	7,144
Akwapim South	rural	53,100	1.6	57,486	2.3	64,408	3.3	75,760	5.3	98,080
	urban	43,000	1.6	46,552	2.3	52,157	3.3	61,350	5.3	79,425
West Akim	rural	10,500	1.4	11,256	1.4	12,066	1.4	12,935	1.4	13,867
	urban	8,200	1.4	8,790	1.4	9,423	1.4	10,101	1.4	10,829
Ga West	rural	125,500	8.7	190,468	8.0	279,860	7.0	392,518	5.0	500,964
	urban	341,100	8.7	516,318	8.0	758,639	7.0	1,064,031	5.0	1,358,003
Ga East	rural	2,300	8.7	3,477	8.0	5,109	7.0	7,166	5.0	9,145
	urban	6,400	8.7	9,670	8.0	14,209	7.0	19,929	5.0	25,435
Accra Metro	rural	2,100	4.3	2,592	4.3	3,199	4.0	3,892	3.0	4,512
	urban	25,700	4.3	31,722	4.3	39,155	4.0	47,638	3.0	55,225
Awutu/Efutu /Senya	rural	8,800	2.1	9,764	2.1	10,833	2.1	12,019	2.1	13,335
	urban	10,000	2.1	11,095	2.1	12,310	2.1	13,658	2.1	15,154
Densu Basin	rural	375,200		462,240		578,233		723,994		878,072
	urban	631,500		842,953		1,128,992		1,487,015		1,844,870
Densu Basin, total		1,006,700	5.4	1,305,193	5.4	1,707,225	5.3	2,211,009	4.3	2,722,942

[(1)] *Growth rates are given in per annum (p.a.) percentages for each 5-year period*

3.1.2 Assumptions for projection of agriculture and industrial water demand

Agriculture

The agricultural water demand category includes water for irrigation and livestock watering. It can be concluded from Section 2.3.4 that the present land under irrigation in the Densu Basin is around 250-270 ha of which 220 ha is located in the downstream part of the river system adjacent to the Weija reservoir (although at present no water is abstracted due to rehabilitation activities carried out under the Weija Irrigation Project). In realistic terms, it is assumed that for the basin as a whole, the period up to year 2020 will see an increase in irrigation of up to one-third of the potential irrigable land identified in the Densu Basin. This implies that 500 ha could be under irrigation at the end of the plan period.

The livestock watering demand constitutes only a small portion compared to the other uses in the basin as shown in Table 2.11, and this situation is not expected to change drastically. Looking at the present usage, the future livestock watering demand can be estimated in average to be at a rate of 15% of the rural population's projected water demand.

Industry

The water demand for industrial, commercial and institutional purposes, which fall within the urban piped schemes' supply areas, is included in the projected potable water demand, and thus is accounted for in the unit figures given in Table 3.1 above.

Additionally, as explained in Section 2.3.5, a number of industries outside these supply areas have their own supply facilities (mostly groundwater based). These industries abstract a volume of water which is about 8% of the present urban water usage within the Basin, i.e. excluding the water "exported" out of the Basin from the Weija water works. It is assumed that this percentage can be used also to estimate the future industrial water demand. This industrial demand is estimated separately.

3.2 Water demand projections

By applying the various assumptions and figures given in the preceding section, the future water demand covering the Densu Basin has been calculated with results given in Table 3.3. It should be emphasised that the figures in the table represent the "ultimate" water demand as required by the whole population of the Densu Basin, i.e. assuming 100% service coverage. Not surprisingly, from Table 3.3 it can be seen that the urban water supply sector is by far the largest demand category, which in year 2020 according to the projections will constitute about 75% of the total water demand, with the rural population and water for irrigation accounting for close to 11% and 7%, respectively.

Table 3.3: Water demand projections, Densu Basin (2005-2020)

User category	2005		2010		2015		2020	
	m^3/day	10^6m^3/yr	m^3/day	10^6m^3/yr	m^3/day	10^6m^3/yr	m^3/day	10^6m^3/yr
Urban population	80,100	29.2	112,900	41.2	163,600	59.7	221,400	80.8
Rural population	16,200	5.9	20,200	7.4	25,300	9.2	30,700	11.2
Irrigation	11,000	4.0	12,300	4.5	16,400	6.0	20,500	7.5
Livestock	2,400	0.9	3,000	1.1	3,800	1.4	4,600	1.7
Industry	6,400	2.3	9,000	3.3	13,100	4.8	17,800	6.5
Densu Basin, total	116,100	42.3	157,4 00	57.5	222,200	81.1	295,000	107.7

3.3 Water balance assessment for whole basin as one unit

Groundwater demand vs. occurrences at basin level

It is implicitly taken for granted that improved water supply to the rural (area-wise scattered) population also in the future by and large will depend on groundwater abstracted from boreholes and wells. Additionally, a certain number of the urban settlements to be provided with pipe-borne supply facilities will also be groundwater-based. In this overall basin-level evaluation it is assumed that 20% of the future urban population will fall in this category. Likewise, individual industries (not served by pipe-borne schemes) will also to a large extent rely on boreholes, tapping water from suitable aquifers, which in some areas within the basin can be high-yielding.

Thus, by the end of the plan period, the total demand for groundwater (ref. Table 3.3, year 2020) will be (20% of 80.8 + 11.2 + 6.5) million m^3 per year = 33.9 million m^3 per year. This amount shall be weighted against the groundwater resources available taken as an average over the Basin. In Table 2.5 the sub-surface water retention and groundwater recharge rate is stated to be 14% of mean precipitation, which gives a gross infiltration/recharge rate of 172 mm per year in average. If it is assumed on the conservative side that only about 15% of this amount is converted into available (exploitable) groundwater, it would on a basin basis imply a sustainable groundwater yield of 67.1 million m^3 per year.

In Section 2.2.1 it is stated that a likely impact from climate change, i.e. reduced rainfall, may result in a 10-15% reduction in groundwater recharge. Even with this scenario taken into consideration, it appears that the basin’s groundwater resources in general are ample to sustain the envisaged future abstractions. This does not mean, however, that locally there will not be problems in finding suitable groundwater occurrences.

As also pointed out earlier, to obtain optimal utilisation of the Basin’s groundwater resources, it is imperative that groundwater schemes are based on state-of-the-art hydrogeological assessment methods, efficient borehole siting techniques as well as proper design, construction and development of the boreholes. It is also implied that future groundwater schemes may have to depend on deeper boreholes than usually drilled to obtain the required amount of water, and on longer pumping mains to bring the groundwater to the point of utilisation.

Suhum groundwater-based supply scheme

The water supply scheme of Suhum, which also serves adjacent settlements, is the largest pipe-borne groundwater-based scheme in the Basin. At present, abstraction takes place from 4 boreholes, which provide 380 m^3/day (ref. Table 2.10) with the largest pump capacity rated at 10 m^3/hour. In the context of this plan and with reference to the description given in Section 2.2.3, it is assumed that new constructed boreholes in this part of the basin in the future will be able to be developed to a safe yield of at least 15 m^3/hour.

The urban portion of the whole Suhum/Kraboa/Coaltar district (within the Densu basin) is projected (ref. Table 3.2) to have a population (year 2020) of 40,939. For calculation purpose it is assumed that the Suhum groundwater-based supply scheme in the future will serve half of the district's urban population through a mix of individual connections and public standpipes. If it is further assumed that this mix in service level can be characterised by an average unit consumption figure of 80 l/c/d, it implies a year 2020 groundwater demand for the Suhum water supply scheme of about 1,640 m^3/day. To this amount should be added an allowance for system losses (leakage, etc), say of 25%.

Against this background it can be stated that one borehole pumping for 12 hours per day can provide at least 180 m^3/day, which indicates that the 2020 water demand of Suhum and its environs will require a total of 11 to 12 boreholes. To put this number in perspective, it means that in average some 1,800 people would be served per borehole – nearly ten times more than the design criteria prescribed in implementing the various projects under the national rural water supply programme.

Surface water demand vs. total runoff at basin level

When the demand for groundwater (year 2020) is subtracted from the total water demand of 107.7 million m^3 per year (Table 3.3), a value of 73.8 million m^3 per year is found to be the demand for surface water to fulfil the requirements of the whole basin at the end of the plan period. Also in this case should be added a 25% allowance for "un-accounted for" water (losses).

With reference to Table 2.6, the average annual runoff of Densu River as it enters the Weija reservoir is given as 248 million m^3 per year. With the inclusion of a 15-20% reduction in annual runoff due to the effects of a likely continued climate change (ref. Section 2.2.1), it appears when considering the basin as one unit that the surface water resources can cater for the future requirements.

It should be emphasised, though, that the above statement is made to provide an assessment and judgement concerning the overall resource availability on an annual basis for the Densu Basin as a unit considering only the water requirements of the population residing within the basin boundaries and the associated socio-economic activities.

However, in this overall, basin-wide assessment other requirements should also be included, viz. the amount of water "exported" from the basin to other areas of the Accra-Tema metropolitan water supply area, which currently amounts to some 64.2 million m^3 per year (ref. footnote in Table 2.11), as well as environmental flow requirements. When these other requirements are considered the indication is that a general water-stressed situation for the basin is gradually emerging.

3.4 Scenario analyses of water availability vs. requirements at demand sites

3.4.1 Introduction to scenario analyses and model assumptions

Irrespective of the water resource overview and general conclusions presented in Section 3.3 above, it is a well known fact that it is the low-flow regime of the Densu River, which determines its viability as a source for a year-round water supply (run-of-the-river scheme), i.e. direct abstraction without in-stream storage capacity provided.

To examine the consequences and extent of future shortages in step with increased demand, the low flow regime – as determined by runoff data series long enough to reflect the hydrologic/statistical features of the river flow – has been introduced in the analysis utilising data referred to in Section 2.2.2 (ref.[9]).

Water requirements at main water demand sites

The following demand sites, which at present are supplied through piped systems relying on the Densu river system, are assumed to continue to be supplied by surface water from schemes to be expanded in step with increase in water requirements in and around these supply areas:

- Apedwa,
- Old-New Tafo,
- Koforidua,
- Nsawam, and
- Weija Dam with abstractions for (i) the Weija treatment plant requirements, (ii) the irrigation farms, and (iii) an environmental flow to the Ramsar wetland site.

Additionally, in the future, other urban settlements (communities above 5,000 in size) will also need to abstract water from the river system or to be included in expansion of the "old" schemes to cater for their water requirements. For reasons of simplicity, in the water accounting and scenario analyses presented below, these various "other urban" surface water requirements are included in the above listed demand sites within the respective districts.

It should also be noted that conclusions reached, based on results of the scenario analyses, only consider coverage in term of water availability as a source for meeting the requirements, and does not take into account the various technical aspects as precondition for attaining the coverage, e.g. appropriateness and efficiency of water intake structure, expansion of transmission mains and distribution outreach.

As far as the Suhum groundwater-based supply scheme is concerned, it is assumed - as also mentioned in Section 3.3 above - that in the future it will supply half of the population of the Suhum/Kraboa/Coaltar district (residing within the basin) with water, whereas the other half is proposed to be supplied from a new surface water scheme, e.g. abstraction of water from a site on the Kuia tributary near Asuboi.

The water requirements of the southern portion of the Densu Basin, which combines parts of Ga West, Ga East, West Akim and Awutu/Efutu/Senya districts, and a portion of Accra Metro area, are assumed to be met from GWCL Weija scheme currently under expansion. When the ongoing expansion of the water works and transmission system is completed, the volume of water processed will increase from the present 200,000 m^3/day to approximately 268,000 m^3/day. During the remaining of the plan period, the future abstractions from the Weija reservoir is assumed to be maintained at this level, i.e. no new expansion of the physical "infrastructure" (raw water pumps, treatment facilities and transmission mains from the Weija plant) is foreseen beyond the facilities being put in place now.

Utilising the projected urban population figures (ref. Table 3.2) and the unit consumption rates as given in Table 3.1, the 2020 water demand situation for these demand sites is summarised in Table 3.4. Other surface water based demand sites (mainly for irrigation purposes) in the basin are established and introduced in the calculations as explained in Section 3.1.

Table 3.4: 2020 projected water demand at surface water abstraction points

Abstraction point/demand site (portion of district within basin)	2020 population to be served (residing within basin)	2020 water demand (m^3/day)
Apedwa (part of East Akim)	8,716	741
New/Old Tafo (part of East Akim)	53,351	6,402
Koforidua (New Juabeng + Akwapim North)	197,793	23,735
Nsawam (Akwapim South)	79,425	9,531
Suhum (Suhum/Kraboa/Coaltar)	40,939	3,889
Weija Dam (Ga West, Ga East, West Akim, Awutu/Efutu/Senya and Accra Metro)	1,464,646	175,758

System losses (un-accounted for water)

It is a fact that the existing piped water supply systems in Ghana generally suffer from unacceptable high rates of un-accounted for water, i.e. physical losses, notable in the transmission mains and distribution network. At present, it is estimated that in average some 40% of water produced can be categorised as un-accounted for water.

It should be noted that a high rate of un-accounted for water not only implies a non-efficient way of using the available water sources, but also results in extra costs related to water treatment, pumping (energy) and other operational aspects.

As part of the alternative water resource utilisation options presented below, it is opted in this plan to assume that system losses will (and must) gradually be brought down to a 25% level, which also is considered a realistic aim to achieve over the plan period. The un-accounted for water percentage figure is added to the demand figures as presented in Table 3.4 to arrive at the actual water requirements at the various abstraction points.

Minimum flow requirements

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 have been based on a low-flow frequency analysis on the monthly flow data (ref.[9]) and determined as the 95-percentile flow (i.e. the 20-year minimum flow return period) in each calendar month. This criterion is also used in the case of Weija dam to ensure a minimum flow downstream of the dam for the benefit of the aquatic ecosystems in the Densu delta and lagoon (Ramsar site).

The WEAP computer model

The computer-based Water Evaluation and Planning (WEAP) Model is used to carry out scenario analyses to facilitate the understanding and description of different water resource development choices, and to establish their consequences. It operates on the principles of water balance accounting and examines alternative water development strategies in form of scenario analyses to provide answers to various "what if" questions.

For each model run (scenario), the various water requirements covering the whole river system are taken into consideration, and the induced upstream-downstream interactions and their consequences are being accounted for and results shown in a number of optional ways to be chosen by the user, such as graphs, in table form or as histograms. Also the percentage of requirements met (coverage rate) at each demand site is calculated with increments of one month throughout the plan period.

The starting point of the basin modelling is to establish and define the basic water related elements of the Basin and their relations as they currently exist. This overview of the existing situation is called the "current accounts". The "current accounts" includes the specification of supply, demand and resource data, including information on dams and reservoirs, as extracted from the information and figures presented in the previous chapters/sections and other sources.

As an example, Map 3.1 (inserted at the end of chapter) provides a schematic overview of the Densu river system and the basic set-up of the river basin model components as extracted from one of the WEAP applications. The map depicts the main elements such as abstraction/demand sites (urban water supplies, irrigation schemes, etc), dam sites, locations for minimum flow requirements, and other main features, like transmission lines, used in the scenario analyses.

3.4.2 Results from the scenario analyses

Introduction

A number of scenarios, comprising various assumptions related to availability of water and different development options and strategies for the utilisation of the Densu water resources have been analysed with results presented in this section. It must be emphasised, though, that the presented scenarios and the associated water resource development options should be regarded as a "point of departure" from which the basin modelling coupled with requirements for detailing can be further developed as the need for planning and decision-making at various levels (basin-wide or project specific) arises.

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 service coverage as calculated at the different demand sites towards the end of the plan period[21].

In harmony with progress towards fulfilling the Millennium Development Goals (MDG), it is adopted that the general water supply coverage rate should at least reach 90% by the end of the plan period (2020) for the supply system to be rated as providing a reliable and satisfactory service. This coverage criterion constitutes the 'yardstick' by which the future water supply situation balanced against availability of water can be judged using the results generated from the computer-aided scenario analyses.

It should be reiterated that in these scenario analyses the withdrawal from the Weija reservoir is determined by the given capacity (when the ongoing expansion works are completed) of the physical infrastructure, i.e. size of dam/reservoir, intake structure and water treatment capacity of the GWCL water works, rather than the ultimate water demand within the area serviced by the expanded Accra-Tema water supply scheme.

For calculation purposes, it is further assumed that the expanded Weija scheme with a capacity of about 268,000 m^3/day will be operational from year 2010 and fully utilised by 2015, and that future withdrawals will be kept constant at this rate, i.e. no further increases in the abstraction rate is foreseen throughout the plan period.

Furthermore, the Weija irrigation farms will withdraw up to 9,000 m^3/day from the Weija reservoir after the irrigation project's pumps and other infrastructure have been rehabilitated and brought back into operation.

In the following, a total of 7 scenario analyses are presented. The first 5 model runs (scenarios 1-5) provide information about the existing situation and assess to which extent, e.g. climate change and more result-oriented efforts towards reducing system losses (un-accounted for water) impact on the water supply coverage rate expected towards the end of the plan period. Against this background, the last model runs (scenarios 6 and 7) provide results of two alternative water resource utilisation options identified to address the projected water-stressed situation of the basin.

<u>Basic scenarios for water resource assessment</u>

Scenario 1: Unchanged ("do nothing") water resource capacity situation

This scenario assumes a future *status quo* situation regarding the resource capacity, which implies that no new dams or additional sources will be introduced. However, the existing water abstraction and other facilities will be expanded in step with the increase in water requirements up to the limit of the present source capacity.

[21] *The indicator used to represent the coverage rate towards the end of the plan period is calculated as the average "% of requirements met"(as generated from the WEAP model applications) during the water-stressed months of the three last years of the plan period, i.e. 2018-2019-2020, for each demand site. In other words, the coverage rate defined in this way provides a measure for the general water supply situation at a demand site during the low- flow periods at the end of the plan period.*

In the water requirements for this "do nothing" scenario, the amount of un-accounted for water (system losses, leakages etc) at each demand site is included at the prevailing rate of 40% of the projected "normal" demand. Minimum (environmental) flow requirements meant for aquatic ecosystem protection are also included as explained in Section 3.4.1 above. In this scenario, the likely effect of climate change with lower runoff as a result is not taken into consideration (ref. scenario 3 below).

Result:

Not surprisingly, as can be seen from the percentages given in Table 3.5 below, a future "do nothing" scenario results in pronounced water shortages during the dry months for all upstream demand sites, i.e. Apedwa, Tafo and Koforidua, whereas the runoff of the Densu river at the Nsawam demand site is sufficient to meet the requirements also during the low-flow periods throughout the plan period.

It can also be mentioned that towards the end of the plan period, only less than half of the Weija reservoir storage capacity is utilised, even with due consideration given to releases of the environmental (minimum) flow requirements downstream of the dam. Hence, it can be deduced that the Weija reservoir still has a sizeable "reserve" storage capacity, also after the current abstraction/treatment expansion works are completed. Therefore, based on the model run for this "do nothing" scenario, it can be concluded that the question about water availability (capacity of the river source) poses a problem primarily for the demand sites in the northern portion of the Basin.

Scenario 2: Introducing transfer of water from Volta Lake

At the end of 2006, GWCL has commissioned the engineering works for final design and construction of a pumping scheme, whereby water will be transferred from the Volta Lake to supplement the supply from Densu river to Koforidua water scheme. Hence, the second scenario examines to which extent the introduction of this inter-basin water transfer scheme will improve the Koforidua water supply situation. It should also be mentioned that the transmission pipe from Volta Lake also will benefit various demand sites en route.

In the analysis, the transfer scheme's design capacity of 13,600 m^3/day is used and assumed to be operational by year 2010. It can be noted that in operational terms, GWCL is given priority to the utilisation of water from the Densu River before supplementary water is pumped across from the Volta Lake to Koforidua.

Result:

This second model run has shown that the transfer scheme as intended alleviates the situation with a full coverage rate for Koforidua up to around year 2015. At that juncture, in step with the increasing demand for water, shortfalls in the supply of water to the expanded Koforidua supply scheme will begin to be experienced once again with the result that water requirements can not be met in a satisfactory way towards the end of the plan period. With reference to Table 3.5, it can be seen that the introduction of the water transfer scheme lifts the coverage rate for Koforidua and environs from 59% to 67%. In this scenario, the situation will not change for the upstream demand sites of Apedwa and Tafo, which maintain the “do nothing” (Scenario 1) results.

As explained in footnote[21], it should be reiterated that the percentages representing requirement met (coverage rate) refer to the supply situation during the low-flow periods only (typically 2-3 months per year) at the end of the plan period.

Table 3.5: Coverage rate, existing situation (Scenarios 1 and 2)

Scenario	Demand site (by end of plan period)				
	Apedwa	**Tafo**	**Koforidua**	**Nsawam**	**Weija Lake**
1. Unchanged (“do nothing”) water resource capacity situation	44%	38%	59%	100%	100%
2. Transfer of water from Volta Lake to Koforidua water supply (works commissioned)	44%	38%	67%	100%	100%

Scenario 3: Impact of climate change

As explained in Section 2.2.1, the effects of a likely climate change can be quantified in terms of an anticipated decrease in surface water runoff. The study referred to in that section indicates that a climate change scenario considered realistically to occur, i.e.10-20% change in rainfall and a 1-2°C rise in temperature, will reduce surface runoff in the range of 15-20% over the coming 20-year period. Furthermore, irrigation water demand would be affected considerably by the simulated climate change adding some 50% to the present water demand for irrigated agriculture.

The reduced runoff caused by a likely climate change has been imposed on the data series used in the calculations, and an alternative model run was made for the “do nothing” situation to compare and get an idea about the “order of magnitude” of a climate change impact on meeting the future water requirements.

Result:

Table 3.6 depicts the result of the model run for the climate change scenario presenting the percentage of requirements met (coverage rate) during the low flow periods towards the end of the plan period in comparison with the Scenario 1 results extracted from Table 3.5.

From the figures presented in Table 3.6, it is clear that the effects from a climate change would reduce markedly the ability of the Densu river to act as a source to meet requirements in any satisfactory way without a water augmentation/alteration scheme introduced. The impact of the climate change will also be felt at the downstream demand sites. For instance, at Nsawam the coverage rate falls from the 100% coverage level to 80%.

Table 3.6: Coverage rate, impact of climate change (Scenario 3)

Scenario	Demand site (by end of plan period)				
	Apedwa	Tafo	Koforidua	Nsawam	Weija Lake
1. Unchanged ("do nothing") water resource capacity situation	44%	38%	59%	100%	100%
3. Unchanged ("do nothing") water resource capacity situation – with impact of climate change	40%	34%	44%	80%	99%

In addition to the decline in service coverage, the model runs further show - not surprisingly - that the impact of climate change also prolongs the period (number of low-flow months) during which shortfalls in water availability will be prevalent.

It goes without saying, that in tangible terms it is not known to which extent a likely climate change will impact on the surface runoff regime, but it is, nevertheless, advisable to think in terms of introducing some form of long-term "contingency plans" in this respect. For this purpose, the alternative water resource utilisation options presented below as Scenarios 6 and 7 incorporate the effect of a possible climate change as quantified above.

Scenario 4: Sensitivity to improvements in water delivery system losses

In this scenario, the result of efforts towards reducing the physical losses is highlighted. As an example, Scenario 1 has been subjected to another model run with a reduced rate of un-accounted for water from the prevailing 40% to the targeted 25%. In principle, this set of model runs can also be used to make a judgement about the effect of introducing water demand management measures as a means to use water more efficiently. The outcome of this analysis is given in Table 3.7.

Table 3.7: Coverage rate, response to changes in system losses (Scenario 4)

Scenario	Demand site (by end of plan period)				
	Apedwa	Tafo	Koforidua	Nsawam	Weija Lake
1. Unchanged ("do nothing") water resource capacity situation – with 40% system losses	44%	38%	59%	100%	100%
4. Unchanged ("do nothing") water resource capacity situation – with 25% system losses	55%	48%	74%	100%	100%

Result:

The table values clearly provide an indication of the impact (sensitivity) to an improved efficiency in water delivery, i.e. by reducing the amount of un-accounted for water and/or by introducing water demand management measures. As a matter of fact, a targeted and well organised programme aimed at reducing water losses, and in general towards using the resource more efficient, could "save" water to such an extent that it would counteract in a sizeable manner the effects of a likely climate change.

Scenario 5: Priority in utilisation of water from Densu River and Volta Lake

As mentioned under Scenario 2 above, when the water transfer scheme aimed at pumping water from the Volta Lake to Koforidua supply scheme is brought into operation, the GWCL stated strategy – for rather obvious economic, operational reasons – will be to give first priority to use water from the Densu river before supplementary water is pumped across from Volta Lake.

The consequence of changing this priority setting is documented in this scenario, whereby the water transfer pipeline's capacity of 13,600 m^3/day should be used more fully, i.e. giving first priority to the Volta Lake water for Koforidua water supply rather than the Densu river. The aim is to take more advantage of the given investment already made and to retain the Densu river source as much as possible for downstream uses, in particular for expanding the Nsawam water supply scheme.

For the purpose of this comparison, the scheme for transfer of water from the Volta Lake to Koforidua water supply (Scenario 2) has been subjected to two model runs, both with the effect of climate change and 40% system losses included, but with changed priority in source utilisation (5a and 5b, respectively). The results are given in Table 3.8.

Table 3.8: Coverage rate, Densu and Volta Lake prioritisation (Scenario 5)

Scenario	Demand site (by end of plan period)				
	Apedwa	Tafo	Koforidua	Nsawam	Weija Lake
5a. Transfer of water from Volta Lake to Koforidua water supply – first priority to use Densu River	40	36	67	80	100
5b. Transfer of water from Volta Lake to Koforidua water supply – first priority to use Volta Lake	40	36	67	98	100

Result:

The results indicate that to use the Volta Lake water with associated high pumping costs as priority over the Densu river will provide a relief to the supply situation downstream, to such an extent that the Nsawam demand can be satisfactorily supplied at the end of the plan period. Further source assessments coupled with economic/financial analyses have to be carried out to clarify how the Volta Lake water pumped through the 13,600 m^3/day capacity transmission main most beneficially can be used as part of meeting the water requirements of the Densu basin rather than the Koforidua water supply alone.

Alternative water resource utilisation options

Faced with the challenges to meet future water requirements, particularly when the impact of a likely climate change is taken into consideration, two possible water source “infrastructure” development options have been included in the WEAP model application as follows:

– introduction of a second (additional) transfer pipe from the Volta Lake; and
– construction of a new dam a few kilometres upstream of the present Koforidua water intake site.

It should be reiterated that in the projected water requirements for these scenarios, the following “extra” demands are also included: (i) un-accounted for water (system losses, leakages etc) at each demand site at 25% of projected “normal” demand, and (ii) minimum flow requirements for aquatic ecosystem protection in all river sections below the various abstraction points.

Scenario 6: Additional transfer of water from Volta Lake

In addition to the water transfer introduced by year 2010 with priority given to use Volta Lake water before Densu river towards meeting the requirements of the Koforidua demand site (similar to Scenario 5b), in this scenario it is assumed that a second, supplementary water transfer pipeline from Volta Lake will be introduced by year 2015, which is around the time when shortages at Koforidua is being realised again as documented in the scenario analyses presented above.

As an integral part of this scheme, it is proposed to construct a transmission line from this new water transfer pipeline to the Old/New Tafo demand sites to curtail the severe water shortages experienced in this part of the basin. When the new transmission line is operational, this scenario calls for an abandonment of the New Tafo water abstraction at the present intake (New Tafo Dam) on the Beira tributary.

Result:

A sequence of model runs were made aimed at finding the appropriate pipe capacity required to fulfil the future water requirements for this expanded (combined) scheme. The outcome of calculations indicates that to attain a satisfactory coverage level, the proposed second transmission pipe from Volta Lake to serve both the Koforidua and Tafo areas, and hence reducing the abstraction requirements from the Densu river itself, should be some 2.5 to 3 three times the capacity of the transmission main presently being designed.

The percentage of requirements met (coverage rate) for this scenario is presented in Table 3.9 below. The figures obtained are from the model run in which the second transmission pipe has a capacity of 37,000 m^3/day and as mentioned earlier is assumed to be operational from year 2015.

Scenario 7: New dam on the Densu River upstream of Koforidua

As an alternative to constructing a second water transfer pipeline from Volta Lake, it is in this scenario proposed - in addition to the first water transfer from Volta Lake as outlined in Scenario 6 above - to build a new dam on the Densu River a few kilometres upstream of the present Koforidua water intake site. Like above, it is envisaged that this dam should be operational from year 2015.

Result:

The result of the model run for this scenario indicates that to attain a satisfactory coverage level towards the end of the plan period, the Koforidua New Dam should be sized to create a reservoir of about 8 million m^3 storage volume[22]. Water abstractions for the water demand centres of Koforidua and Old/New Tafo will both take place from the new reservoir. When the new dam and new transmission lines to the two demand sites are in place, the existing Tafo abstraction site as well as the water intake for Koforidua water supply on the Densu River can both be abandoned, whereas the existing Koforidua treatment facilities appropriately can be maintained for processing of raw water now to be delivered (pumped) from the new reservoir.

The percentage of requirements met (coverage rate) for this scenario is also presented in Table 3.9.

To get an indication about the required size of the new dam (impact on the storage volume) in relation to a different river runoff regime, a model run was also made for a situation where a likely climate change will not occur. In this case, a much smaller dam of about 3.5 million m^3 storage volume would be required to provide 100% coverage at the two demand centres towards the end of the plan period.

Table 3.9: Coverage rate, alternative options (Scenarios 6 and 7)

Scenario	Demand site (by end of plan period)				
	Apedwa	Tafo	Koforidua	Nsawam	Weija Lake
6. Additional water transfer from Volta Lake	43%	94%	97%	100%	100%
7. New dam on the Densu River upstream of Koforidua present intake	43%	98%	99%	98%	100%

3.4.3 Overall assessment based on the scenario analyses

Considering availability of water only, i.e. without taking into account the various technical infrastructure requirements in abstracting and transmitting and distributing the water to consumers, and not the least the economic and financial consequences, the scenario analyses have highlighted that it is particularly in the northern half of the Densu Basin, where water resource utilisation measures need to be put in place to meet future requirements of the people residing in the Basin and to maintain the growing socio-economic, industrial and agricultural activities being realised.

If a climate change impact is not taken into consideration, the analysis also indicates that downstream of the Kuia-Densu river confluence, water availability appears sufficient for the projected requirements of the Nsawam demand site and other urban

[22] *A preliminary field reconnaissance revealed that the maximum size of a dam (reservoir) to be constructed at this upstream site on the Densu river is about 10 million m^3.*

communities in the Akwapim South district without introducing any specific water resource utilisation schemes. Furthermore, the storage capacity of the Weija reservoir is large enough to provide for the water required at the Weija Water Works, also after the ongoing expansion works are completed with the present water abstraction of 200,000 m^3/day to be boosted to 268,000 m^3/day (and then kept constant at this rate throughout the plan period).

As mentioned previously, in the alternative water resource scenario analyses, which provide the basis for making assessment about to which extent water requirements are met, minimum (environmental) flow requirements, water scheme and distribution losses, and importantly, impacts of a likely climate change are all included.

Based on the scenario analyses, an assessment of the general situation at each major demand site suggests options concerning utilisation and development of the water resources, as follows:

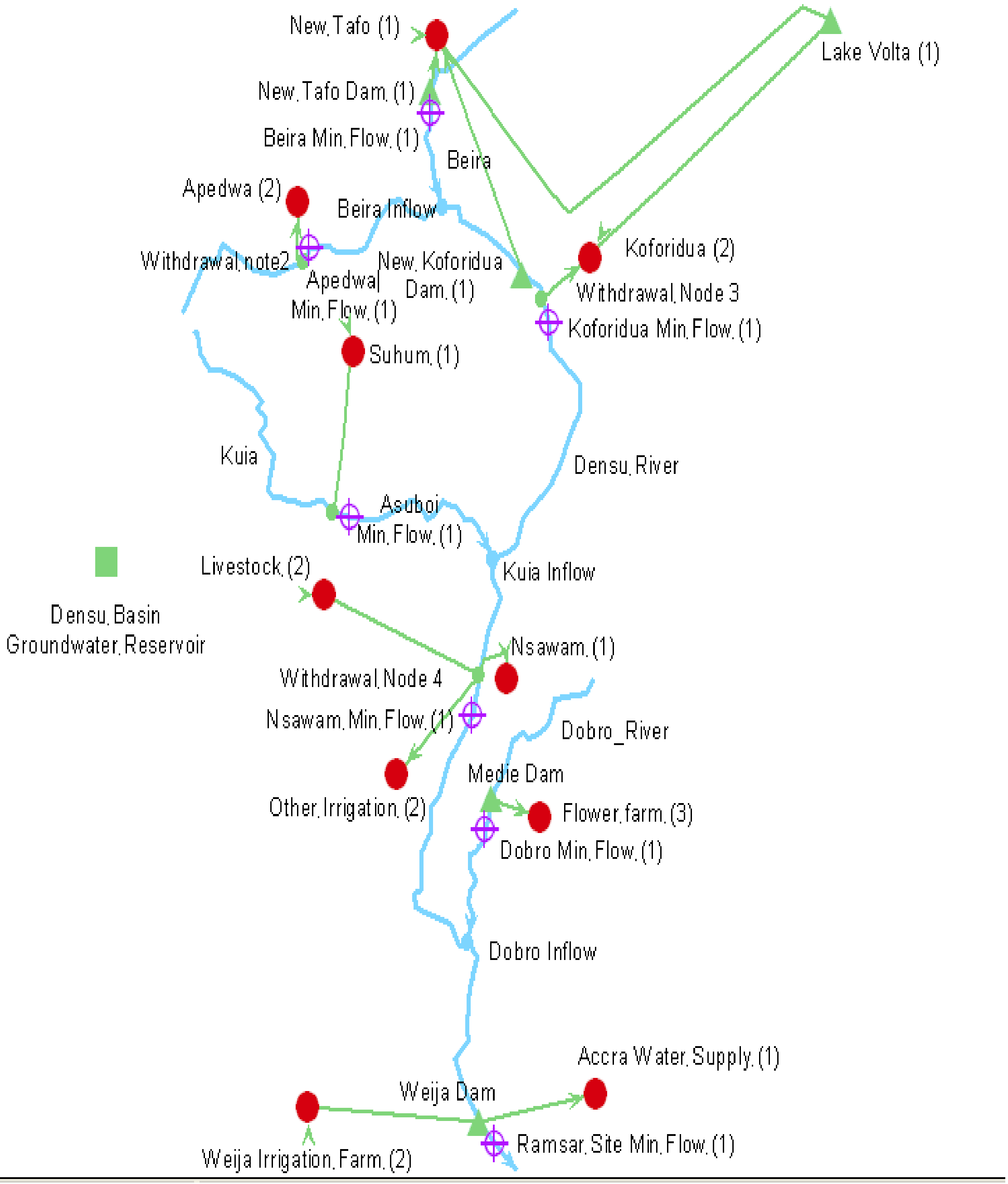
- The Apedwa demand site and adjacent future urban communities in parts of East Akim district will have to rely on piped groundwater/spring supply, which for best yield conditions should tap water from aquifers in the Birimian geological formation located relatively close by in the north-westerly part of the Basin.
- The various demand sites within and adjacent to the New and Old Tafo areas (including future urban communities in the eastern part of East Akim district) and Koforidua town (including future urban communities in the western parts of New Juabeng and Akwapim North districts) are proposed in the future to be supplied by one scheme. The water requirements for such "dual" expanded scheme can be met either (i) by adding an extra water transfer pipeline from Volta Lake to be laid in parallel with the transmission line about to be constructed, or (ii) by construction of a new dam located a few kilometres upstream of Koforidua on the Densu River. The idea is to connect both the Koforidua and Tafo areas with transmission pipes (pumping mains) branching off from the second transmission pipeline from the Volta Lake or directly from the new reservoir site, depending on which alternative scheme configuration will be decided on.
- As far as the Nsawam demand site (including future urban communities in the western part of the Akwapim South district) is concerned the water availability situation needs to be looked at cautiously when approaching the latter part of the plan period. Firstly, it is recommended to change the stated operational policy in which the Densu river will have precedence over the Volta Lake water (when the 13,600 m^3/day capacity pumping scheme is operational) to a strategy whereby the Densu river rather will be used to supplement the water pumped across from Volta Lake. This will "save" water in the Densu river for the benefit of the Nsawam water supply scheme too. Secondly, it is also recommended to introduce piped groundwater-based supply schemes to supplement and, hence, alleviate the stress on the river source in this part of the basin.

- The favourable prospects for groundwater exploitation in the district of Suhum/Kraboa/Coaltar points to a scenario in which half of the district population can be assumed to be served appropriately by piped groundwater supply schemes and the other half from surface water with a proposed intake site on the Kuia tributary to be located in the vicinity of Asuboi.
- Concerning the southern heavily populated part of the Basin it is assumed that the Weija dam/treatment facilities – after the ongoing expansion works and gradual extension of the distribution network are being realised – to a large extent will serve the sprawling urban population south of the Akwapim South and Suhum/Kraboa/Coaltar districts (within the basin boundaries). The Ga West district alone is projected by 2020 to host about 75% of the total urban population residing in the Densu basin. Also in this part of the basin it is recommended to introduce piped groundwater-based supply schemes to supplement and thus alleviate the stress on the Weija reservoir as the sole source.
- Finally, is should be mentioned that in the utilisation of the Basin's water resources, it is assumed that the rural population also in the future to a large extent will continue to be supplied from groundwater through non-piped handpump equipped boreholes or through piped (mechanised) borehole supply schemes.

In parallel to these developments, it is paramount that efforts are being introduced more vigorously to bring down the unacceptable high rate of un-accounted for water (water supply system losses). A number of measures exist to assist towards the reduction of physical losses, some of which can be implemented by the service provider (GWCL), e.g. leakage detection/repair and renovation of old distribution network, and other measures which direct themselves more to the consumers, that be industrial, institutional and individual users. In this context, the number of illegal connections needs also to be addressed.

The introduction of water demand management measures is also an important aspect in curtailing the otherwise ever increasing demand. In the water demand projections presented above, the departure point in the calculations is a list of pre-set unit consumption figures (ref. Table 3.1). The aim must be to halt the continuously increasing trend as reflected in the table values through measures, including public awareness raising, which should address e.g. behavioural changes towards being "waterwise" individually and collectively, and being conscious about water (ab)uses.

Other measures which should be considered include changes to building codes to make it mandatory to install water-saving devices (self-closing taps, low-flush toilets etc) particularly in public buildings, boarding schools, military barracks and other large building complexes. Additionally, the introduction of roof catchment systems for rainwater harvesting meant for washing, garden watering and other "grey water" purposes should be promoted.



Map 3.1: Schematic overview of main elements in Densu WEAP model

4. CONSULTATIVE PROCESS

4.1 SEA applied in the IWRM planning process

This IWRM plan is based on hydrological and other technical data, socio-economic trend analysis, and population census information that only partly has been presented earlier and not as an integrated assessment with the purpose of describing the present and future situation within the Densu Basin concerning the availibility and quality of the water resources.

In parallel with the technical assessments and description of the water resource-related challenges as presented in Chapters 2 and 3, a consultative process has been carried out with the involvement of basin-based stakeholders aimed at capturing the local perception and actions required in addressing the identified water management issues and problems areas.

In the Ghanaian context well anchored procedures exist whereby 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 named Strategic Environmental Assessment (SEA). SEA procedures and tools[23] have been adapted and applied as part of the Densu Basin IWRM planning process.

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 on 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 institu-

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

tional 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 be taken into account to achieve a future sustainable management of the basin's water resources, and as such provide a framework for local water management planning at 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 planning on other existing plans and programmes. The IWRM plan may entail legal and institutional consequences that might cause conflicting management structures, which then need to be coordinated and adjusted to ensure an efficient implementation of the plan.

4.2 IWRM issues and problems as identified by stakeholders

In adherence with the SEA principles and embracing a participatory approach, a number of stakeholder meetings with planners from District Assemblies, governmental departments, Densu Basin Board and water user organisations were convened by WRC during elaboration of the IWRM Plan.

Table 4.1 presents the identified issues and problems within the Densu Basin as perceived and ranked at a stakeholder workshop at the onset of the IWRM planning process. The information in the table reflects the answers as provided by four working groups, which the workshop participants were divided into.

Table 4.1: Ranking of IWRM problems as formulated at initial stakeholder workshop

Planners from Akwapim North and Ga West Districts	Planners from Akwapim South, Akim East and Akim West Districts	Planners from Suhum-Kraboa-Coaltar, Atewa and Awutu-Effutu-Senya Districts	Members of Densu Basin Board
Ranked list of problems (11)	**Ranked list of problems (10)**	**Ranked list of problems (10)**	**Ranked list of problems (15)**
1. Clearing of vegetation along river banks, which affects the run-off pattern. 2. Dumping of solid and liquid waste 3. Use of chemicals and other undesirable methods of fishing. 4. Building beyond the buffer zones. 5. Water vegetation, which disrupts smooth flow etc. 6. Lack of alternative livelihoods for communities. 7. Conflicting activities in various districts, which may work against integrated development of the basin. 8. Sand winning close to the riverbed, which affects river flow. 9. Water borne diseases, e.g. buruli ulcer, bilharzias etc. 10. Lack of access between communities on both sides of the river, e.g. risk of children crossing to school. 11. Low level of women's involvement in water management activities.	1. Lumbering and indiscriminate farming activities in the watershed. 2. Dumping of liquid and solid waste into the river. 3. Water pollution due to activities of small and medium scale miners. 4. Lack of community support to watershed management. 5. Pollution from stray animals. 6. Proliferation of aquatic weeds in the watercourse. 7. Expansion of residential housing developments close to river banks. 8. Use of unauthorized fishing methods, e.g. use of chemicals and explosives. 9. Health hazards from onchocerchiasis and bilharzias. 10. Periodic flooding caused by siltation.	1. Bush clearance and burning which expose the land to soil erosion and silting of water channels. 2. Dumping of solid and liquid waste into streams and rivers. 3. Farming along riverbanks. 4. Felling of trees for charcoal production. 5. Pollution from domestic animals especially cattle drinking from rivers. 6. Non-implementation of physical plans by District Assemblies leaving most towns and villages with poor drainage systems. 7. Surface mining and washing of minerals with poisonous chemicals in streams polluting the water. 8. Land tenure problems especially in connection with acquisition of suitable sites for water facilities. 9. Weed growth in the river that causes pollution and reduce volume of water in basins. 10. Use of poisonous chemicals for fishing.	1. Improper solid and liquid waste management. 2. Farming close to the river banks. 3. Use of unapproved agro-chemicals. 4. Use of harmful chemicals for fishing. 5. Indiscriminate felling of trees. 6. Encroachment of reserve areas. 7. Lack of harmonized buffer zone policy. 8. Lack of institutional capacity by DA's. 9. Lack of awareness among residents about water management. 10. Lack of political will to enforce development control. 11. Deforestation in the upper reaches of the basin. 12. Building/construction activities near the river banks. 13. Mining sites, e.g. bauxite mining. 14. Discharge of industrial waste in water course. 15. Inadequate water resources (water availability) in the basin.

It can be concluded from the table that:

- a diversity in opinion exists among stakeholders as to the main problems to be addressed and how they should be prioritised; and
- main issues to be addressed are based on individual perceptions of problems in everyday life without a view to implications for the Basin as a whole and future development trends.

For compilation of the findings from the SEA meetings, the following categories were applied in accordance with commonly used criteria for description of the sustainable development in Ghana with reference to issues on:

- natural resources,
- social and cultural conditions,
- economy, and
- regulatory, administrative and institutional conditions.

In summary, the problems to be addressed can be grouped as shown in Table 4.2. The numbers indicate how often a specific category of problem was counted among individual members of the working groups (ref. Table 4.1).

Table 4.2: Main categories of identified problems

Category of problem	No.
Natural Resources	**46**
Protection of river banks	8
Forests and protected areas	7
Farming and farming methods	6
Inappropriate fishing and fishing methods	6
Waste disposal	6
Effects of mining	3
Water pollution and quality	3
Water weed	3
Domestic animals	2
Flooding	1
Availability of water resources	1
Social cultural conditions	**5**
Water-borne diseases	2
Alternative livelihood, land tenure and land use	1
Women’s participation	1
Crossing of streams/rivers	1
Economy	**0**
-	0
Regulatory, administrative and institutional	**5**
Lack of resources and capacity	2
Enforcement	2
Prevention and resolution of water related conflicts	1

Based on the summarised presentation of the identified problems in Table 4.2, it can be concluded that:

- most attention is paid to problems related to management of natural resources, but the availability of water within the basin, which is one of the main focus areas of the IWRM planning, is not perceived as a major concern;
- the awareness of existing regulating instruments and delegated responsibilities are not obvious, as a number of problems proposed to be addressed falls within already existing management structures;
- economy as the main tool for initiating any new or additional management activities is not addressed as a problem at all; and
- lack of resources and capacity, lack of enforcement and lack of coordination among institutions are to some extent seen as the reason for management problems within the basin, but not as described above, as a consequence of insufficient economic resources.

4.3 Existing legal and institutional framework

Implementation of the IWRM plan should address the findings from consultations, but additionally, will need further assessments beyond the articulated (local) perception of the IWRM issues.

For this purpose, the existing legal framework as well as already established institutional responsibilities and enforcement practices are outlined in Table 4.3[24] (6 pages) below to help in identification of procedures and actions needed for an efficient implementation of the IWRM plan, particularly as it relates to role of various involved partners (institutions, agencies, departments etc.). The description in the table below is listed in accordance with the identified water management problems as given in Table 4.2 above.

[24] *Based partly on: Assessment of Water Governance in Ghana. Meta-Meta Research and Nii Consult (draft report, January 2006).*

Table 4.3: Existing regulatory framework and institutional responsibilities in IWRM

Category of problem	No.	Existing regulatory mechanisms	Planning authorities and coordination with other plans and programmes	Controlling activities and responsible institutions/agencies
Natural Resources	46			
Protection of river banks	8	There is no official policy on river banks protection, even if the problem is a matter of much concern and discussion. Land Planning and Soil Conservation Ordinance 1953 (Cap 32) mandates a Minister to designate areas for protection of the environment including river banks, rivers and dams. Regulations for river banks protection will need the involvement of the Lands Commission. The Lands Commission Act 483 1994 mandates the Land Commission to manage public land vested with the president and to advise authorities at all levels of public administration, traditional authorities and private land owner organisations on land use planning.	Protection of river banks does not necessarily require planning when legal requirements and guidelines for protection of river banks have been established. Control and enforcement of regulations will be the main issue	In WRC an Inspectorate division exists (as per Water Use Regulations 2001, LI 1692) but it is not operational. When the Inspectorate Division is made operational and guidelines or more legally binding regulations for protection of river banks are introduced agreements must be made on how to segregate the controlling activities between WRC and controlling activities in district administrations
Forests and protected areas	7	Land Planning and Soil Conservation Ordinance 1953 (Cap 32) mandates a Minister to designate areas for protection of the environment including river banks, rivers and dams generally and also to designate areas for reforestation. Forests Ordinance 1927 (Cap 157) delegates the right to establish forest reserves to safeguard water supply within Districts. Lands Commission Act 483 of 1994 mandates the Land Commission to manage public land vested with the president and to advise authorities at all levels of public administration and traditional authorities on land use planning. WRC Act 522 of 1996 (Section 31) provides for special measures to be introduced by the Minister for protection of water resources by declaring an area to be a protected catchment area.	Protection and establishment of forests and protected areas may in the future be a planning tool for protection of ground and surface water resources as well as water quality. In that case protection of forests and the establishing of forest reserves may be considered as a special case of land use planning within IWRM planning to be coordinated with the Lands Commission	When land use planning will be introduced as part of IWRM planning it must be coordinated with the activities of the Lands Commission and the Forestry Commission
Farming and farming methods	6	Ministry of Agriculture teaches farmers farming methods that reduce land degradation	With Lands, Forestry and Minerals Commissions and District Assemblies	MOFA, Extension Services, EPA, at District level.
Inappropriate	6	The Fisheries Law PNDCL 256 of 1991 and the Fisheries	Irregular fishing does not require planning	WRC has the overall responsibility to advice

Category of problem	No.	Existing regulatory mechanisms	Planning authorities and coordination with other plans and programmes	Controlling activities and responsible institutions/agencies
fishing and fishing methods		Commission Act 457 of 1993 provide for the regulation and management of the utilisation of the fishery resources of Ghana and the coordination of policies in relation to them, and hence, to some extent regulate fishing methods and environmental effects from fishing.	or coordination with other plans and programmes but control for enforcement of regulations.	on regulation of water impacts within the basin. WRC Inspectorate Division in WRC is not yet operational. When resources will be allocated for controlling activities of the Inspectorate it will still be needed to agree with the Districts and Fisheries Commission on how to distribute responsibilities for controlling fishing methods.
Waste disposal	6	The National Development Planning Commission Act 479 of 1994 provides the legal background for NDPC to provide guidelines for district planning including planning of waste disposal. The Local Government Act 462 of 1993 delegates planning responsibilities on waste to District Assemblies The WRC Act 522 of 1996 appoints WRC to advise control agencies to prescribe acceptable levels of pollution also from waste disposal sites.	It is under the mandate of the District Assemblies to provide waste disposal plans and to allocate waste disposal sites.	It is the task of WRC to advice on control of impacts from waste disposal on water bodies. Controlling activities of districts on waste disposal for protection of water bodies needs coordination and clarification, when the Inspectorate Division in WRC is made fully operational.
Effects of mining	3	The Minerals and Mining Law PNDCL 153 of 1986 stipulates some regulation of environmental effects and use of water for mining activities. Water to be used for mining activities requires a license. WRC is expected to issue licenses on water use under Water Use Regulations 2001, LI 1692. The effluent discharges have to be approved by EPA under LI 1652 of 1999.	Irregular use and pollution of water from mining does not require planning or coordination with other plans and programmes, but rather compliance monitoring for enforcement of regulations.	Should be regulated through campaigning and awareness creation mining companies/miners and controlling of licenses. The role of WRC concerning control of impacts from mining activities on water bodies needs clarification.
Water quality and pollution	3	No specific laws regulate water quality and control of pollution. The EPA Act 490 empowers EPA to stipulate standards on water quality issues, and to be in charge of issuance of waste discharge permits. The WRC Act 522 appoints WRC to advise control agencies to prescribe acceptable levels of water pollution. The NDPC Act 479 of 1994 mandates NDPC to provide guidelines for district planning on water and sanitation. Local Government Act 462 of 1993 delegates planning of	WRC is the advising and planning agency on water pollution control and of water quality, and through a Memorandum of Understanding collaborates with EPA on issuance of waste discharge permits. In conjunction with NDPC to provide guidelines for planning of water supply facilities to local communities, there is also a need for coordination of plans and	The WRC and EPA collaborate as stipulated in a Memorandum of Understanding to fulfil the role to monitor compliance with waste discharge permits. When the Inspectorate Division under WRC is fully operational, the distribution of controlling responsibilities must be agreed on and segregated from similar activities in districts.

Category of problem	No.	Existing regulatory mechanisms	Planning authorities and coordination with other plans and programmes	Controlling activities and responsible institutions/agencies
		water and sanitation to District Assemblies and other local authorities.	programmes with activities of WRC and visa versa.	
Water weeds	3	A National Water Weeds Control Committee is hosted by EPA. However, regulation of water weeds is expected to be a special case of regulating water quality and control of pollution, and as such to be regulated through the WRC Act 522 of 1996.	Regulation of water weeds does not require planning, but monitoring and initiation of actions and measures to curb the infestation.	The role of WRC on regulation of water weeds in relation to local executing authorities needs clarification
Domestic animals	2	Water pollution effects from domestic animals searching for drinking water is a special case of water pollution that in principle should be handled under WRC Act 522 and Local Government Act 462 as described above.	Regulation of the behavioural effects from stray animals needs no planning	Water effects from stray animals should be regulated through campaigning and awareness creation of owners of animals by district authorities, MOFA extension officers etc.
Flooding	1	WRC Act 522 assigns WRC to regulate and manage water resources within river basins. Standard Engineering code of practice requires that provision be made that part of a dam's storage capacity is set aside for flood control. Hence, IDA, GWCL and others are mandated to make such provision. HSD by administrative arrangements is responsible for flood control in primary drains in urban areas.	Planning of flood control should be an integral part an IWRM plan to be provided by WRC and coordinated with GWCL, CWSA, IDA in rural settings and HSD on primary drains in urban areas. Also coordination with metro-, municipal and district assemblies over secondary and tertiary drains in urban areas is needed.	Control of flood and implementation of flood control measures need clarification among WRC, CWSA, GWCL, IDA, HSD and MDAs.
Availability of water resources	1	WRC Act 522 of 1996 assigns WRC to regulate and manage water resources within river basins. Local Government Act 462 of 1993 delegates planning of water and sanitation and implementation of plans and programmes to District Assemblies and other local authorities. The Public Utilities Regulatory Commission (PURC) Regulations (LI 1651 of 1999) mandates PURC to regulate the activities of public water utilities providing water to consumers. GWCL is working under the jurisdiction of PURC, but plans the availability of water for all major piped water supply schemes, including the use of water from the Weija Dam for the Metro Accra area. Under the Water Use Regulations (LI 1692 of 2001) of the WRC all agencies or water abstractors must be registered and their abstractions granted by licence.	WRC is responsible for IWRM planning within the basin to ensure the availability of water in cooperation with districts and water service providers. NDPC provides the guidelines for planning and use of water resources in the districts There is a need for coordination of guidelines, plans and programmes on water use between organisations concerning water availability.	District Assembly plans address water use, but these plans are not yet linked to the basin-based IWRM planning. Licensing of water permits is the tool for regulating water use and, hence, for water resource management. Densu Basin Board under WRC constitutes a broad spectrum of representatives of stakeholder organisations within the basin, including district and regional authorities, water service providers (GWCL and CWSA), NGOs and ministerial departments. However, as a new planning approach, there is a need to clarify how IWRM planning as a basin-wide activity shall be addressed in

Category of problem	No.	Existing regulatory mechanisms	Planning authorities and coordination with other plans and programmes	Controlling activities and responsible institutions/agencies
				district planning, and for that matter in connection with planning by other organisations. The planning in districts is based on coordination and guidelines of NDPC, which also has a unit to monitor implementation of district plans. As it is now, IWRM planning by WRC is not coordinated and monitored by NDPC, and the same goes for GWCL planning activities.
Social cultural conditions	5			
Water-borne diseases	2	Local Government Act 462 of 1993 delegates regulation of water hygiene and sanitation aspects to District Assemblies and other local authorities.	Planning of measures to prevent water-borne diseases is addressed in local hygiene and sanitation planning.	Campaigning on behavioural change is the controlling tool and compliance monitoring of regulations is the task of local authorities.
Alternative livelihood, land tenure and land use	1	Lands Commission Act 483 of 1994 mandates the Land Commission to manage public land vested with the president, and to advise authorities at all levels of public administration and traditional authorities on land use planning. Land Planning and Soil Conservation Ordinance 1953 (Cap 32) mandates a Minister to designate areas for protection of the environment, including river banks and surface waters in general, and also to designate public land for reforestation. Presently, the EPA Act regulates general environmental protection, the WRC Act was enacted to manage the use of water resources and river catchments, and the Forestry Commission to manage the activities in relation to forests, their conservation and reforestation.	Land use planning to regulate water use for irrigation and other heavily consuming water activities, protection of the environment and pollution from industries in specific areas may be an instrument to include in future coordinated IWRM planning activities.	The Lands Commission has only an advisory role on private owned land. At present the existing traditional administration of land as well as land use practices may conflict with public land use planning and traditional private property rights. A control system on land use and land use planning does not exist at present.
Women's participation	1	It is part of the National Water Policy to promote the participation of women to meet their needs and to use their experience in water supply/management, specifically at local level.	Women's organisations are as stipulated in the Act represented in WRC and in Densu Basin Board.	Campaigning on women's participation in water management at all levels of public administration is the tool used for women's participation in water management practises
Crossing of streams/ rivers	1	Planning and management of minor infrastructure facilities for crossing water courses should be an integral part of	Procedures to ensure proper access to new and planned facilities are included in	Users of new facilities in everyday life are the controlling actors to ensure proper

Category of problem	No.	Existing regulatory mechanisms	Planning authorities and coordination with other plans and programmes	Controlling activities and responsible institutions/agencies
		district planning and is regulated through Local Government Act 462 and NDPC guidelines on planning.	guidelines to local planners to ensure a coherent implementation.	services.
Economy	0			
-	0	The WRC Act 522 of 1996 delegates the right for WRC to generate revenue from issuing of water use permits (Water Resources Management Account). The PURC Act (LI 1651 of 1999) delegates the responsibility to the Public Utilities Regulatory Commission to regulate urban water tariff rates and structures. CWSA Guidelines of 2005 provides for tariff settings for water services in rural areas and communities/small towns. At present, resources for capacity building within the water sector is predominantly made available through donor funding.	For implementation of the IWRM plan there is at the moment no financing capacity except for revenue from issuing of permits in WRC. The IWRM plan addresses problems to be solved within the whole basin. Accordingly, the availability of resources and capacity will require financial resources based on either additional consolidated budget allocations and/or other water user contributions within the basin.	WRC, PURC, GWCL, CWSA and IDA will have to agree on a common system for financing of activities within the basin.
Regulatory, administrative and institutional	5			
Lack of resources and capacity	2	Lack of resources and capacity is considered mostly as a consequence of the economic situation within the water sector - existing regulatory mechanisms are as such described above under economy.	See above under economy	See above under economy
Enforcement	2	Lack of enforcement is partly considered as a consequence of not sufficient resources and capacity, and not clearly demarcated delegation of institutional responsibilities that needs clarification.	IWRM planning is a new activity. It is the scope of the IWRM plan to describe the impact on other plans and programmes, and consequently to plan and coordinate activities to solve possible conflicts within existing legislation, and to clarify delegation of responsibilities.	A scheduled and prioritised set of actions to solve possible conflicts with other planning and programmes is part of the IWRM planning aimed at ensuring a stepwise and long-term implementation of the plan in close collaboration with other stakeholders in the water sector.
Prevention and resolution of water related conflicts	1	All major stakeholder authorities and water user representative organisations are presented on the Densu Basin Board and in the WRC in accordance with requirements in WRC Act 552. WRC can for discharge of its functions establish	The IWRM plan is not only intended for water management, but also for coordination and conflict resolution with other plans and programmes to ensure an efficient	For resolution and clarification of specific problems, WRC can establish sub-committees with specific mandates for discharge of its functions. Such sub-

Category of problem	No.	Existing regulatory mechanisms	Planning authorities and coordination with other plans and programmes	Controlling activities and responsible institutions/agencies
		sub-committees as stipulated in the Act.	implementation of the plan.	committees may be the basis for conflict resolution and clarification in relation to IWRM planning and water resource utilisation.

4.4 Prioritisation of problems and delegation of responsibilities

The actions and mitigating measures required to address the variety of problems identified during the consultative process need to be implemented by different actors ("who does what"). For that reason, a ranking procedure based on scoring tables with the purpose of making a separation and delegation of responsibilities was prepared and subsequently used at a consultative meeting with selected stakeholders including the Densu Basin Board. The procedure used questionnaires applied in working groups to make a distinction[25] between -

- management of basin-wide problems that need to be addressed with a holistic, coordinated and integrated approach, where the introduction of mitigation measures interacts with problems to be solved elsewhere in the basin (addressing measures targeting such problems is part of WRC's responsibility); and
- management of local, but commonly encountered problems within the basin, where the introduction of mitigation measures predominantly has a local effect (measures targeting such problems are part of the District Assemblies' implementation responsibility, but may need coordination through activities supported by WRC and/or Densu Basin Board).

In preparing the questionnaire and scoring table the categories of problems identified at the initial stakeholder workshop were revisited and in some cases supplemented with additional information, for instance in light of the results generated from the water balance scenario analyses, to clarify and expand the problem formulation for the stakeholders.

In Table 4.4 below the results from this SEA-guided second stakeholder consultations are summarised with the scores obtained for prioritisation of problems to be managed either using a basin-wide or a local district-based approach.

Some general conclusions from this phase of consultations can be listed as follows:

- the distinction between basin-wide and local problems was not immediately understood and needed clarification and discussion;
- the present and future availability of water was considered as a major problem to be addressed on a basin-wide basis (contrary to what was the case at the initial stakeholder meeting); and
- the promotion of good governance, democratic principles and transparency in decision-making in water management was considered a valued supplementary aspect to be included as and when found appropriate in the IWRM planning process.

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[25] *Procedures for making a distinction between cross-cutting basin wide problems and local problems are given in Reference 23 (see Section 4.1 above).*

Table 4.4: Result of tool application to identify delegation of responsibilities

Initial categories of problems	Clarifying formulation of problems	Score
Natural Resources		
The availability of water resources	-The availability of water to Metro Accra area -The availability of surface water -The availability of groundwater	14 12 7
The quality and pollution of water	-Management of waste water discharges -Management of water quality	8 8
Forests and protected areas	-Protection of "red list" species -Reforestation	7 7
Flooding	-Including flood management	7
Protection of river banks	-Including rehabilitation of river banks	7
Farming and farming methods	-Including soil degradation	7
Waste disposal	See under quality and pollution of water	6
Fishing and fishing methods	-Including fishing methods and effects on environmental conditions	5
Water weeds	See under quality and pollution of water	-
Small-scale mining	See under quality and pollution of water	-
Social cultural conditions		
Water borne diseases	-Including need for attitudinal and behav-ioural change	8
Women's participation	-Traditional and benign cultural and gender practises	6
Alternative livelihood, land tenure and land use planning	-Land use and land use planning	6
Economy		
Economy and financing of basin-wide initiatives	-Distribution of costs for initiation and implementation of basin wide planning -Assessment procedures and tools for prioritisation and financing of measures -Procedures for efficient collection of payments for water services	12 12 6
Regulatory, administrative and institutional		
Enforcement and good water governance	-Enforcement of decisions for initiation of basin-wide initiatives - Enforcement of rights and obligations of land owners - promotion of good water governance, transparency in information sharing and decision-making	11 7 14
Prevention and resolution of water related conflicts	-Institutional collaboration and capacity building	11
Lack of resources and capacity	See under economy	-

Based on experience from similar applications of this tool, it can be stated in general terms that scores falling in the range of 7 and above indicate basin-wide problems, whereas problems with scores below 7 can be categorised to be of local nature, although rather commonly encountered in the basin.

Therefore, the scores as presented in Table 4.4 provide a means to distinguish between the two levels of planning, and where responsibilities should be placed and tasks assigned in addressing the identified IWRM problems. Nevertheless, in some instances, it is also evident - regardless of the scores - that both planning levels in one way or another will be involved. The result of this exercise is given in Table 4.5.

Table 4.5: Prioritisation of water management problems

Prioritisation	Problem/issue to be addressed	Magnitude (extent) of problem
1	Water availability	Basin-wide management problem
2	Prevention and resolution of water related conflicts	Basin-wide + local management problem
3	Enforcement and good governance	Basin-wide management problem
4	Economy, financing and lack of resources/capacity	Basin-wide management problem
5	Water quality, pollution of water and waste disposal	Basin-wide management problem
6	Water-borne diseases and sanitation	Local management problem
7	Forests and protected areas	Basin-wide + local management problem
8	Farming and farming methods	Basin-wide + local management problem
9	Protection of river banks	Basin-wide + local management problem
10	Flooding	Basin-wide management problem
11	Water weeds infestation	Local management problem
12	Small-scale mining	Local management problem
13	Women’s participation in water management	Local management problem
14	Livelihood, land tenure and land use planning	Basin-wide management problem
15	Fishing and fishing methods	Local management problem

The next step in the process is for each of the above listed IWRM problems/issues to define specific actions to address the specific issues. This part of the IWRM plan is elaborated on in the following Chapter 5.

5. ACTION PROGRAMME

5.1 Introduction

The Densu River is arguably a highly stressed water source and one of the most exploited rivers in Ghana. As highlighted in the previous chapters, the environmental health of the basin and the river's role as an indispensable source for supply of water are threatened in various ways such as:

- indicriminate harvesting of wood from its source to below midstream of the system,
- farming along the banks of the river and at its headwaters,
- use of agrochemicals in mechanised farming and harmful chemicals in fishing,
- infrastructural development and urbanisation which unabated evade large portions of the basin without physical/land use plans or zoning principles being followed,
- inappropriate disposal of solid and liquid waste from domestic and industrial sources into the river course,
- sand winning, quarying and other smale-scale mining in the basin, and
- ever increasing water abstractions for domestic water supply, industrial purposes and irrigation to the extent that dry season flows cease in certain portions of the Basin.

It is against this background that the Densu River Basin IWRM Plan has been prepared and in line with stipulations in the WRC Act 522 (1996) to "propose comprehensive plans for utilisation, conservation, development and improvement of water resources."

During preparation of the IWRM plan, two concurrently running – and equally important – paths have been followed, i.e. (i) an assessment with scenario analyses incorporating technical water resource (hydrologic) characteristics to highlight water availability versus future requirements, and (ii) a SEA-driven approach aimed at identifying the water management problems from a basin-based stakeholder perception. In the present chapter both information sources have been used in bringing together an action programme comprising of a number of prioritised activities and measures for implementation to meet various of the IWRM challenges.

At this stage, the required resources (concerning financing and institutional capacity) to implement the IWRM plan and its associated activities have not been addressed.

5.2 Actions identified to address the IWRM problems

For each of the fifteen IWRM problems/issues listed in Table 4.5, a number of specific actions (measures) have been defined to constitute the core of the IWRM plan implementation (the action programme). These actions are presented in Table 5.1 below (5 pages).

The table also provides information related to which institution, agency and/or authority should be involved, and which one should be responsible partner in initiating and overseeing imlementation of the actions. This latter information is derived from the consultative process as explained in the previous chapter.

In addtion to the action programme outlined in Table 5.1, other more localised IWRM activities need to be carried forward supported at DA level, but initiated and implemented at lower levels, e.g. by institutions and/or communities. Specifically the following three activities can be grouped in this category:

- More systematic introduction of rainwater harvesting, that be from naturally occuring improved mini-catchment and construction of roof harvesting systems at schools, barracks or other larger buildings (industries).
- Construction of dug-outs and/or small earth embankments to store water primarily for farming purpose, that be for small-scale irrigation or cattle watering.
- More vigorous promotion of sound environmental sanitation practices at household level, e.g. by encouraging building of VIP latrines, and promoting modern technology to dispose of liquid waste and use of biogas toilet systems.

It can be seen that the action programme includes a broad range of activities, which all – in one way or another – facilitate and assist towards achieving the main aim of bringing the Densu River Basin and its water resources back to an acceptable quality level, and to a state in which an ecological and water resource utilisation balance exists for future sustainable socio-economic development within the Basin.

Table 5.1: Proposed actions for addressing identified IWRM issues/problems

Actions/measures	Purpose	Involved parties	Responsible partner(s)
Issue/problem: *Water availability*			
Use results from the water demand/ water availability scenario analyses to prepare strategy on how to meet the future water requirements of the Densu basin. The scenarios take into account stronger emphasis on groundwater utilisation, environmental flow require-ments, possible impact of climate change, inter-basin water transfer, new storage (reservoir) facility upstream in the Densu basin and additional abstractions from the Weija reservoir.	-to be taken into account in future district planning; - to be applied as a framework for WRC licensing of water permits; - to engage in a dialogue with particularly GWCL, and larger irrigation and industrial enterprises.	WRC, GWCL, IDA and others	General, basin-wide issue, i.e. responsibility of WRC to address and initiate action on.
Through further studies provide evidence for increased reliance on groundwater (geographical location of high yielding formations, aquifer vulnerability, etc).	- to argue for and justify the strategy that groundwater should be used increasingly in water supply schemes for urban communities.	WRC, WRI, GWCL, CWSA	General, basin-wide issue, i.e. responsibility of WRC to address and initiate action on.
Prepare guidelines on institutionalising water demand management measures (to reduce un-accounted for water) and promotion of rainwater harvesting systems.	- to find alternative means and ways of reducing the reliance on the Densu river.	WRC, GWCL, CWSA, DAs	General, basin-wide issue, i.e. responsibility of WRC to address and initiate action on.
Review and amend as required NDPC guidelines to reflect IWRM requirements in district planning.	- to ensure that IWRM principles are taken well anchored in the district planning process.	WRC, NDPC, DAs	General, basin-wide issue, i.e. responsibility of WRC to address and initiate action on.
Intensify public awareness raising activities on prudent use of water and its conservation, including adoption of traditional knowledge and cultural practices.	- to educate and drive towards "a water-wise" society.	Densu Basin Board, DAs, NGOs and traditional authorities	- General, basin-wide issue, i.e. respon-sibility of WRC to initiate action on. - DAs responsibility with traditional authorities to carry out the activities accordingly in respective districts.
Issue/problem: *Prevention and resolution of water related conflicts*			
Establish a sub-committee under Densu Basin Board to be the focal point for discussions and negotiations between stakeholders in case conflicting interests arise on new water management issues and mechanisms during implementation of the IWRM plan.	- to create an agreed procedure and fixed venue for lodging concerns and holding discussions aimed at preventing disputes and in case solve conflicts through coordination and collaboration.	WRC, Densu Basin Board, DAs and other stakeholders	- General, basin-wide issue, i.e. responsibility of WRC to initiate action on. - Densu Basin Board responsibility to carry out the activities accordingly.

Actions/measures	Purpose	Involved parties	Responsible partner(s)
Issue/problem: ***Enforcement and good water governance***			
Work towards ensuring that the WRC Inspectorate is properly staffed and well functioning to carry out the tasks and services as required in WRC Act 522.	- to have a well functioning unit to oversee compliance by water abstractors of their granted licences, and to ensure that transparent decision-making and democratic principles are adhered to in decisions related to water allocation etc.	WRC, Densu Basin Board, DAs	General issue, WRC to initiate action.
Review NDPC Act 479 (1994), Local Government Act 462 (1993), PURC Regulation LI 1659 (1999) and other pertinent legislation to identify gaps, overlaps or discrepancies related to the practicing of IWRM.	- to facilitate policy making on harmonised district and IWRM planning; - to identify legislative amendments in form of district bye-laws to regulate water use and introduce effective enforcement procedures.	WRC	General, basin-wide issue, i.e. responsibility of WRC to address and initiate action on.
Issue/problem: ***Economy, financing and lack of resources/capacity***			
For the highest prioritised IWRM actions prepare cost estimates for their implementation and identify funding (consolidated funds, internally generated funds, district-based common funds, IWRA, donor funding or specific local levies).	- to generate revenue for financing of proposed IWRM activities.	WRC, PURC, GWCL, CWSA, IDA, WUAs, MFEP	General issue, WRC to initiate action. Basis for negotiations is the PURC Act LI 1651, the Water Use Regulations LI 1692 and CWSA tariff regulations.
Issue/problem: ***Water quality, pollution of water and waste disposal***			
Prepare basin map which depicts the "hot spots" along the river system and outline activities on how the pollution hazards can be abated.	- to provide input to the individual district planning exercises.	WRC, EPA, DAs	General, basin-wide issue, i.e. responsibility of WRC to address and initiate action on.
Operationalise and bring into practice the Memorandum of Understanding (between WRC and EPA) on the issuance of waste discharge permits.	- to use the permitting system as intended as a mechanism to reduce pollution of the Densu river.	WRC, EPA, DAs	General, basin-wide issue, i.e. responsibility of WRC to address and initiate action on.
Prepare guidelines for location of waste dump sites and prescribe remedial activities on how to minimise the risk of groundwater and surface water pollution from waste disposal sites (waste management strategy).	- to provide input to the individual district planning exercises.	WRC, EPA, DAs	- General, basin-wide issue, i.e. responsibility of WRC to initiate action on. - DAs responsibility to carry out the activities accordingly at district level.
Intensify public awareness raising activities on best waste disposal practices in local communities.	- to raise awareness on why and how to avoid pollution from waste disposal locally	Densu Basin Board, DAs	DAs responsibility to carry out the activities in respective districts.

Actions/measures	Purpose	Involved parties	Responsible partner(s)
Prepare technical discussion paper on the economics and technical viability of introducing water-borne sewerage and treatment facilities in urban settings of the basin.	- eventually, the future piped water supply areas will also to a large extent have to be serviced by piped sewer/treatment systems.	WRC, EPA, GWCL, DAs	General, basin-wide issue, i.e. responsibility of WRC to address and initiate action on.
Institute mechanisms to control in-stream activities such as washing of vehicles, bathing/washing with soap, etc.	- to prevent water pollution from activities directly in the open water bodies.	Densu Basin Board, DAs, NGOs.	DAs responsibility to oversee that control mechanisms are introduced.
Issue/problem: ***Water-borne diseases and sanitation***			
Intensify public awareness raising activities concerning water-related contracted diseases and good hygienic practices in local communities.	- to raise awareness and hence reduce incidences of diseases among the population fetching water directly from the river.	Densu Basin Board, DAs, MDAs and NGOs.	DAs responsibility to carry out the activities in respective districts.
Introduce local monitoring of hygienic parameters, e.g. through schools.	- to raise awareness and introduce local control of water quality standards.	Densu Basin Board, DAs, GES, NGOs.	DAs responsibility to carry out the activities in respective districts.
Issue/problem: ***Forests and protected areas***			
Review previous tree planting programs, and plan for and initiate tree planting programs and forest protection activities.	- to learn lessons from successes and failures, and factors contributing to them. - to arrest deforestation trend and increase the areas with protective land cover.	Densu Basin Board, Forestry Commission, DAs, NGOs	DAs responsibility to carry out the activities in respective districts.
Identify areas in the basin vulnerable to bush fires and prepare guidelines for protection.	- to protect land area against erosion and thereby reduce siltation of the water course with improved water quality as a result.	Densu Basin board, DAs, NGOs	DAs responsibility to carry out the activities in respective districts.
Issue/problem: ***Farming and farming methods***			
Plan for and initiate a campaign to promote practical guidelines on best available agricultural practices for small-scale farming or introduce modifications to existing methods.	- to raise awareness of the adverse effects from inappropriate farming methods	Densu Basin Board, DAs, MDAs and NGOs	DAs responsibility to carry out the activities in respective districts.
Carry-out a basin-wide survey concerning use of fertilizers and pesticides in the agriculture sector, and on that basis introduce regulatory activities for control of identified inappropriate farming methods.	- to provide procedures for supervision of and introduction of protection measures to be applied by districts.	WRC, EPA, MOFA, DAs	- General, basin-wide issue, i.e. responsibility of WRC to initiate action on. - Densu Basin Board and DAs responsibility to carry out activities.

Actions/measures	Purpose	Involved parties	Responsible partner(s)
Issue/problem: *Protection of river banks*			
Based on the buffer zone policy under preparation, prepare LI on establishment and maintenance of buffer zones, and prescribe control activities for protection of river banks.	- to protect the river system against effects of soil erosion (siltation) and uncontrolled pollution, and to increase the retention of water in the river system.	Densu Basin Board, DAs and NGOs	- General, basin-wide issue, i.e. responsibility of WRC to initiate action on. - Densu Basin Board and DAs responsibility to carry out the activities accordingly.
Intensify public awareness raising activities concerning protection of river banks in local communities.	- to raise awareness of the need of river banks protection.	Densu Basin Board, DAs and MDAs	DAs responsibility to carry out the activities in respective districts.
Issue/problem: *Flooding*			
Prepare monograph for Densu Basin, including mapping of the actual flooding situation with demarcation of flood prone areas, potential for dredging, etc.	- to make available an up-to-date background document on which to make further decisions among key players about "who does what - and when".	WRC, HSD, IDA, GWCL	General, basin-wide issue, i.e. responsibility of WRC to address and initiate action on.
Formalise procedures with HSD, IDA and GWCL on how to incorporate flood control warnings/measures as part of the water management initiatives in the basin.	-to establish a system to facilitate implementation of measures.	WRC, HSD, IDA, GWCL	General, basin-wide issue, i.e. responsibility of WRC to address and initiate action on.
Issue/problem: *Water weeds infestation*			
Carry-out a survey along the entire Densu river course to delineate the scope of the water weeds problem and prepare guidelines for remedial activities.	- to provide up-to-date facts about the extent and nature of the water weeds problem and how to move forward with curative measures.	WRC, Densu Basin Board, Das and MDAs	- General, basin-wide issue, i.e. responsibility of WRC/Densu Basin Board to initiate action on. - DAs responsibility to carry out activities in respective districts.
Issue/problem: *Small-scale mining*			
Enter into a campaign/dialogue for prevention of illegal or inappropriate water use and pollution arising from small-scale mining activities.	- to raise awareness and to reduce effects from small scale mining activities in affected areas.	Densu Basin Board, DAs, Minerals Commission.	DAs responsibility to carry out the activities in respective districts.
Prescribe guidelines and control activities for small-scale mining	To provide procedures for monitoring small-scale mining activities to be applied by districts.	Densu Basin Board, DAs, Minerals Commission.	DAs responsibility to carry out the activities in respective districts.

Actions/measures	Purpose	Involved parties	Responsible partner(s)
Issue/problem: ***Women's participation in water management***			
Ensure women's participation at the various levels of water management.	- to enforce a policy of women's involvement in all aspects of water management. This issue is cross-cutting and must be incorporated in most of the various problem areas and the associated actions.	Densu Basin Board, DAs and MDAs.	DAs responsibility to carry out the activities in respective districts.
Issue/problem: ***Livelihood, land tenure and land use planning***			
Identify conflict areas concerning traditionally owned land and publicly owned land in relation to Land Planning and Soil Conservation Ordinance 1953 (Cap 32) and the new Lands Commission Bill as it relates to IWRM.	- to facilitate long-term policy making on land use planning as a mechanism for protection and preservation of water resources and ecological fragile areas.	WRC, Lands Commission, Town and Country Planning Department, other MDAs	General, basin-wide issue, i.e. responsibility of WRC to address and initiate action on.
Issue/problem: ***Fishing and fishing methods***			
Prepare guidelines and carry out a campaign for prevention of illegal fishing and inappropriate fishing methods.	- to raise awareness of fishing and fishing methods in local communities.	Densu Basin Board, DAs, MOFA	DAs responsibility to carry out the activities in respective districts.
Prescribe control activities for fishing and fishing methods.	- to provide procedures to monitor fishing methods.	Densu Basin Board, DAs, MOFA	DAs responsibility to carry out the activities in respective districts.

5.3 Prioritisation of actions

5.3.1 Actions included in first phase implementation

At a third broad-based workshop, the SEA procedures, which have been guiding all through the IWRM planning process, also provided a methodology ("tool") for stakeholders to assess the importance and relevance of the various actions in Table 5.1 above. The application of this tool resulted in a ranking of the proposed actions according to their relative performance and effect. This in turn provided the means to prioritise the actions and subsequently be able to identify a sequence for the various activities to be initiated and carried out.

Out of the total 32 actions listed in Table 5.1, a "short-list" was drawn up containing the 10 actions/measures perceived by the workshop participants/stakeholders to be the most relevant and important to embark on initially. These 10 highest ranked actions are listed in Table 5.2 below. The table also provides information and some explanatory remarks to be taken into consideration when the planning is further detailed towards implementation of the actions.

Table 5.2 Prioritised list of proposed actions/measures

Ran-king	Action	Explanatory remarks related to implementation of actions
1	Intensify public awareness raising activities on prudent use of water and its conservation, including adoption of traditional knowledge and cultural practices..	• The goal is to facilitate public educational activities and promote behavioural changes towards creating a "water-wise" society. • Activities will incorporate specially targeted curricula development for schools, use of the public media, NGO spearheaded campaigns, public meetings and facilitation by traditional authorities.
2	Work towards ensuring that the WRC Inspectorate is properly staffed and operationalised to carry out the tasks and services as required in WRC Act 522.	• Although the unit exists, the Inspectorate needs to be properly fitted to oversee compliance by water abstractors of their granted licences. • WRC needs to employ additional staff for this purpose and to introduce guidelines for the work and field monitoring activities by the Inspectorate.
3	Prepare guidelines for location of waste dump sites and prescribe remedial activities on how to minimise the risk of ground-water and surface water pollution from waste disposal sites.	• Waste management plans (strategy) should be developed and implemented specifically covering the densely populated sections of the basin. • DAs to acquire landfill sites for disposal of solid waste in "safe" distance from river banks, and adopt modern methods to dispose liquid waste, e.g. composting. • Provision should be made to introduce adequate refuse receptacles at vantage points, and regular collection of waste to the final disposal sites should be normalised. • Eventually, waste treatment facilities should be constructed along side the introduction or expansion of piped water supply scheme.

4	Based on the buffer zone policy under preparation, prepare LI on establishment and maintenance of buffer zones, and prescribe control activities for protection of river banks.	• WRC to facilitate that the LI preparation process gains momentum ending with an LI enactment. • Existing buffer zone bye-laws, sector specific policies and guidelines, and other regulations for protection of river banks must be harmonised for effective implementation. • Building laws/regulations need to be enforced, and public education to sensitise people on buffer zones and their demarcation should be intensified. The educational activities must in particular target traditional rulers.
5	Use results from the water demand and water availability scenario analyses to prepare strategy on how to meet the future water requirements of the Densu basin	• The scenario analyses carried out at this stage use a planning period ending year 2020. The calculations provide “water balance” results in which future water requirements are balanced against water availability taking into account impacts of possible climate change, inclusion of environmental flow requirements and stronger emphasis on groundwater utilisation. Water source alterations/augmentations are also analysed by the inclusion of an inter-basin water transfer scheme or alternatively construction of a new dam upstream in the Densu basin. • Based on the scenario analysis, a strategy should be mapped out by WRC aimed at outlining the future path to be taken concerning water source utilisation and development in the basin. The strategy paper should be discussed with and fine-tuned in a dialogue with GWCL, and larger irrigation and industrial enterprises.
6	Operationalise and bring into practice the Memorandum of Understanding (between WRC and EPA) on the issuance of waste discharge permits.	• The purpose is to use the permitting system as intended as a mechanism to reduce pollution of the Densu river caused by uncontrolled dumping of liquid and solid waste into the river system. • A Joint Technical Appraisal Team shall be set up by EPA and WRC, and the modalities, application forms etc shall be made ready for receiving waste discharge applications and subsequent granting of waste discharge permits.
7	Review previous tree planting programmes, and plan for and initiate tree planting programs and forest protection activities.	• Over the years many tree planting activities have been carried out in Ghana, the latest larger scale programme is the “Greening Ghana Initiative”. It is important to learn lessons from successes and failures, and factors contributing to them, and how to uphold forest protection laws/regulations. • A basin-wide plan with demarcation of areas in most need of afforestation programmes should be prepared, and eligible NGOs should be approached to spearhead implementation of such activities. • The plan should also identify areas in the basin vulnerable to bush fires, and guidelines for protection should be prepared.
8	Vet existing legislation in relation to practicing of IWRM, including:	• The purpose is to facilitate long-term policy making and harmonisation of regulations on land use planning as a mechanism for protection and preservation of the

	(i) identification of conflict areas concerning traditionally owned land and publicly owned land in relation to Land Planning and Soil Conservation Ordinance 1953 (Cap 32) and the new Lands Commission Bill; (ii) reviewing NDPC Act 479 (1994), Local Government Act 462 (1993), PURC Regulation LI 1659 (1999) and other LI's to identify gaps or discrepancies.	Densu river system. • Provision should also be thought about creating alternative livelihood support systems for people/communities living close to the river system. • DAs should more vigorously follow-up on implementing physical plans for towns and communities, and enforce bye-laws on granting of building licences etc. • The intention is to facilitate policy making on harmonised district and IWRM planning, and to identify legislative amendments in form of district bye-laws to regulate water use and introduce effective enforcement procedures.
9	Plan for and initiate campaigns to promote practical guidelines on best available agricultural practices for small-scale farming or introduce modifications to existing methods.	• A basin-wide survey should be conducted to provide overview of the use of fertilizers and pesticides in the agriculture sector. • The intention is to raise awareness of the adverse effects from inappropriate farming methods, and to educate/train farmers on the use of environmentally friendly agro-chemicals. • Dugouts or other water retaining structures should be constructed for the exclusive use of domestic animals (cattle) to prevent pollution from stray animals of the open water bodies.
10	Formalise procedures with HSD, IDA and GWCL on how to incorporate flood control warnings/measures in IWRM planning.	• A monograph should be prepared for the Densu basin, including mapping of the actual flooding situation with demarcation of flood prone areas, potential for dredging, etc. • On that basis the involved parties should establish collaborative procedures to facilitate implementation of measures to alleviate the risk and minimize damages due to floods.

The above prioritised list of actions and measures attempts to address a broad spectrum of the water management issues identified for the Densu Basin, such as water availability and water quality/pollution as well as the "enabling" environment in reviewing and improving on the institutional and legislative framework aimed at putting IWRM high on the agenda at the various planning and administrative levels within the basin.

It should be emphasised that the remaining 22 actions outlined in Table 5.1 of Sub-chapter 5.2 above are all an integral part of the IWRM Plan's action programme and as such should be considered for implementation when opportunities concerning additional capacity and availability of resources, i.e. financially and institutionally, are becoming evident. During annual reviews and updates of the IWRM Plan these aspects must be assessed with the aim of “upgrading” the presently non-prioritised actions to be incorporated in subsequent implementation phases.

5.3.2 Sustainability test of IWRM plan

At a last workshop during this planning phase, the action programme was subjected to a test (using a pre-designed SEA tool) aimed at assessing the overall sustainability of the IWRM plan by the concerned decision-makers and other stakeholders. Application of the tool provided a visual and quantitative measure as to which extent the proposed actions are capable of supporting an environmentally sustainable development. For this purpose, a number of pre-defined sustainability criteria (aims) were considered, and the outcome of the test (scores) revealed whether the action programme when implemented “supports the individual criteria (aims)”, “has a neutral effect” or “works against the stated criteria (aims)”.

As previously explained, the term “environmental” in this context includes both (i) natural resources conservation, (ii) social-cultural conditions, (iii) economic aspects, and (iv) the regulatory, administrative and institutional setting in which the IWRM plan is to be implemented.

The outcome of the test showed a uniform and coherent group of answers among the participants with scores indicating that the action programme in general is perceived to support the various sustainability criteria with only a few cases where the scores pointed to the category of “has only neutral effect”. Based on the results of the sustainability test, the relevant actions in Table 5.1 and 5.2 above were revisited and amended to respond to these findings accordingly.

5.4 Towards implementation of the action programme

5.4.1 Way forward

Economic and financial aspects

Implementation of the actions listed above needs funding. Some of the activities can be initiated directly through current (rolling) budget allocations at DA level, through allocation from the WRC grant-based donor support, and through proceeds from the water abstraction licence fees lodged in the Water Resources Management Account. The further detailing of the action programme will have to incorporate ways and modalities of the financing.

Furthermore, where relevant, the actions shall be analysed for their economic implications and/or value. The contribution from an economic analysis can well be incorporation of additional considerations, which were not directly included during preparation of the present plan, and hence, could alter the priority (desirability) of the actions in the action programme.

Implementation of major water infrastructure projects such as a dams, inter-basin water transfer scheme, new or expanded water supply schemes, waste disposal and treatment facilities etc. will be decided on and finances negotiated at other levels based on financial viability analyses, and hence, are beyond the scope of the IWRM plan at this stage. Implementation of such activities are expected to serve the interests of the population of the basin, but the coordination, planning and assignment of tasks, including the involvement of WRC, is expected to take place in accordance with time schedules required for investment in major infrastructure projects and to be coordinated with the financing capabilities of donor agencies, the government and external investors.

However, except for investments in larger infrastructure projects (ref. Action 5) most of the actions are concerned with institutional capacity building, adjustment of legislation, and clarification of institutional and departmental responsibilities, which can be initiated within relatively short time and without major investment requirements.

Role of WRC, Densu Basin Board and other partners

It is important for proper implementation of the IWRM plan that the Densu Basin Board is mobilised with a clear mandate from WRC to address common problems to be solved through interactive collaboration between the Board and the District Assemblies. The mandate of the Board shall in addition to coordination activities include obligations to initiate campaigns and to contribute towards elaboration of best practice papers and guidelines on water demand and environmental management as required during implementation of the action plan

Another precondition for successful implementation and enforcement of the plan is that a platform for inter-institutional governmental cooperation is established to solve a number of specific tasks outlined in the IWRM plan. Such tasks should not only be addressed as part of the agenda for regular meetings of the WRC or the Densu Basin Board, but within the framework of sub-committees. Such sub-committees should have clear mandates, including specification of the professional profile of the members and a time schedule for making recommendations to decision-makers in WRC and the Densu Basin Board.

Preparing "project/action summary sheets"

An immediate first activity required to spearhead the way forward towards initiating some of the actions in the IWRM plan is for WRC in close collaboration with the Densu Basin Board and other involved partners to prepare concise descriptions of the portfolio of the prioritised actions (Table 5.2). This should be done in a structured, easily understandable way using a pre-scribed standard form ("project/action summary sheet") providing information about the action as follows:

– main objective;
– components/main activities;
– expected outputs;
– milestones and benchmarks;
– modalities for implementation and involved/collaborating partners;
– time duration;
– inputs and estimated costs; and
– mode of financing/funding.

5.4.2 Monitoring and regular reviews of the plan

As part of the further detailing and preparation for commencing implementation of the prioritised actions, the milestones and benchmarks mentioned above should be detailed and expanded to provide information about progress indicators and sub-outputs to be achieved. It is against this background that progress towards commencing and carrying out the actions' activities can be monitored.

It is proposed that the Densu Basin Board at its regularly convened quarterly meetings as a fixed agenda item will be given a "progress reporting" and discusses the efforts made in carrying the IWRM plan forward towards action implementation. Additionally, once a year the IWRM plan – or rather its action programme – should be reviewed, and as found necessary be updated. In practical terms it would entail a revision of and/or amendment to the project/action summary sheets.

The present document constitutes the first version of the Densu Basin IWRM Plan. 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.