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Rapid Impact Assessment Matrix (RIAM) – An Analytical Tool in the Prioritization of Water Resources Management Problems in Ghana

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The rapid impact assessment matrix (RIAM), which was developed in Denmark, is a new tool for the execution of environmental impact assessments. RIAM is quite flexible, transparent and leaves a permanent record, which can be independently checked, validated or updated. RIAM has successfully been used to prioritize water resources management problems in Ghana in the order of which problems call for the most urgent attention. The priority list was easily validated and accepted to be the true reflection of the situation at a national workshop in which experts and representatives from water agencies, donor agencies, university faculties and departments, research institutes, private institutions and organizations including Non Governmental Organizations (NGOs) participated. The study has shown that RIAM, which can also be used in a developing country like Ghana, is a very useful tool in such prioritization process as has been applied in this exercise.

Key words: *Water resources management problems, prioritization, impact indicators, RIAM, river basins, Ghana*

1 INTRODUCTION

1.1 Introduction to the challenge of water resources management in Ghana

Until recent times, there was an incorrect perception in many developing countries, including Ghana that considerable water resources were available. Faced with increasing population, intensification of agricultural, mining, and industrial activities together with natural events, the demand on both the quantity and quality of Ghana's water resources is now becoming a major concern. The population of Ghana increased from 6.7 million in 1960 to 8.6 million in 1970 to 12.3 million in 1984 to 18.9 million in 2000. The increasing population in Ghana contradicts sharply with the observed decline in rainfall in many parts of the country (Opoku-Ankomah and Amisigo, 1998; Gyau-Boakye and Tumbulto, 2000), the rising temperatures nation-wide (Gyau-Boakye and Tumbulto, 2000), and the pollution of water bodies from both natural and human activities. The water resources of Ghana are thus vulnerable and must have to be efficiently managed and utilized to sustain the socio-economic growth of the nation.

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The Water Resources Commission (WRC) of Ghana, which was established through an Act of Parliament in 1996 (Act 522, 1996), is responsible for managing the water resources and also to establish a regulatory framework for water allocation and control, among others. The WRC has recognized that available information generated through a water resources management study (WARM, 1998) and other studies carried out in the past do not identify specific water resources management issues in such details as would be required for making an operational and prioritized plan for interventions. It therefore commissioned the Water Research Institute (WRI) of the Council for Scientific and Industrial Research (CSIR) to undertake water resources management problems identification, analysis and prioritization study (Water Resources Commission, 2000). While the methodology used in the identification of the water resources management problems is beyond the scope of this paper, the nationally identified problems in Ghana are as follows (Water Resources Commission, 2000):

(a) Flooding;
(b) High fluoride concentrations in groundwater;
(c) High iron concentrations in groundwater;
(d) Lack of comprehensive institutional and legal framework/inadequate reliable management information and data on water resources management (institutional problems);

(e) Seawater intrusion and high salinity of groundwater;
(f) Water pollution;
(g) Water shortage; and
(h) Water weeds.

1.2 Scope of work

After the identification of the water resources management problems had been done in a similar study, the Water Resources Commission wanted to take some mitigation and intervention measures to improve the situation and manage the water resources on a sustainable basis. However, due to financial constraints, the Water Resources Commission wanted to know which of the water resources management problems call for the most urgent attention and intervention. The Water Resources Commission, with the support of the Danish Government through the Danish International Development Agency (DANIDA), therefore contracted the Water Research Institute (CSIR) at a cost of about $50,000 to help prioritize the identified water resources management problems. The schedule included a national workshop at the end of the project by all stakeholders in water to help validate the results. The purposes of the study are therefore:

(a) to prioritize the specific water resources management problems which had been identified in the river basins, and thereby; and
(b) to provide information on which of the problems call for the most urgent attention and intervention in each river basin in the country.

The Rapid Impact Assessment Matrix (RIAM), whose attributes are described below was selected to prioritize the water resources management problems.

2 RAPID IMPACT ASSESSMENT MATRIX (RIAM)

The Rapid Impact Assessment Matrix (RIAM), the analytical tool that was used in prioritizing the water resources management problems was originally developed for carrying out Environmental Impact Assessment (EIA) (Pastakia, 1998). RIAM has an advantage over the existing EIA methods. In particular, it minimizes the element of subjectivity and introduces some degree of transparency and objectivity. It also provides a transparent and permanent record of the analysis process while at the same time organizing the EIA procedure, which in turn considerably reduces the time taken in executing EIAs (Pastakia, 1998). The simple, structured form of RIAM allows reanalysis and in-depth analysis of selected components in a rapid and accurate manner. This flexibility makes the method a powerful tool for both executing and evaluating EIAs. The scales in RIAM allow both quantitative and qualitative data to be assessed. RIAM, which is used in several impact studies, was therefore the preferred method and subsequently selected because of its flexibility and the numerous advantages over the known EIA methods as outlined by Pastakia and Jensen (1998).

RIAM was conveniently adapted to the prioritization of water resources management problems based on the following assumptions:

(a) Water resources management problems are considered to impact negatively;
(b) Positive impacts of water resources management issues do not pose any threat and therefore not considered relevant; and
(c) The importance of a problem could be localized or widespread.

In the RIAM process the impacts of project activities are evaluated against the environmental components, and for each component a score (using the defined criteria) is determined, which provides a measure of the impact expected from the component. The important assessment criteria fall into two groups:

A. Criteria that are of importance to the condition, that individually can change the score obtained; and

B. Criteria that are of value to the situation, but should not individually be capable of changing the score obtained.

For group A, the overall quotation system consists in multiplying the marks attributed to each criterion. The principle of multiplication insures that the weight of each criterion intervenes directly.

For group B, the overall quotation system consists in adding the marks attributed to each criterion. This insures that a mark taken in isolation cannot affect much the overall result.

The process is thus expressed by the following set of equations (Jensen, 1998):

$$(a1)\ \mathrm{X}\ (a2) = a\mathrm{T} \qquad (1)$$
$$(b1) + (b2) + (b3) = b\mathrm{T} \qquad (2)$$
$$(a\mathrm{T})\ \mathrm{X}\ (b\mathrm{T}) = \mathrm{ES} \qquad (3)$$

where,

$(a1)$ and $(a2)$ are individual criteria scores that are of importance to the condition (group A), and which can individually change the score obtained;
$(b1)$ to $(b3)$ are the individual criteria scores that are of value to the situation (group B), but individually should not be capable of changing the score obtained;
aT is the result of multiplication of all (A) scores;
bT is the result of summation of all (B) scores; and
ES is the assessment score for the condition.

For more detailed description of the RIAM concept, readers are referred to Pastakia (1998).

3 DEFINITIONS OF THE WATER RESOURCES MANAGEMENT PROBLEMS

The main water resources management problems identified in a previous study and their definitions are described in the following sections.

3.1 Flooding

Flooding occurs whenever a stream/river channel overflows its bank. Flooding thus occurs in almost all river basins, however, the effects of flood damage are more devastating in the basins, where human settlements are close to river courses and flood plains.

3.2 High fluoride concentrations in groundwater

Concentration level of fluoride exceeding the World Health Organization's (WHO) limit of 1.5 mg/l was considered high in the study. It was found to occur in some of the basins.

3.3 High iron concentration in groundwater

Concentration level of iron exceeding the WHO limit of 0.3 mg/l was considered high in the study and this was also found to occur in some of the basins.

3.4 Lack of comprehensive institutional and legal framework/inadequate reliable management information and data on water resources management (institutional problems)

These are institutional problems that have in one way or another contributed greatly to water resources management problems such as inadequate water supply for domestic, commercial, agricultural and industrial uses, flooding, and water pollution. These institutional problems, often times epitomized by lack of appropriate infrastructure, were found to be widespread in all the basins.

3.5 Seawater intrusion and high salinity of groundwater

Seawater intrusion and high salinity have been found to be most prevalent in the coastal areas of the country.

3.6 Water pollution and improper land use

Pollution of the country's water bodies is caused by a number of factors, significant among them are:

(a) disposal of solid and liquid wastes into river channels;
(b) disposal of untreated mining effluents into rivers;
(c) discharge of wastes from small-scale industrial and mining activities;
(d) inadequate sewage treatment and waste disposal facilities;
(e) leaching of agro-chemicals from agricultural farms into rivers; and
(f) extensive deforestation and other land use practices.

3.7 Water shortage

Water shortage results from drying up of water sources be it a river, stream, reservoir, or aquifer at any point in time or from a low level such that it cannot satisfy the demand for domestic, commercial and industrial use, irrigation, and hydropower generation. Alternatively, water shortage is deemed to have occurred whenever the purpose for which a water resource system was developed is not fully achieved for want of the resource.

3.8 Water weeds

Water weeds are water plants that are found in areas where they are not wanted within water bodies, appearing among natural or cultivated plant community and growing profusely to the detriment of other species, often depriving them of space, nutrients, and/or light.

4 IMPACT INDICATORS

Based on these water resources management problems, the study adopted the following, which are among the most relevant and widely used impact indicators for the assessment and analyses of the problems:

(a) Environmental quality;
(b) Safe water supply/consumption;
(c) Incidence of water-borne/water related diseases;
(d) Forced migration of people;
(e) Direct and indirect cost/benefit to the country (e.g. high cost of health delivery);
(f) Income of people/poverty reduction;
(g) Bio-diversity/ecosystem;
(h) Degree of tolerance to the public and politicians;
(i) Health implications;
(j) Equity; and
(k) Relevance/implications to national development priority (e,g. Ghana's Vision 2020 Programme).

Even though some of these impact indicators appear to be correlated (e.g. safe water supply/consumption and, incidence of water-borne/water related diseases and health implications), this paper drew some lines of distinction between them. For example, whereas incidence of water-borne/water related diseases has been limited to the direct human contact with water like guinea worm and bilharzia infestation, the health implications have more to do with the water acting as habitat for disease carrying vectors like mosquitoes and black flies (*Simulium damnosum*).

The above listed impact indicators were subsequently grouped into four components (Jensen, 1998) as follows:

(a) Physical/Chemical components (PC);
(b) Covering the physical and chemical aspects of the water resources management problems;
(c) Biological/Ecological components (BE);
(d) Covering the biological and ecological aspects of the water resources management problems;
(e) Social/Cultural components (SC);
(f) Covering all human and cultural aspects of the water resources management problems;
(g) Economic/Operational components (EO); and
(h) Covering all economic consequences of the water resources management problems, both temporary and permanent.

Since these groups were established on the basis of the manifestation of the impact indicators, some of the impact indicators fell under more than one group.

4.1 Scoring, evaluation and assessment criteria

The impacts of the water resources management problems under the four different components (i.e. PC, BE, SC and EO) were assessed and given scores on the basis of the criteria indicated in **Table 1**. The model then computed the scores to arrive at the final Environmental Scores (ES) from which the range bands indicated in **Table 2** were selected. The scoring was done by a group of experts, e.g. from the following disciplines: hydrologist, hydrogeologist, biologist, environmental health scientist, environmental biologist, fisheries, sociologist. The involvement of these experts minimizes the element of subjectivity in the scoring.

5 RESULTS

The results are as presented in **Fig. 1** in the set of histograms. The histogram labelled PC represents physical/chemical component, BE represents biological/ecological component, SC represents socio-cultural component and EO represents economic/operational component.

The range bands are indicated on the horizontal scale of the histograms. To the left of the neutral point N are the negative impacts of the various components. The farther left one moves away from N the more significant the impact. This is to say that from the analysis the most significant negative impact of all the problems falling under the various components is –D. What this means is that –D, the most significant of all the impacts registered in the programme, calls for the most urgent attention and intervention. A major characteristic of the model is that the most significant impact (in this case –D) is considered as the impact that should receive the most urgent attention in terms of mitigation and intervention measures before the next significant impact (in this case –C). Consequently, a problem registering a single –D takes precedence over a problem which registers say twice or more –C in terms of which of them requires the most urgent attention and intervention.

These negative impacts have been summarized in **Table 3**. *Flooding* registered the highest number (10) of significant negative impacts (-D) followed by *lack of comprehensive institutional framework and lack of management information and data* with 6 and 4 significant negative impacts (–D), respectively. *Water pollution* is the next to follow with 3 significant negative impacts (-D). *Water shortage and Water weeds* tied with 2 significant negative impacts each (-D). However, the former has 5 moderately negative impacts (-C) while the latter registered 4. Again, the former registered 6 more negative impacts (-B) as against 4 registered by the latter. This makes the former a more problem issue than the latter. *Seawater intrusion* was next with 3 moderately negative impacts (-C) and the least problem issue recorded is *high iron and fluoride concentrations in groundwater* with 8 negative impacts (-B).

5.1 Validation of results

A national workshop was organized in Accra, the capital city of Ghana, for stakeholders in the water sector to discuss and build consensus on the findings as depicted in the results. Notable among them were experts and representatives from water agencies, donor agencies, university faculties and departments, research institutes, private institutions and organizations, NGOs and District Assemblies. In all 75 participants attended the workshop the proceedings of which involved plenary paper presentations on the priority list of water resources management problems as indicated in the results (**Table 3**) followed with discussions at working groups and plenary sessions. At the plenary sessions, the participants were given the opportunity to come up with their own scorings. Even though some of the scorings were sometimes different from what was obtained in the study, the general outcome (the priority list), however, was the same as the results presented in this paper. This confirms the RIAM as not only a powerful tool but also a transparent method that leaves behind permanent records that can always be checked and easily validated or updated where necessary, particularly when the situation changes.

6 DISCUSSION AND FOLLOW-UP ACTIONS

Having prioritized water resources management problems on a national scale, the same exercise was extended to the individual river basins in Ghana. The sponsors of the Water Resources Commission (the Danish International Development Agency (DANIDA)) were quite satisfied with the output of this work since the results agreed with what was obtained during the validation at a national workshop by the stakeholders and experts. By this application, RIAM, which was developed in a developed country (Denmark), has proved to be a useful tool, which can equally be used in a developing country like Ghana.

After the successful prioritization of the water resources management problems nationally and on individual river basin scale, the Water Resources Commission has set in motion a mechanism to intervene in the most urgent situations. The Water Resources Commission has set up a pilot study in the Densu river basin, whose top priority is pollution, to introduce the basin to Integrated Water Resources Management (IWRM). Another pilot study is being set up in a sub-basin of the White Volta basin. The two river basins (Densu and White Volta) have been selected as pilots to test capacity building, participation and public awareness strategies, regulations and water resources planning within a decentralized administrative framework with the river basin as the unit for planning.

Financial resources used in the pilot projects were obtained from local and external sources. The Government of Ghana has so far committed 25% of the total budget, which basically covered part of the operating expenditure. The Water Resources Commission's capacity to operate fully and effectively in the pilot basins was stifled as a result of austere government funding, particularly in respect of services and investment. This meant that the Water Resources Commission could not carry out all the intended services and investment activities as envisaged. However, DANIDA, the principal external source, has contributed the remaining 75 % covering the entire investment and part of operating expenditure of the pilot projects.

Table 1 Assessment criteria (Pastakia & Jensen, 1998)

Criteria		Scale	Description
a1:	Importance of condition	4	Important to national/international interest
		3	Important to regional/national interests
		2	Important to areas immediately outside the local condition
		1	Important only to the local condition
		0	No importance
a2:	Magnitude of change/effect	+3	Major positive benefit
		+2	Significant improvement in status quo
		+1	Improvement in status quo
		0	No change/status quo
		-1	Negative change in status quo
		-2	Significant negative disbenefit or change
		-3	Major disbenefit or change
b1:	Permanence	1	No change/not applicable
		2	Temporary
		3	Permanent
b2:	Reversibility	1	No change/not applicable
		2	Reversible
		3	Irreversible
b3:	Cumulative	1	No change/not applicable
		2	Non-cumulative/single
		3	Cumulative/synergistic

Table 2 Conversion of environmental scores to range bands (Pastakia & Jensen, 1998)

Environmental Score	Range Bands	Description of Range Bands
+72 to +108	+E	Major positive change/impacts
+36 to +71	+D	Significant positive change/impacts
+19 to +35	+C	Moderately positive change/impacts
+10 to +18	+B	Positive change/impacts
+1 to +9	+A	Slightly positive change/impacts
0	N	No change/status quo/not applicable
-1 to -9	-A	Slightly negative change/impacts
-10 to -18	-B	Negative change/impacts
-19 to -35	-C	Moderately negative change/impacts
-36 to -71	-D	Significant negative change/impacts
-72 to -108	-E	Major negative change/impacts

Table 3 Impacts of water resources management issues on environmental indicators

No.	Water Resources Management Issue	-D	-C	-B	-A
1.	Flooding	10	7	2	-
2.	Lack of comprehensive Institutional framework	6	-	1	-
3.	Lack of Management Information and Data	4	-	-	-
4.	Water Pollution	3	8	5	-
5.	Water Shortage	2	5	6	5
6.	Water Weeds	2	4	4	10
7.	Sea Water Intrusion	-	3	-	2
8.	High Iron/Fluoride concentrations in groundwater resources	-	-	8	1
	Total	**27**	**27**	**26**	**18**

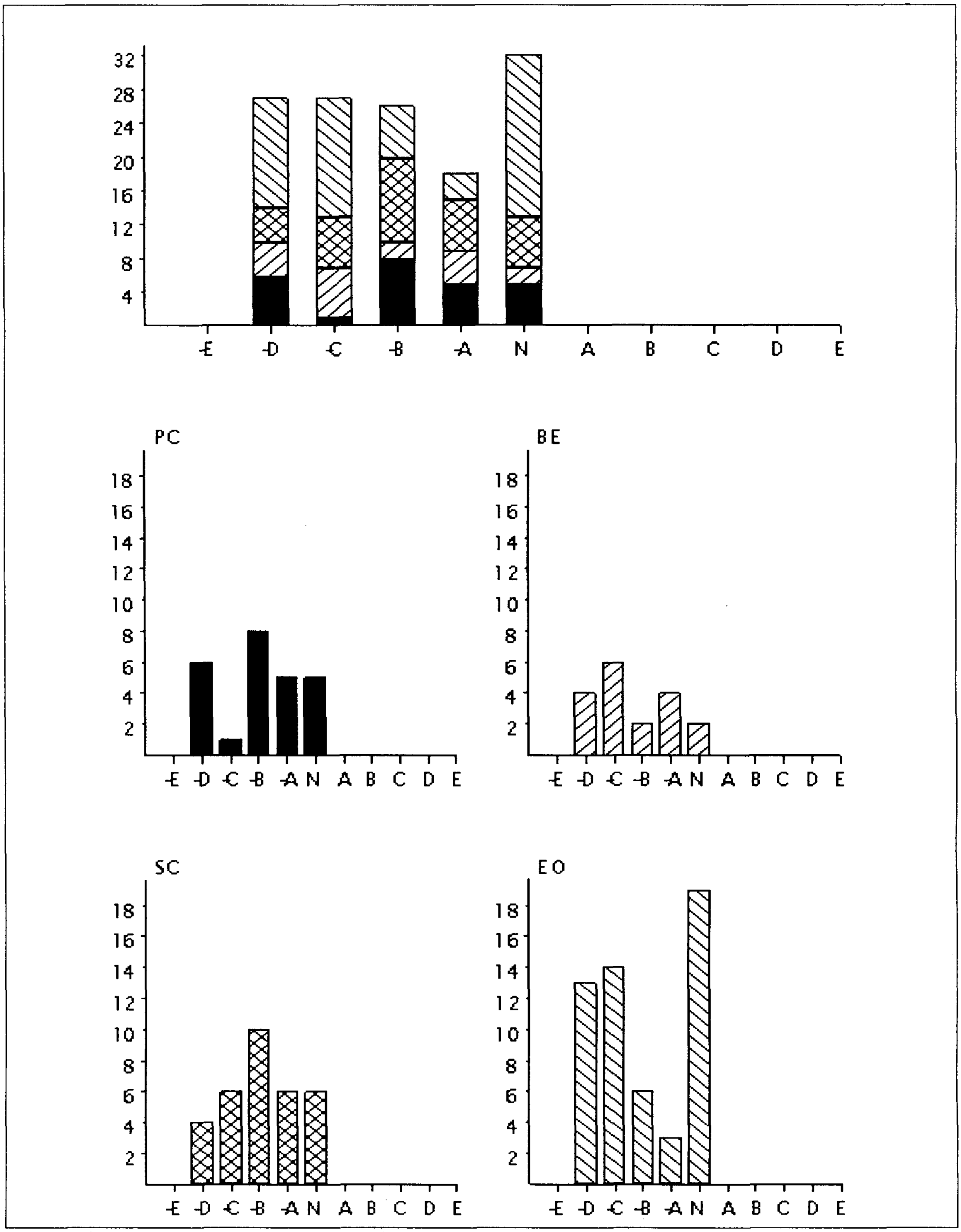

Fig. 1 Prioritising water resources management problems

7 CONCLUSION

The conclusions of this paper are:

(a) RIAM has successfully been used to prioritize water resources management problems in Ghana in the order of which problems call for the most urgent attention;

(b) The overall results (priority list) was the same as obtained in a national workshop in which experts and representatives from water agencies, donor agencies, university faculties and departments, research institutes, private institutions and organizations, and NGOs participated and in which the participants sometimes came up with different scorings; and

(c) The RIAM method is quite transparent, particularly as it leaves behind a permanent record that can be independently checked, validated or updated.

The sponsors (DANIDA) of the Water Resources Commission (WRC) were quite satisfied with the priority list of the water resources management problems and are funding pilot studies in two river basins (Densu and White Volta) to introduce the basins to Integrated Water Resources Management, the results of which will be applied to the other river basins. The study has shown that RIAM is a very useful tool in such prioritization process as has been applied in this exercise to a developing country even though it was originally developed in a different environment, i.e. in a developed world.

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