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Integrated water resources management plan for Densu River Basin, Ghana

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Integrated water resources management is a comprehensive and coordinated approach to the development and management of water, addressing its management as a resource and within the framework of providing water services. Densu River Basin was selected as first priority basin to undergo integrated water resources management activities in Ghana. Using a plan horizon up to year 2020, an assessment of water availability to meet future water demand in the basin was carried out using a computer-based model for scenario analyses of different water resource development choices and to establish their consequences. The scenarios analysed included impact of climate change, improvement in water delivery system losses, inter-basin water transfer and creation of a new storage facility in the upstream section of the river system.

Introduction

Ghana's approach to mainstreaming integrated water resources management (IWRM) includes a planning process in which individual basin IWRM plans are being prepared. This process would eventually lead to the development of a National IWRM strategy/plan. The first priority basin selected for integrated water resources management activities was the Densu River Basin.

The Densu River traverses a densely populated part of Ghana, and is one of the two main sources of water supply to the capital city, Accra, as well as it serves the protected Sakumo lagoon (Ramsar site). It is one of the most exploited rivers in the country considering its size. The basin features accelerating land and water quality degradation. Furthermore, it is marked by occasional water shortages in an otherwise perennial river system caused, among other factors, by the rapid population increase (urbanization) due to its proximity to the Accra metropolitan area.

One of the main activities undertaken was to develop an IWRM plan, which involved participation of basin-based stakeholders such as water users, planners, policy makers, guided by Strategic Environmental Assessment (SEA) principles and tools. This paper highlights some features of the process towards preparation of the Densu River Basin IWRM Plan (ref [1]) and various results derived from it.

Scenario analyses of water availability vs. requirements

It is a well known fact that it is the low-flow regime of a 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 a simulated 30-year runoff series reflecting the hydrologic/statistical features of the runoff – was introduced in the planning process through various regression analyses for the purpose of filling in gaps as well as extending measured discharge records.

To assess the adequacy of the water availability to meet projected water demand, a computer-based Water Evaluation and Planning (WEAP) Model was used to carry out scenario analyses to facilitate the understanding and description of different water resource development choices. It operates on the principles of water balance accounting and examines alternative water development strategies in the form of scenario analyses to provide answers to various "what if" questions.

Main water demand sites

The following demand sites, which at present are supplied through piped systems relying on the Densu river 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 reservoir with abstractions to supply water to the Accra metro area.

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 and financial losses caused by water produced but not paid for. At present, it is estimated that up to 40% of water produced can be categorised as un-accounted for water. As part of the alternative water resource utilisation options presented below, it was assumed that these losses will (and must) gradually be brought down to a 25% level, which also is considered realistic to achieve over the plan period.

Minimum flow requirements

To sustain river flows for environmental 'maintenance', minimum flow requirements were introduced downstream of each water abstraction point and dam site. The assessment of the minimum flow requirements had been based on a low-flow frequency analysis on the monthly flow data and determined as the 95-percentile flow (i.e. the 20-year minimum flow return period) in each calendar month. This criterion was also used in the case of Weija reservoir to ensure an appropriate flow downstream of the dam for the benefit of the aquatic ecosystems in the Densu delta and lagoon.

Scenario analyses

The scenarios analysed included the following:

- Unchanged ("do nothing") water resource capacity situation;
- Impact of climate change;
- Improvement in water delivery system losses (un-accounted for water);
- Inter-basin water transfer of water from Volta River Basin to Densu River Basin; and
- Construction of a new dam on the upstream section of the Densu River.

It should be emphasised, that the results of the scenario analyses only consider water supply coverage rate in terms of water availability as a source for meeting the requirements, and do 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 network, as well as the financial consequences of making the water available.

It should be noted that the indicator used to represent the coverage rate towards the end of the plan period was 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. Table 1 presents summarised results of the various scenario analyses as further described in the following.

Unchanged ("do nothing") water resource capacity situation

This scenario assumed 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.

Not surprisingly, a "do nothing" scenario resulted 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 was sufficient to meet the requirements also during the low-flow periods throughout the plan period.

Impact of climate change

The effects of a likely climate change on water resources can be estimated in terms of an anticipated decrease in surface water runoff. The study (ref [2]) indicates that a climate change scenario considered realistic 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. 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.

It is clear from the figures in Table 1 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 100% to 80%.

Improvements in water delivery system losses (un-accounted for water)

The "do nothing" scenario was also 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 could also be used to make a judgement about the effect of introducing water demand management measures as a means to use water more efficiently.

This scenario clearly provides 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 efficiently, could "save" water to such an extent that it would counteract in a sizeable manner the effects of a likely climate change.

Inter-basin water transfer from Volta River Basin to Densu River Basin

At the end of 2006, Ghana Water Company Ltd. (GWCL) commissioned the engineering works for final design and construction of a pumping scheme, whereby water would be transferred from the Volta Lake to supplement the supply from Densu River to Koforidua water scheme. Therefore, this scenario examined to which extent the introduction of this inter-basin water transfer scheme would improve the Koforidua water supply situation.

The analysis revealed that by year 2015 the Koforidua supply scheme will once again begin to experience water shortages under this scenario. Therefore, as an integral part of this scheme it is proposed to construct an additional transmission line from the Volta Lake to supply water to Koforidua and Old/New Tafo demand sites to curtail the apparent water shortages.

Construction of new dam on the upstream section of Densu River

As an alternative to constructing a second water transfer pipeline from Volta Lake, this scenario proposes - in addition to the first water transfer from Volta Lake - to build a new dam on the Densu River a few kilometres upstream of the present Koforidua water intake site. As in the case of the second transmission pipe, it is envisaged that this dam should be operational from year 2015 and also supply water to Old/New Tafo.

The result of the model run 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. Water abstractions for the water demand centres of Koforidua and Old/New Tafo will both take place from the new reservoir.

Consultative process

In addition to the technical assessments and description of the water resource-related challenges, a consultative process was carried out with the involvement of the key stakeholders in the basin. The process captured the local perception and actions required in addressing the identified water management issues and problems. This process was guided by principles which form part of the concept named Strategic Environmental Assessment (SEA). SEA procedures and tools were adapted and applied as part of the Densu River IWRM planning process (ref [3]).

Based on the IWRM problems/issues identified by the stakeholders, more than 30 actions were defined during the consultative process to constitute the core of the IWRM plan implementation (the action programme). Furthermore, the application of the SEA tools resulted in a ranking of these actions according to

their relative performance and effect. This in turn provided the means to prioritise the actions with the 10 highest ranked actions/measures listed in Table 2.

Concluding remark

The Densu River Basin IWRM Plan should be seen as a process that needs to be subject to periodic review and updates as the needs arise in future. It is expected that this plan will be a useful catalyst towards accelerating concrete IWRM activities in the Densu River 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 the other vulnerable river basins in Ghana.

Table 1: Demand sites and demand coverage (% of water requirement met)

Demand site	Do nothing with 40% system losses	Do nothing with impact of Climate Change	Do nothing with 25% system losses	Transfer of water from Volta Lake	Additional transfer of water from Volta Lake	New dam at Koforidua
Apedwa	44%	40%	55%	44%	43%	43%
Old/New Tafo	38%	34%	48%	38%	94%	98%
Koforidua	59%	44%	74%	67%	97%	99%
Nsawam	100%	80%	100%	100%	100%	98%
Weija Plant	100%	99%	100%	100%	100%	100%

Table 2: Prioritised list of proposed actions/measures

Ranking	Action
1	Intensify public awareness raising activities on prudent use of water and its conservation, including adoption of traditional knowledge and cultural practices.
2	Work towards ensuring that the Water Resources Commission (WRC) Inspectorate is properly staffed and operationalised to carry out the tasks and services as required in WRC Act 522.
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.
4	Based on the buffer zone policy under preparation by WRC, prepare Legislative Instrument (L.I.) on establishment and maintenance of buffer zones, and prescribe control activities for protection of river banks.
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
6	Operationalise and bring into practice the Memorandum of Understanding (between WRC and Environmental Protection Agency) on the issuance of waste discharge permits.
7	Review previous tree planting programmes, and plan for and initiate tree planting programs and forest protection activities.
8	Vet existing legislation in relation to practicing of IWRM to identify gaps or discrepancies in and between the relevant acts and regulations.
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.
10	Formalise procedures with Hydrological Services Department, Ghana Irrigation Development Authority and Ghana Water Company Limited on how to incorporate flood control warnings/measures in IWRM planning.

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Sadly I. Asamoah died in a traffic accident a month before the conference. The paper was presented in his memory by Ronald Abrahams.