Advice on
Terms of Reference for EIA for Wadi Bana Dam Project

-Yemen-

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TABLE OF CONTENTS

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Appendices

1. INTRODUCTION

1.1 Project setting

The Ministry of Agriculture and Irrigation in Yemen is planning to construct a large dam in wadi Bana (view Appendix 1 for a map of wadi Bana).
The Ministry of Agriculture and Irrigation in Yemen is planning to construct a large dam in wadi Bana. Wadi Bana together with the Wadi Hassan flows almost parallel for ten kilometer in the Abyan delta before they flow into the Gulf of Aden.
Although the proposed projects for wadi Bana and wadi Hassan are closely interlinked, this advisory report only deals with the proposed project for wadi Bana[1]. The reason is that the construction of the project in wadi Bana can be implemented separately from the construction of the proposed project for Hassan. Mutual impacts of the projects need to be considered in an integrated way.
Between 1954 and 1987 a number of structures like weirs, head regulators , main-secondary and tertiary canals have been constructed to enhance irrigation in the Abyan delta. The biggest flood recorded in the Abyan delta in 1982 destroyed most of the irrigation structures as well as part of the agricultural lands. The total cultivable command area in the Abyan delta is about 31,000 hectares (6,000 for Hassan and 25,000 for Bana).
The objective of the Bana construction works is storage, flood control and control of irrigation supplies for the command area of wadi Bana. The following works will be constructed; split into two components[2]:

A. Main concrete gravity dam, maximum height 66.5 meters and main spillway, auxillary spillway, outlet sluices and 4.5 km access asphalt road.
B. Three weirs; Diyyu, Makhzan, Ogma Sada with canal head regulator and silt ejectors; Intake structures: Masan'a, Sammah, Ghazi with canal head regulators and silt ejectors. Canals 26 km in total; Masan'a, Makhzan, Ogma Sada, Al-Feesh, Khameela. Canal structures cross regulators, head regulators and drop structures.

The total estimated costs for the construction of those works are US $147 Million (component A: Bana dam works US $ 85 Million and component B: Works in wadi Bana US $ 62 Million).

1.2 Request for advice and objectives

On request of the Minister of Water and Environment of Yemen dd. 14-07-2007, see Appendix 2, this advice is prepared by the Netherlands Commission for Environmental Assessment (hereafter called "the Commission")[3]. In a verbal explanation the Minister asked the Commission to review the existing EIA reports for the dam planned in wadi Bana and provide guidelines for supplementary information, in case necessary.

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[1] For the EIA report for wadi Hassan the Commission has prepared a separate report.
[2] This information and the figures about costs are based upon presentation of the dam projects by Associated Consulting Engineers – ACE to the Ministry of agriculture and irrigation on May 26, 2007.
[3] The Netherlands Commission for Environmental Assessment is an independent advisory body, has a legal basis and was established in 1985. For more information see the website: www.eia.nl

The purpose of this advice prepared by the Commission is to advise the Minister of Water and Environment on:

- firstly, the quality of the EIA report. Criteria applied are relevance, completeness and correctness of the information and;
- secondly, if necessary, provide guidelines for supplementary information to the EIA reports.

The Environmental Protection Authority, under responsibility of the Minister for Water and Environment, is responsible for approving the Terms of Reference for the EIA as well as the review of the EIA-report.

1.3 Justification of the approach

Working group

This advice is prepared by a working group of experts of the Commission. The group represents the Commission and comprises expertise in the following disciplines: geo-hydrology, irrigation, water management, ecology and sociology. For the composition of the working group, see Appendix 3. For the preparation of this advice, Yemen was visited from 28 September – 6 October 2007. The wadi Bana downstream basin including the proposed site for the dam was visited during a one day field visit. Appendix 4 presents the programme of the visit and the people that the Commission has spoken to.

Review framework

It has been confirmed by the Ministry of Water and Environment and the Ministry of Agriculture and Irrigation that there are no Terms of Reference (ToR) available for the EIA study that was part of the Final report phase (2004) for the dams projects. According to the Ministry of Agriculture and Irrigation all the reports including the EIAs have been submitted to the Ministry of water and environment for review about one year ago. The Ministry of Water and Environment has received these reports informally, but never received a formal request for approval of ToR nor review[4]. The Ministry of Environment takes the position that the EIA procedure still has to start since neither a ToR has been proposed nor a draft EIA report have been formally submitted.

The Commission does not take a position but underlines that the formal procedure should be followed. The Commission has decided to take the presently available information as the point of departure for review:

- Ministry of Agriculture and Irrigation. Updating the feasibility study and detailed design for Abyan Dams project:

  Final report – Phase 1 (August 2004)[5]
  Volume 4:
  - Works in the wadi
  - Development of access roads
  - Construction schedule and organization
  - Environmental impact Assessment
  - Economic appraisal

[4] Since the promulgation of the law in 1995, the ministry of agriculture and irrigation has not requested any ToR nor any review of an EIA study towards the Ministry or agency responsible for EIA.

[5] Volume 1, 2 and 3 have not been made available to the Commission.

Final report - Phase 2 (November 2006)[6]
Volume 1: Executive summary
Volume 4: Detailed design of Bana dam works
Volume 5: Detailed design of works in Wadi Bana

There was no existing approved ToR that could be used as reference for the review of the EIA report. In addition to its own expert judgement based on extensive international experience, the Commission has used the following review frameworks:

- Environmental Protection Law (EPL) of Yemen (1995) that provides the requirement for the contents of an EIA report;
- Ministry of Water and Environment (February 2006): Draft Directive on EIA for Dam projects;
- World Bank Operational Policy 4.01: Environmental Assessment, 1999, and Bank Procedure 4.01, Annex B: Application of EA to Dam and Reservoir projects;
- Guidelines for EIA prepared by the World Commission on Dams in 2000 (www.dams.org).

In preparation of the guidelines for supplementary information to the EIA, the Commission has referred to a number of documents listed in Appendix 5. In addition, to the above mentioned review frameworks, the following guidelines have been used: Millennium Ecosystem Assessment (2003): Ecosystems and Human Well-being: A Framework for Assessment www.MAweb.org

[6] Volume 2 and 3 deal with wadi Hassan.

2. MAIN REVIEW FINDINGS

2.1 Main conclusion

The Commission noticed that the EIA chapter for the wadi Bana project does not meet the EIA requirements as stated in (i) the Environmental protection law of 1995; nor (ii) the EIA guidelines by the World Bank guidelines and the guidelines on EIA by the Commission on large dams (2000). Also when taking into account the additional information provided in the feasibility study, the information remains insufficient.
The Commission observed that the proposed dam elaborated in available reports, is a multi-purpose dam aiming to control the floods and store water for irrigation purposes by creating a reservoir that can last for several months. Alternatives, other than the proposed dam (such as a flood retention dam that only controls floods, not designed to store water in a reservoir) might also solve the problem(s) and achieve the objectives, but these are not elaborated. As a consequence, no comparison of alternatives, including the autonomous development alternative, has been made. Therefore, decision makers cannot judge whether the most sustainable solutions are proposed, according to the three pillars of sustainability (environmental, social and economic aspects).
Therefore, the Commission has come to the conclusion, that crucial information in the EIA report is missing and part of the available information is incorrect. This information is considered to be essential for well informed decision-making by the Environmental Protection Authority.
The following essential shortcomings are identified in the EIA reports. A more detailed review and field observations are presented in chapter 3.

- Objectives of the proposed project and the problems to be solved by the proposed project are not clearly identified and described in the reports. An in depth problem analysis for the study area is lacking.

- Whether the proposed project solves the problems and achieves the objectives has not been justified. Trends in the water balance and socio-economic situation for the past, the current situation and the autonomous development have not been described adequately. This information together with a description of problems and objectives is necessary to justify the project.

- The presented groundwater model has not been calibrated. Thus, it is highly questionable whether the gains said to be accrued from the project can actually be accomplished.

- Information on expected water resources development activities in the upstream catchment has not been included.

- Operational rules for management of the dam and weirs have not been described. As a consequence it remains unclear which impact dam operation will have on the rate of sedimentation in the reservoir.

- The institutional context of the project has not been described. In other words, it remains unclear how and by whom the dam and other infrastructure is going to be

operated. Recent studies on other dam project in Yemen (IWMI, 2004) indicate a great risk of failure by the lack of clear institutional arrangements.

- The available documents do not provide information whether directly or indirectly affected stakeholders in the area have been informed or consulted, or whether they participated in the design of the projects.

2.2 Main recommendation

The Commission recommends to remedy the essential shortcomings and therefore provides guidelines for an EIA, see chapter 4. Due to the fact that the shortcomings are so fundamental it is recommended to prepare an EIA stand alone report for the wadi Bana project. Relevant existing information can of course be incorporated in this EIA report.

3. DETAILED REVIEW AND FIELD OBSERVATIONS

3.1 Description of the present situation

The Commission noticed the following problem. Irrigation from the Wadi Bana (Abyan Delta) has a long history. To divert the high intensity floods of short duration, which are typical for wadi's in Yemen, spate irrigation was developed. In 1980 about 9400 ha was irrigated from the Wadi Bana. The floods of 1982 (2000 m^3/s) damaged most of the irrigation infrastructure. Since then the Bateis weir was rebuild in 1984. Lack of funds prevented the repair of the reaming system to date. Because of the lack of proper downstream diversion weirs, spates entered the main canals and caused considerable erosion of irrigated land along the wadi. At places, the wadi widened from 100m to 500m. In addition water does not reach the tail end of the canal system, resulting to water shortage and abandoned farms. Water that otherwise would serve these farms now recharges the aquifer and discharges into the sea.

3.2 Proposed project and impacts

Purpose of the works

The multiple purposes of the Bana Dams Works as described in the consultant's report differ considerably from the perception of local staff. The ACE report gives as main purposes storage and flood control. Based on interviews with field staff, the Commission assumes the following purposes of the "Bana Dam Works" [7]:

1. Construction of the Bana dam. The dam will create a flood retention reservoir to reduce the flood peaks from as high as 4650 m^3/s (100 year return period) to 400 m^3/s (annual return period). This results to floods (spates) of longer duration that are easier to manage.
2. Construction of three diversion dams downstream of Bana dam that divert spates into the related irrigation canal systems.
3. Reconstruct the upstream part of main canals and some secondary canals. This includes the control structures and drop structures in these canals.
4. Construction of access roads along canals for operation and maintenance. These roads also will give villages access the main road system.

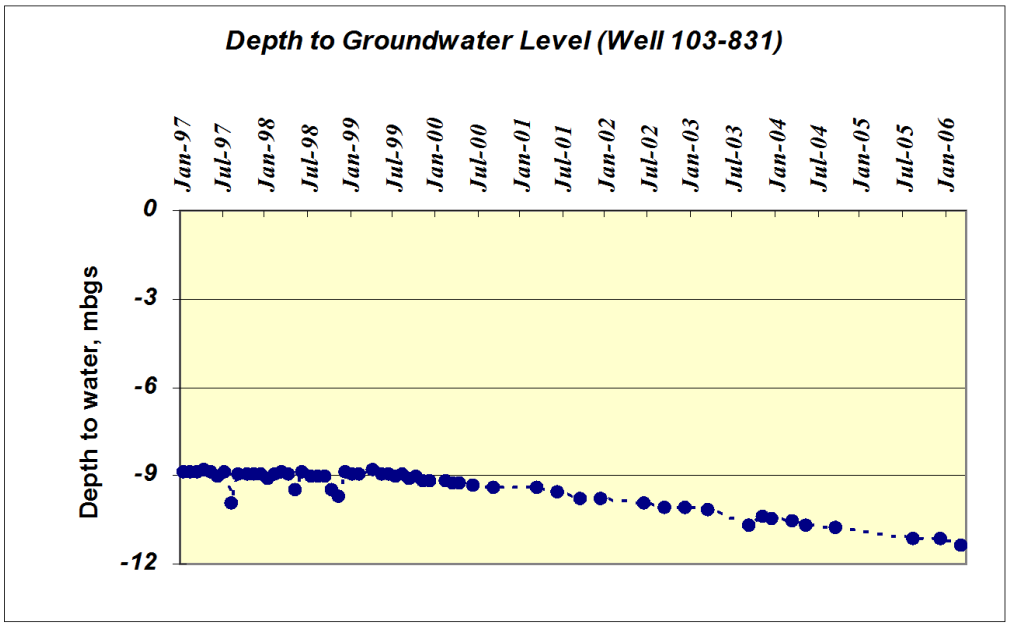
No comparative study between the two potential purposes of the Bana Dam (e.g. flood retention only or multi-purpose flood control and storage) was made. In this context a remark by ACE (page 4-10) raises questions: "However, considering the size of the catchment area and very little storage capacity of proposed reservoir it looks like that the flood control or mitigation purpose will not be served unless multiple dams or reservoirs are planned and implemented in the river basin." The economic justification of a proposed dam not serving its purpose is not given.

Water balance

The water balance of the Wadi Bana basin is not well known. Despite the fact that water is a limiting resource for economic development, wadi discharges (e.g. at Bateis), diverted flows, groundwater abstraction, aquifer recharge, etc. are not monitored with sufficient detail. However, according to Ali (2006), based on 20 monitoring wells located

[7] The name Bana Dam Works is misleading. The proposed works consist of a retention reservoir, diversion dams, irrigation canals plus related control structures, and access roads.

throughout the Delta, 16 wells showed a groundwater level decline (see Fig below), while 4 wells did not show a significant trend;



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export of water has not been documented.

Bana dam height

The height of the Bana Dam is not well justified. After a minimal discussion, the ACE report writes: “The storage required for flood protection in case of Wadi Bana is not substantiated” (also see remark above on ACE report page 4-10). The ACE report relates the storage capacity to the irrigation water requirements; thus using Bana Dam as a storage reservoir. A volume of 44 to 46 MCM is mentioned to supply 70% of the irrigation water demand. Subsequently, a 55m high dam is selected without further justification. A study on dam height as a function of the purpose of the dam (flood routing only as envisaged by local experts) is recommended.

Reservoir operation

The anticipated method of operation of Bana Dam, as described in the ACE report, is not consistent with information received from the Ministry of Agriculture and Irrigation in Aden. The ACE report gives a storage capacity of 46 MCM (34% of mean annual flow) to meet 70% of the irrigation water demands. The Ministry, however, indicates the sole function of the dam is flood retention. The latter would make the dam significantly less vulnerable for sedimentation and could be lower. For example, a dam with an un-gated bottom opening (orifice) with sufficient capacity to discharge a 5-year flood before the spillway starts to overflow would be sufficient.

Sedimentation

Despite the storage function of the reservoir as envisaged by the ACE report, the same report considers a trap efficiency of only 10% of all sediments entering the reservoir

(page 4-12). No justification is given for this low percentage. A detailed study for alternative reservoir operation schedules on sedimentation is recommended.

Irrigation water requirements

The irrigation water requirements are given as 132.64 MCM for an irrigable area of 9410 ha (Table 4.8)[8]. The annual flow at the Bana Dam site is reported to average 134.49 MCM (Table 4.7) being about equal to this irrigation water requirement. The impact of irrigation water use and water consumption on the water balance downstream of the dam is not given. The environmental impact (increasing groundwater salinity, sea water intrusion) should be studied. The study of these effects should be done in combination with the effects of the proposed works in wadi Hassan.

Impact of the Bana Dam Works on the public drinking water supply

Impact in the area, the National Water and Sanitation Authority (NWSA) Aden branch operates the Al-Ruwa well-field, also known as Upper Abyan well-field. This well-field consists of some 20 wells and is present as three well rows (northern, central, an southern row) between Subaybah and Giar. Total abstraction of this well-field is estimated at 9 to10 MCM/yr. In addition, NWSA-Giar branch operates a number of small well-fields for local town water supply. These are the Giar well-field (9 wells), El-Kod (3 wells), and Al-Husn (2 wells). Finally, there is a well-field (3 wells) from a cooperation in the vicinity of Subaybah. Total abstracted amount of all these smaller well-fields collectively is some 5 MCM/yr. The majority of the wells is located in between Wadi Hassan and Wadi Bana in the central part of the Delta. Since each well-field bears a great strategic importance, the impact of the dam, either in the Wadi Hassan or Wadi Bana, needs to be carefully assessed. The Commission estimates that due to increased recharge, as a result of the construction of the Bana or Hassan dam, groundwater quality might:

1. improve, because the quality of the recharged water from the wadis is in general better than of groundwater;
2. deteriorate further, because of the increased leaching of accumulated salts in the soil that are being flushed to the underlying Quaternary aquifers.

Socio-economic impacts

After the flood of 1982 original farmers of the irrigated area have deserted to nearby villages in Abyan delta. The Commission has not had the opportunity to talk extensively with the farmers in Wadi Bana. The MAI – Aden brach informed the Commission that farmers will return to their land once the floods will be controlled by the proposed dam and weirs.

No clear figure of the amount of farmers who left the Wadi Bana area was provided. Also there is no clear data about the socioeconomic characteristics of the original farmers although officials confirm that they are registered in their records.

Although land rights are known and respected in the area as mentioned above, a long time has elapsed since the 1982 flood and there is a good possibility that these farmers have sold their lands, or even migrated to other areas. In that case, the land distribution plan needs to be made clear to the public and communicated in complete transparency.

[8] On page 4-13, however, 70% of the irrigation water demands are given to be 44 MCM (100% would be 63 MCM).

Failing to do so could lead farmers taking wrong decisions due to lack of correct information. For example, they could sell their lands to speculators or choose to migrate somewhere else. Also involving the public will help the key officials to better design the proposed dam and weirs.

The original dam site in Wadi Bana was not acceptable for one of the villages because their graveyard should be flooded by the reservoir. As a result another site more upstream was selected for dam construction. At this site it seems that no houses and only small amounts of agricultural land might be flooded by the reservoir.

4. GUIDELINES FOR EIA

4.1 Approach and scope of study

During the field visit in Abyan delta the Commission was informed about the idea to construct a flood retention dam instead of a flood retention reservoir dam. Based upon expert judgment the Commission is of the opinion that this alternative of a flood retention dam might provide better opportunities to achieve the objectives of agricultural development than the proposed dam against less costs. Therefore, the Commission recommends to study this and another third alternative (explained in section 4.3.3) in the EIA study and make a comparative assessment of the overall costs and benefits.

The draft Water Resources Management plan for Tuban – Abyan delta region (2007) provides a lot of information that can be used for the preparation of the EIA study.

The guidelines presented in this chapter are based on the Millennium Ecosystem Assessment (2003): Ecosystems and Human Well-being: A Framework for Assessment. Box 1 provides a brief explanation of the assessment framework developed by the Millennium Ecosystem Assessment.

Box 1: Explanation

Ecosystem services are the benefits that people obtain from ecosystems, encompassing natural ecosystems and man-made land use systems. These benefits (goods and services) represent economic, social (including cultural) and ecological values for society. For example, the reliable supply of surface water is a provisioning service for agriculture; good quality groundwater is a provisioning service for public water supply as well as agriculture, while freshwater intrusion in a wadi delta provides a regulatory service to counteract the underground intrusion of seawater. The same resource thus provides multiple services to different groups of stakeholders. Stakeholders can speak on behalf of these services and should consequently be involved in an impact assessment process. In general four types of ecosystem service are recognised:

- Provisioning services: harvestable goods such as water, fish, timber, fruits, genetic material.
- Regulating services such as water storage by aquifers, water purification by wetlands, sediment transport, carbon sequestration, pollination of commercially valuable crops, coastal defence.
- Cultural services providing a source of artistic, aesthetic, spiritual, religious, recreational or scientific enrichment, or nonmaterial benefits.
- Supporting services necessary for the production of all other ecosystem services, such as soil formation, nutrients cycling and primary production.

The recognition of ecosystems services provides a relatively simple tool to assess the consequences of interventions in natural resources. Instead of defining impacts in terms of withdrawal or provision of water (or any other natural resource), the multiple services provided by affected ecosystem or land-use type are identified and linked to

various groups of stakeholders. This provides a more comprehensive picture of interests at stake. It facilitates the identification of relevant issues to be assessed, notably those beyond sector horizons which are often overlooked in project planning.

Demarcation of the project and study area

The project area for the EIA is the area that will be affected directly or indirectly by the proposed project. This means that the project area consist of the area upstream of the proposed dam site that will be flooded, predominantly the reservoir area and the area downstream of the site where the main dam is constructed, including the coastal area along the Gulf of Aden as far as affected by wadi Bana.

The study area for the EIA is the area that has an impact on or is affected by the impacts of the proposed project. The study area is much larger than the project area and includes the entire basin. Because developments in the upstream part of the basin will influence the discharge of water and sediment flow. For the study area it is recommended to use the boundaries of the Bana river basin.

4.2 Legal and administrative framework

The purpose of describing legislation, regulations and policies is: (i) to check if the intended initiative complies with these and (ii) to get insight in the opportunities and constraints concerning the development of alternatives

In the EIA study, legislation and existing as well as proposed policies and plans should be considered that provide opportunities or constraints for the development of alternatives. At least the following policies and plans should be considered:

- National Water strategy 2005-2009;
- National agricultural policy or plan;
- Draft water resources management plan for Tuban – Abyan delta region

Other relevant policies and plans have to be considered as well.

Each identified alternative should be checked on its consistency with the relevant existing policies and plans. Such a consistency check provides insight in the way the proposed alternatives are contributing towards the achievement of objectives in the approved plans and policies. In this manner the impact assessment instrument contributes to the enhancement of coherence between national, regional and local policies, plans, programmes and ultimately projects implementation.

4.3 Problem analysis and development of alternatives

4.3.1 Problem analysis and objectives

The purpose of describing the problem analysis and objectives is to assess if the proposed activity does solve the observed problem and to assess if the project objectives will be achieved.

For an insight in the current and future problems it is necessary to carry out an in-depth analysis of the problems in the defined project area and its underlying causes. As the initial project proposal does not provide such a problem analysis, the Commission uses as point of departure the apparent existence of a regional water resources management problem in the downstream section of wadi Bana.

The Commission recommends to use the ecosystem services provided by Wadi Bana (see below) and its associated aquifer in the defined area as a starting point for the problem analysis.

For each of these services an analysis of the historical and future trend has to be described. The future trend is the autonomous development. Since a number of these ecosystems services depend on upstream developments, outside the defined project area, these developments have to be taken into account.

4.3.2 Description of the present situation

The purpose of this step is to gather base line information in order to be able to describe the autonomous development which serves as a reference situation or alternative

The following information on the present situation is necessary for a comparative assessment of the costs and benefits of the proposed and other alternatives:

- Water balance for the entire river basin. Therefore information is required on precipitation, discharges, actual evapotranspiration per land use, export from basin. The spatial distribution of precipitation and actual evapotranspiration of the river basin can be quantified through the use of satellite remote sensing. Discharges have to be measured in the wadi. Upon calibration of the water balance for one (hydrological) year, trends in water balance components can be determined by using satellite images of previous years;
- Water balance for the part of the river basin upstream of the proposed dam site. The basin of wadi Bana is one of the largest in the Southern highlands. The basin part upstream of the proposed dam site is considerable and densely populated and used for agriculture. Autonomous and planned developments that may influence the water balance and sediment flow might have a significant influence on the water discharge at the proposed dam site. Two scenarios on expected change in water discharge (one with minimum and one with maximum change in discharge) could be described for a period of 10 years.
- Water balance for the part of the river basin downstream of the proposed dam site.
- Water use and water consumption for each of the identified stakeholders (water users) as listed in section 4.4 b.
- The existing draft basin plan for Tuban – Abyan delta provides a part of this type of information for the down stream part of wadi Bana[9].

[9] In recent years it has become common practise in many countries to have a strategic environmental assessment (SEA) parallel to or integrated with the formulation proces of such a basin plan. Basin plan and SEA provide the boundary conditions for EIA at project level. Yemen started to introduce SEA.

Following the approach of the UN Millennium Ecosystem Assessment (MA, 2003 [10]) Wadi Bana can be described as an ecosystem providing multiple services for human well-being. Enhancing one of these services may go at the cost of other services, and may consequently negatively affect stakeholders depending in these services. The following ecosystem services can be identified, with a short description of their present status and the value these services represent to people:

- Water supply for spate irrigation: traditionally the sudden floods of the wadi are spread over the floodplains by means of weirs. Rapid infiltration of water into the subsoil avoids water losses due to evaporation and provides opportunities for agriculture. It is unknown how much water presently reaches the Wadi Bana dam site and further downstream. The data used in the feasibility study date back many years. Wadi Bana has a large upper catchment area, relatively densely populated. Population growth, expansion of agriculture, construction of small dams, will all have their impacts on the downstream availability of water. Even though a water plan is available for the Abyan delta, this plan does not include the upper catchment of the wadi. Therefore it is unclear what recent developments in the upper catchment have taken place and how this influences the availability of water in the Abyan delta. Due to large floods in 1982, a large proportion of the spate irrigation infrastructure has been destroyed, part of the cultivated lands have been degraded, and people have moved out of the area. A large new weir has been constructed, but 5 more would be needed to optimise spate irrigation. Presently a significant proportion of the water flows directly into the Gulf of Aden, which is considered a lost opportunity for spate irrigation. Both wadi Bana and wadi Hassan converge in the Abyan delta; a roughly estimated 20 MCM per year flows into the Gulf of Aden. Wadi Bana is the largest contributor (figures have not been made available). The project aims at enhancing spate irrigation by a retention dam, new weirs and improved irrigation infrastructure. A retention dam significantly reduces the size (and investment needs) of the weirs. The proposed project in Wadi Bana will result in significantly increased availability of surface water for spate irrigation and thus also increased infiltration.

- Over-seasonal storage of water through recharge of groundwater: water which infiltrates without being directly used for agriculture is automatically stored. Underground storage has always been considered the best way to store water in a hot dry climate where evaporation losses are high. The traditional Yemeni system of agriculture provides a good example of rational use of an erratic water supply. The Abyan delta receives water from both Wadi Hassan and Wadi Bana. As both wadi's share the same aquifer from the foot of the escarpment down to the Gulf of Aden, it is necessary to take both wadi's into account when assessing the impacts of measures in one of the wadi's. Lack of sanitation measures in the villages of the Abyan delta and recycling of groundwater in agriculture are a threat to groundwater quality.

- Water supply for irrigation through groundwater pumping: groundwater is pumped for irrigation, either as a sole source of water, or for conjunctive use in areas under spate irrigation. It is unclear whether the present rate of groundwater exploitation is sustainable or not. There is contradictory information whether the level of exploitation exceeds the annual recharge from rains and floods from wadi Bana and wadi Hassan. Depending on the design of

[10] Millennium Ecosystem Assessment (2003) Ecosystems and Human Well-being: A Framework for Assessment. Island Press. (http://www.millenniumassessment.org/en/products.aspx))

the dam the reservoir will either lead to loss of water by evaporation (semi-permanent storage in ACE design) or lead to a reduced flood peak and increased infiltration in the reservoir area (limited flow through permanent open gates and retention of excess water for several days in MAI – Aden branch design). Enhancement of spate irrigation will lead to increased infiltration.

- Agriculture on fertile floodplain soil. The deposition of sediments has created soils suitable for agriculture in the Abyan delta. Presently the numbers of hectares of farmland, that fully or partially depends on the Wadi Bana for spate irrigation in the Abyan delta, are unknown. The lands lost in the 1982 flood can be rehabilitated (old land and water rights are still valid). In the area foreseen as temporary storage reservoir there is no agricultural activity.

- Public water supply from groundwater: groundwater from the Abyan delta is the main source of public water supply for Aden and other Abyan delta towns. Intensifying land use, lack of sanitation, and the use of agrochemicals are a threat to the quality of groundwater as the soils are highly permeable and the groundwater is directly exposed to infiltration from the surface.

- Sediment transport and deposition: forces of erosion are strong and vegetation cover is minimal in the upstream catchment. Maintenance of terraces in the upstream area is reportedly neglected, leading to increased erosion. Consequently, soil protection is minimal and considerable amounts of eroded material are washed away by seasonal rains. When in spate the wadi transports these sediments to the Abyan delta, where finer sediments have created fertile soils. Floods are still valued for the silt they bring onto the lands, thus maintaining soil fertility. The high sediment load of the wadi is a constraint on the lifetime of dams with reservoirs in the main course of the river as these silt up rapidly.

- Maintaining underground fresh-saltwater balance in coastal zone: there is permanent flow of fresh groundwater towards the sea, thus forcing heavier seawater downward and maintaining a layer of freshwater. Overexploitation of freshwater (resulting in more surface evapotranspiration and less infiltration) upsets the fresh-saltwater balance. The seawater wedge moves further inland, and the overlying layer of freshwater is reduced in depth, thus threatening services depending on freshwater. This process starts at the coastal fringes, gradually moving inland.

- Miscellaneous services provided by reservoir area: the area of the proposed reservoir is sparsely covered by natural vegetation with associated wildlife. It lies in a remote canyon. This area may be used for wood collection and grazing of sheep. An unknown area of natural vegetation and associated wildlife will be severely degraded or lost by the creation of a reservoir. It is unclear whether any valued or threatened biodiversity will be affected. The scenery at the dam site is quite spectacular; it is unclear whether the tourism potential of the site has ever been identified. A dam and access road may provide opportunities for touristic exploitation, although the reservoir area will be seriously degraded.

- Coastal fisheries: the wadi spate waters reach the Gulf of Aden, thus providing an important influx of sediments and nutrients in the coastal sea. The proposed project will lead a reduced flow into open sea. It is relevant to have some estimate of the influence of reducing the flow of wadi's to the coastal wetlands and sea as this may have a significant impact on productivity of fisheries resources.

Table 1: This table provides an overview of a qualitative assessment of the expected impacts of the autonomous development (without project), the proposed ACE project, and the alternative design presented by MAI-Aden branch. Impacts relate to the proposed dam and reservoir site and further downstream, expressed as changes in ecosystem services, based on exert judgment by the Commission.

Ecosystems service	Autonomous development		ACE design		MAI-Aden design	
Water supply for spate irrigation	?	Upstream developments may lead to lower spate flows. Climate change may lead to increased spate flow.	+	Operational rules unknown; potential reservoir losses due to evaporation	++	Clear-cut improvement of spate irrigation.
Underground storage	-	Quality may deteriorate due to lack of sanitation and over-exploitation by agriculture.	?	Unclear what the net result is of evaporation losses and improved spate irrigation.	+	Less water 'lost' to open sea; better management of spate flow; improved infiltration. Water quality risk due to lack of sanitation and overexploitation.
Groundwater for irrigation	-	Overexploitation probable, leading to lowering water tables.	?	Unclear what the net result is of evaporation losses and improved spate irrigation.	+	More water available for irrigation. Balance needs to be found with public water withdrawals.
Agriculture	X	Agriculture remains suboptimal; displaced people cannot return to their legally owned land.	+	Reclamation of downstream irrigable lands.	++	Reclamation of lost lands. More lands can be irrigated compared to ACE design because of reduced evaporation losses.
Public water supply	-	Overexploitation probable, leading to lowering water tables.	?	Unclear what the net result is of evaporation losses and improved spate irrigation.	+	More water available for public water supply. Balance needs to be found with agricultural withdrawals. Water quality issues need to be addressed.
Sediment transport	?	Large upper catchment areas with many developments may lead to increased sediment loads.	--	Rapid silting up of reservoir; short life time.	-	Silting up of reservoir, but very slow if dam is constructed with permanently open gates.
Maintaining under-ground fresh-saltwater balance	?	Unclear	?	Unclear	+/-	Improved infiltration will halt saltwater intrusion, unless freshwater withdrawals remain unsustainable
Miscellaneous services reservoir	X	No change	--	Total loss under permanent reservoir.	-	Some loss due to short inundation and sediment deposition.
Coastal fisheries	?	Unclear	-	Reduced run-off to sea	-	Reduced run-off to sea

4.3.3 Development of alternatives

The purpose of describing the development of alternatives is to investigate any potential alternatives that may present environmentally sustainable, socially acceptable and economically feasible solutions.

The Commission recommends to develop the following alternatives:

1. Alternative A – ACE design: Bana Dam including diversion weirs, this is the existing design in which the purpose is a storage cum flood control dam. This design has been elaborated in the feasibility study and has been subject to EIA. The site selection of the dam has to be justified. The borrow pits for the construction material have to be described.

2. Alternative B – MAI Aden design: Bana Dam including diversion weirs, in this alternative there is flood retention dam with orifices that hydraulically control (reduce) the flow rate of the spates. This design is presented by the Aden branch of the Ministry of agriculture and irrigation during the field visit of the Commission. The site selection of the dam has to be justified. The borrow pits for the construction material have to be described.

3. Alternative C: the Commission recommends to develop a third alternative that only consists of diversion weirs that control the flow diverted into the main canals. No dam would be constructed in this alternative. Because of the lack of a flood retention dam, the weirs in this alternative should be able to deal with much larger spate flows.

4. Autonomous development as a reference situation or alternative. A comparison of the impacts of the proposed alternatives with the reference situation should provide the justification for the selection of one of the alternatives.
The water balance is the starting point for the description of the autonomous development. Based on the expected future changes in availability of water in the project area, the listed ecosystem services will change in quality and/or quantity. By linking these ecosystem services to stakeholders, the impact of changes in ecosystem services on human well-being can be assessed. For the description of the consequences of autonomous development use should be made of at least two development scenarios, taking into consideration:

- growth of the population, extrapolation of national figures;
- economic growth (BNP), extrapolation of national figures;
- expected change in precipitation due to climate change, two extreme climate change scenarios for this part of Yemen should be used, for climate change scenarios it is necessary to use a time horizon of 50 to 100 years;
- extraction of water for Aden domestic water supply (export of water from the river basin).

The autonomous development should be described for a period of 10 and 30 years.

In the process of developing alternatives ideally representatives of the identified stakeholders should be involved.

4.4 Impacts of the alternatives

Impacts can be related to the construction phase and to the operational phase of the project. For the present project the impacts of the operational phase are considered to be, by far, the most important impacts in terms of effect on human well-being (positive as well as negative), since these are of significant magnitude and of permanent and irreversible nature. For reasons of clarity we will discuss these impacts in this section. The following section provides an overview of potential impacts during the construction phase that need to be studied and which may be in need of mitigation measures. Such mitigation measures have to be included in an environmental management plan, as part of the EIA report.

Starting point for impact assessment are the ecosystem services that are listed and described in section 4.2. Impacts on these ecosystem services need to be quantified for each alternative as much as possible, following a three steps approach:

a) **Changes in ecosystem services.** Describe and quantify the actual services provided and the expected change under various alternatives. Suggestions for the way in which services can be expressed are provided below:

Agriculture

- Water supply for spate irrigation: amount of water available (MCM); change in frequency of occurrence of floods of certain volume.
- Groundwater supply for irrigation: amount of water annually recharged.
- Agriculture on fertile floodplain soil: cultivated areas (hectares).

Public water supply

- Public water supply: amount of water annually recharged; expected changes in water quality in relation to health standards.

Natural resources

- Over-seasonal storage of (ground)water: rate of recharge versus rate of extraction
- Sediment transport and deposition: change in sediment load reaching proposed dam site; change in sediment deposition on agricultural lands.
- Maintaining underground fresh-saltwater balance: changes in depth of underground saltwater wedge and distance to coast.

Biodiversity

- Maintaining biodiversity: change in habitat of species with internationally recognised status (red listed).
- Loss of surface area for grazing; loss of fuelwood production (in cubic meters)
- Breeding of disease transmitting organisms: expected vector breeding site in relation to human presence near breeding site results in number of potentially exposed people.
- Maintaining coastal wetlands: change in quality or surface area of wetlands.
- Change in productivity of commercially exploited fish stocks (total catch and catch per unit effort).

Table 2 provides an example of how change in ecosystem services can be scored for each alternative. Quantification is limited to 5 categories only (++, +, 0, -, -- and ? in case it is unknown to the Commission).

b) **Affected stakeholders.** Description of the (groups of) stakeholders affected by or making use of these services. Define for each ecosystem service the area of influence; a change in a service may affect stakeholders beyond the boundaries of the project area. Different services may have different areas of influence. At least the following groups of stakeholders have to be identified:

- farmers relying on conjunctive use of surface water and ground water, which are mainly located in the upper catchment zone;
- farmers relying on the use of wadi base flow;
- farmers relying on spate irrigation and ground water irrigation
- farmers relying only on ground water irrigation;
- citizens in the downstream Bana basin using groundwater for domestic purposes;
- citizens near vector breeding sites;
- government for its national policies or international obligations concerning valued or threatened biodiversity;
- non-governmental organisations representing biodiversity conservation.

c) **Social and economic assessment**. Two tools are available two make a weighted comparison between alternatives, based on costs and benefits, cost benefit analysis and multi criteria analysis. To capture the diverse nature of the different changes several these should be used in combination:

- Cost benefit analysis should be applied to the changes which can be relatively easily quantified. Examples are the changes in the agricultural

production system (incomes at farm and project level), in the fishery sector (income) and in the supply of drinking water (costs of production, expected water prices). The changes should be specified for different stakeholder groups (by location or income group). Cost benefit analysis can be further refined by applying different weights to income improvements for different target groups (so-called social economic cost benefit analysis).

- Multi Criteria Analysis (MCA) or expert interviews. MCA is designed to make quantitative comparisons between such varying expressions of values and is very useful when impacts cannot easily be expressed in financial terms;
    - MCA; The changes in ecosystem services are expressed in terms of changes in social and economic values for stakeholders. Values can be expressed in their own terms, such as number of employed people, agricultural production, number of people served by public water supply, number of threatened species being affected, contribution to gross regional product, etc. etc.
    - Interviews with experts or key resource persons to describe the importance of different effects.

Each assessment method has its own advantages and disadvantages. Cost benefit analysis requires specific economic expertise and access to information. Not all effects can be captured in a cost benefit analysis, and the experts should clarify the limitations of the method (bias towards monetary effects). In general, cost benefit analysis, in some cases extended to social cost benefit analysis, is an important first step to quantify effects.

For subsequent assessments, multi-criteria analysis (MCA) techniques, stimulate to provide arguments for according effect scores, help to compare the different effects clearly and rapidly and allow for structuring sensitivity analysis. MCA requires careful documentation of each step in the process: defining the effects and the criteria and subsequently weighing the scores. Because MCA is based on participatory methods involving experts and stakeholders, its application needs to be very specifically prepared for each step: participant selection, assessment and documentation.

Finally, interviews with experts and key resource persons result in adequate insight into effects and stakeholders but are less appropriate to compare the importance of different effects. When interviews are carried out in different rounds and interviews are confronted with each others' view on the effects, the results will become more credible. The relatively low costs of the latter method are a main advantage compared to MCA and CBA.

4.5 Construction phase: impacts and mitigation

For the construction phase of the proposed project alternatives, the following issues need to be addressed:

- Borrow pits and quarries: depending on location these may create breeding sites for disease vectors, be disruptive for the landscape, lead to land degradation, soil erosion, etc.
- Disturbance of human settlement: dust, noise, use of toxic materials or explosives, and heavy traffic pose health risks to human population.
- Location of work camps: sanitary facilities, pollution, waste disposal and other disturbing influences.

- Temporary settlement of labourers: large numbers of temporary workers from outside the area may create social tensions, and may put additional pressure on local social services.
- Sites of interest from cultural history perspective.
- Sites of interest from a nature conservation perspective
- Land acquisition for temporary use: land owners should be compensated in a satisfactory manner.

Mitigating measures to prevent or reduce negative environmental or socio-economic impacts of the identified alternatives must be described in an environmental management plan.

4.6 Public participation and resettlement

Public participation

Besides the identified stakeholders, one specific group need to be involved in the process, i.e. the group of farmers the government wants to re-settle on the land to be reclaimed. Early identification of this target group is important for a successful implementation of re-settlement.
It is recommended to involve and inform all stakeholders during the following phases in order to get the necessary commitment for the implementations of the project:

Start and scope of the study; In this phase the people have to be in-formed about the objectives and the scope of the study as well as the planning (timeframe), procedure and their involvement in the study. Already in this phase a resettlement plan should be ready and presented to all affected stakeholders. In addition the communication with the target group should start.

Present consequences of autonomous development and develop alternatives; The consequences of the autonomous development for the livelihood of the people should be presented and widely discussed. This is an important step in the process. Practise learned that people can only be convinced to change current practises when they are aware of the problems. One could think of taking stakeholders to other parts of Yemen where the water situation is worse but comparable with their expected future situation. Commitment from the stakholders is necessary before alternatives will be adopted. This consultation should result in the development of alternatives in consultation with the stakeholders.

Assessment of the impacts of the alternatives; Identified stakeholders that will be affected could be involved in the valuation of impacts of the different alternatives.

Presentation of the draft study report; The findings of the study report should be widely discussed.

Minutes of public consultation meetings should be reported and annexed to the EIA report.

Resettlement of farmers

One of the objectives of the project is land reclamation and resettling of farmers. To facilitate this process in a transparent and accountable way it is recommended to develop a resettlement plan. One of the important aspects of such a plan is the way communication with the target groups is set up and how will be dealt with "registered" land rights and disputes.

Although land rights are known and respected in the area, yet a long time has elapsed since the 1982 flood and there is a good possibility that these farmers have sold their lands, or even migrated to other areas. In that case, the land distribution plan need to be made clear to the public and communicated in complete transparency. Failing to do so could lead farmers taking wrong decisions due to lack of right information so for example they could sell their lands to speculators or choose to migrate somewhere else.

Again the same socio-economic characteristics of expected in-comers need to be studied and socio-economic indicators need to be developed to monitor the changes which are expected during the coming phases. A resettlement plan should be developed with particular attention for the original farmers who are expected to reclaim their lands. There is thus a risk of these expected settlements being undertaken with insufficient clarity of social goals The government has to make clear provisions for both social and physical infrastructure, especially that land will take some years before it yields any crops. In short, there needs to be an integrated resettlement plan prepared by different ministries to effect a balanced physical, economic and social development of the area. So rather than assuming that the settlers will reproduce the way they have known elsewhere or assuming that they can be directed, the government has an opportunity explicitly to define and respond to national social goals and promote them among settlers. This is also because human welfare and economic decisions need to be conceived at the conceptualization stage in participation with the people themselves. For example, a new tenure system may pose problems to the settlers. A new demographic composition leading for example to predominance of a certain age group , male or female may create problems in family relations. A transformation of agriculture from subsistence farming to a market economy may require food provision to new settlers. It is thus clear that human settlement program is fraught with problems that could work against building viable communities.

A community development association (CDA) could be established in the area to assist the local people in overcoming difficulties especially in the first years and to help meet people's minimum needs at the right time in the right manner. Some women empowerment activities could be undertaken by the CDA to help mitigate the effects of new settlement.

In case people have to be resettled due to proposed project, the Commission recommends to make use of the World Bank Operational Policies 4.12: Involuntary settlement.

4.7 Comparative assessment of the alternatives

The purpose of comparing the impacts of alternatives is to get insight in the differences of the impacts of the alternatives in order to enable the selection of the preferred alternative.

To facilitate a transparent comparative assessment the costs and benefits of the alternatives should be described and presented in a clear manner by making use of one of the methods for cost benefit analysis and matrices.

4.8 Gaps in information and knowledge

The purpose of describing gaps in information and knowledge is to verify the risks involved in the implementation of a project as a consequence of : (i) gaps in knowledge and information; (ii) more or less uncontrollable events that will influence the future functioning and sustainability of the project.

The study should identify the gaps in knowledge and information. Based on a sensitivity analysis the risks of these gaps for the efficacy of the alternatives should be identified.