

**Advice on  
Terms of Reference for EIA for Wadi  
Hassan Dam Project**

**-Yemen-**

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# 1. INTRODUCTION

## 1.1 Project setting

The Ministry of Agriculture and Irrigation in Yemen is planning to construct a large dam in Wadi Hassan (view Appendix 1 for a map of Wadi Hassan). Wadi Hassan flows for ten kilometres almost parallel to Wadi Bana through the Abyan delta before flowing into the Gulf of Aden. From the foothill point where wadi's Hassan and Bana enter the Abyan delta, they both share the same Abyan delta aquifer.

Although the proposed projects for Wadi Hassan and wadi Bana are closely interlinked, this advisory report only deals with the proposed project for Wadi Hassan<sup>1</sup>. The reason is that the construction of the project in Wadi Hassan can be implemented separately from the construction of the proposed project for Bana. Mutual impacts of the projects will be considered in an integrated way.

Between 1954 and 1987 a number of structures such as diversion weirs, head regulators, main-, secondary and tertiary irrigation canals have been constructed to enhance agriculture in the Abyan delta. The biggest flood recorded in the Abyan delta occurred in 1982. It destroyed most of the irrigation infrastructure as well as part of the agricultural lands. The total cultivable command area in the Abyan delta is approximately 31,000 hectares (6,000 for Hassan and 25,000 for Bana).

The objective of the proposed Hassan construction works is storage, flood control and control of irrigation supplies for the command area of Wadi Hassan. The following works are foreseen to be constructed, split into two components<sup>2</sup>:

- A. Main concrete gravity dam, maximum height 20.5 meters and;  
Three saddle dams, earthen dyke and associated structures;  
(including overflow type spillway, flood sluice and irrigation outlet and 10 km access asphalt roads);
- B. Four weirs with fuse plug earthen sections, 42 km of main canals and more than 100 canal distribution structures and drop structures.

The Abu Dhabi fund has agreed with the Government of Yemen to secure funding of a part of the total estimated costs of US \$103 Million for the construction of the works (component A: Hassan dam works US \$ 54 Million and component B: Works in Wadi Hassan US \$ 49 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")<sup>3</sup>. In a verbal explanation the Minister asked the Commission to review the existing EIA report for the Wadi Hassan dam project and provide guidelines for supplementary information, in case necessary.

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<sup>1</sup> For the EIA report for wadi Bana the Commission has prepared a separate report.

<sup>2</sup> This information and the figures about costs are based on a presentation of the dam projects by Associated Consulting Engineers – ACE to the Ministry of agriculture and irrigation on May 26, 2007.

<sup>3</sup> 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](http://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 report.

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 Hassan basin 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 which is included in the update of the feasibility study and detailed design for Delta Abyan Dams Project, Final report phase 1, Volume IV (2004). According to the Ministry of Agriculture and Irrigation all the reports - including the EIA - 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 of the EIA report<sup>4</sup>. The Ministry of Environment takes the position that the EIA procedure still has to start because a ToR has not been proposed and a draft EIA report has not been formally submitted yet.

The Commission does not take a position but underlines that the formal procedure should be followed. The Commission has decided to take the information available at present, as 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)<sup>5</sup>

Volume 4:

- Works in the wadi
- Development of access roads
- Construction schedule and organization

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<sup>4</sup> The Ministry of Agriculture and Irrigation is the competent authority for the approval of irrigation dams. 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.

<sup>5</sup> Volume 1, 2 and 3 have not been made available to the Commission.

- Environmental impact Assessment
- Economic appraisal

Final report - Phase 2 (November 2006)

Volume 1: Executive summary

Volume 2: Detailed design of Hassan dam works

Volume 3: Detailed design of works in Wadi Hassan

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](http://www.dams.org)).

The Abu Dhabi fund for development does not require environmental or social safeguards ([www.adfd.ae](http://www.adfd.ae)) and has not subscribed the Equator principles<sup>6</sup>.

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](http://www.MAweb.org))

## **2. MAIN REVIEW FINDINGS**

### **2.1 Main conclusion**

The Commission observed that the EIA chapter for the Wadi Hassan 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 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

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<sup>6</sup> The "Equator Principles" are a financial industry benchmark for determining, assessing and managing social & environmental risk in project financing [www.equator-principles.com](http://www.equator-principles.com)

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 feasibility report that includes the EIA report. 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 Hassan dam and the diversion weirs have not been described with sufficient detail. As a consequence, the impact of gate operation on sedimentation in the reservoir remains unclear.
- 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 projects in Yemen (IWMI, 2004<sup>7</sup>) indicate a great risk of failure by the lack of clear institutional arrangements.
- The available documents do not provide information on whether directly or indirectly affected stakeholders in the area have been informed or consulted, or whether they participated in the design of the projects.
- Land lost to the 1982 floods, and additional new land will be reclaimed for agriculture. How the newcomers, who will use the reclaimed land, will be guided is not elaborated nor communicated with these people.
- On the design:
  - The design presented in the report on the diversion weirs and irrigation canals is inconsistent, and not in line with international standards.

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<sup>7</sup> Douglas L. Vermillion & Said AL-Shaybani (2004). Small dams and social capital in Yemen. How assistance strategies affect local investment and institutions. IWMI Research Report Nr. 76. Colombo, Sri Lanka.

- The height of the Hassan dam has been justified by the storage requirements for irrigation water. This storage function causes sedimentation in the reservoir and reduces the life expectancy of the dam. If the dam were to be designed for flood retention only, it could be lower, it would be easier to operate, and it would have an extended life expectancy.

## 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 Hassan project in which three alternatives are elaborated and compared with the autonomous development. 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 observed the following problem: Irrigation from the wadi Hassan (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 3000 ha was irrigated. The floods of 1982 (2000 m<sup>3</sup>/s) damaged most of the irrigation infrastructure. Lack of funds prevented the repair of the system to date. Because of the lack of proper diversion weirs, spates entering the main canals 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 in 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

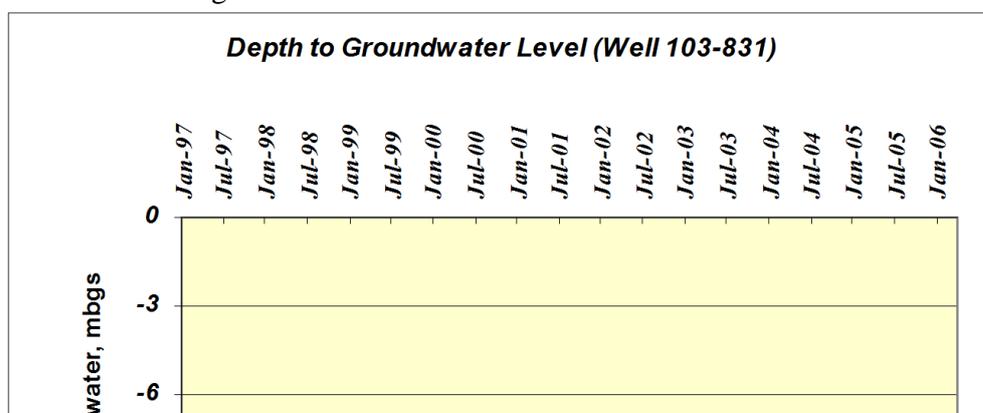
The multiple purposes of the proposed Hassan Dams Works have not been described in the consultant's reports. Based on interviews with field staff, the Commission assumes the following purposes of the "Hassan Dam Works"<sup>8</sup>:

- Construction of the Hassan dam. The dam will create a flood retention reservoir to reduce the flood peaks from as high as 2800 m<sup>3</sup>/s (100 year return period) to 400 m<sup>3</sup>/s (annual return period). This results in floods (spates) of longer duration that are easier to manage.
- Construction of four diversion weirs downstream of the Hassan dam that divert spates into the related irrigation canals.
- Reconstruction of the upstream part of main canals and some secondary canals. This includes control structures and drop structures in these canals.
- Construction of access roads along canals for operation and maintenance. These roads also will give villages access to the main road system.

No comparative study between the two potential purposes of the Hassan Dam (e.g. flood retention only or multipurpose flood control and storage) was made.

##### Water balance

The water balance of the Wadi Hassan basin is not known. Despite the fact that water is a limiting resource for economic development, wadi discharges, diverted flows, groundwater abstraction, aquifer recharge, etc. are not monitored with sufficient detail. However, according to Ali (2006), based on 20 monitoring wells located throughout the Delta, 16 wells showed a groundwater level decline (see figure 1 below), while 4 wells did not show a significant trend.



<sup>8</sup> The name Hassan diversion dam.

reservoir,

Figure 1: Depth to groundwater as a function of time of well 103-831 (near Ba-Gedar in between Wadi Hassan and Wadi Bana in the south part of the Delta).

After the destruction of infrastructure by the 1982 floods, it is estimated that wadi's Hassan and Bana together discharge about 30 Million Cubic Meters (MCM) of surface and groundwater into the sea (in an average year). A flood retention reservoir would reduce this flow having a positive influence on the water balance of the delta.

With the growth of population in Aden the demand for urban and industrial water will increase above the present 15 MCM. Pumping of groundwater for Aden from the aquifer will reduce water availability for irrigation. The environmental and social impacts of this export of water have not been documented, neither have the impacts of the Wadi Hassan dam works on water supply to Aden been documented.

#### **Hassan dam height**

The height of the Hassan Dam is not well justified. After a minimal discussion, the ACE report writes: "The storage required for complete flood protection works in case of Wadi Hassan varies between 3.46 to 25.16 MCM for 100 year and 1.5x100 years floods frequency respectively." Subsequently, a capacity of 35.4 MCM is selected. However, this dam height is related to the storage capacity needed for irrigation water supply. This short-term storage of water, however, will cause significant sedimentation in the reservoir. If the dam would be used for flood retention only, its height could be about 2m lower while no movable gates are needed on the flow control orifices. A study on dam height as a function of the purpose of the dam (flood routing only) is recommended.

#### **Reservoir operation**

The anticipated method of operation of Hassan Dam as described in the ACE report, is not consistent with information received from the Ministry of Agriculture and Irrigation (Aden branch). Page 3-13 of the ACE report gives a storage capacity of 25 MCM (65% of mean annual flow) to meet irrigation water demands, while page 3-12 indicates that the reservoir is foreseen as a storage facility. The Ministry, however, indicates the sole function of the dam is flood retention. As mentioned, the latter would make the dam significantly less vulnerable for sedimentation and the dam could be lower. For example, a dam with an un-gated bottom opening with sufficient capacity to discharge a 5-year flood before the spillway starts to overflow would be sufficient.

#### **Irrigation water requirements**

The irrigation water requirements are given as 39.76 MCM for an irrigable area of 2835 ha (Table 3.9 ACE report). The annual flow at the Hassan Dam site is reported to average 39.15 MCM (Table 3.7 ACE report) being lower than this water requirement. The impact of irrigation water use on the water balance downstream of the dam is not given. The

possible environmental impacts (increasing groundwater salinity, sea water intrusion) and their consequences for all water uses should be studied. The study of these effects should be done in combination with the effects of the proposed Bana Works.

#### **Impact of the Hassan dam works on the public drinking water supply**

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 20 wells and is present as three well rows (northern, central, and southern row) between Subaybah and Giar. Total abstraction of this well-field is estimated at 9-10 MCM/yr. In addition, NWSA-Giar branch operates a number of small well-fields for local town water supply. These are the Giar wellfield (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 is about 5 MCM/yr. The majority of the wells are 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 dams and related works, 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 Hassan and / or Bana dam, groundwater quality might:

1. improve, because the quality of the recharged water from the wadi 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**

The original farmers in the tail-end of the irrigated area have deserted their lands to nearby villages in Abyan delta after the flood of 1982 which resulted in serious land degradation. The land in Wadi Hassan, as reported by the officials, is one of the most fertile lands in Abyan Delta.

Talking to farmers living around Wadi Hassan confirmed their high expectations of Wadi Hassan Dam. Farmers who are members of the basin committee explained that building the Hassan Dam to control the flood intensity will enable the farmers to return to their lands and will boost the whole area's economic situation.

Talking to farmers about the issue of land distribution in Wadi Hassan, they all confirmed that original land ownership is respected and guaranteed and that no conflict over land distribution will arise simply because it is a revered tradition to respect each other's property.

No clear figure of the amount of farmers who left the Wadi Hassan area was provided but an area of 5000 feddans (according to key officials) is expected to flourish with agriculture and economic activity. 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. 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 and maybe find out that there is a better location for the dam?

Talking to the women head of community development association and head of women union about the gendered expected impact, women's overall accrued benefits from the flourishing of agriculture as a result of the construction of the dam was confirmed.

Women's access to resources is expected to remain the same after dam construction.

At the proposed dam site in Wadi Hassan, it seems only a few buildings might be flooded by the reservoir.

## 4.

### GUIDELINES FOR EIA

#### 4.1 Approach and scope of study

During the field visit to the Abyan delta, the Commission was informed by the Aden branch of the Ministry of Agriculture and Irrigation about the idea to construct a flood retention dam, instead of the flood control cum storage dam presented in the feasibility study. 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, while investment and operation costs would be lower. Therefore, the Commission recommends to include this 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 information that can be used for the preparation of the EIA study, and may act as a reference for decision making.

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 consists of the reservoir area upstream of the proposed dam site that will be flooded, 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 Hassan.

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 significantly larger than the project area and includes the entire wadi basin. Developments in the upstream part of the basin may influence the discharge of water and sediment flow in the lower Abyan delta. For the study area it is recommended to use the boundaries of the Hassan 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. The following policies and plans should at least 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 (or opportunity) in the downstream section of Wadi Hassan. The 1982 floods have created problems which persist up to this date, but the availability of water also provides a water resources development opportunity.

The Commission recommends to use the ecosystem services provided by Wadi Hassan (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, which should be studied as one of the alternatives in the EIA. 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 dam's project and other alternatives:

- Water balance for the entire river basin. 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. For the upstream part planned interventions and autonomous developments should be considered as far as they influence the water balance and erosion 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 Hassan<sup>9</sup>.

Following the approach of the UN Millennium Ecosystem Assessment (MA, 2003 <sup>10</sup>) Wadi Hassan 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:

##### Agriculture

- 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 soil avoids water losses due to evaporation and provides opportunities for agriculture. It is unknown how much water presently reaches the Wadi Hassan dam site and further downstream. The data used in the feasibility study date

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<sup>9</sup> 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 process of such a basin plan. Basin plan and SEA provide the boundary conditions for EIA at project level. Yemen started to introduce SEA.

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

back many years. Therefore, it is unclear what recent developments in the (relatively small) upper catchment have taken place and how this influences the availability of water in the Abyan Delta. Due to the large flood of 1982, of this so-called 'wild wadi', 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. Presently a significant proportion of the water flows directly into the Gulf of Aden, which is considered a lost opportunity for spate irrigation. The project aims at enhancing spate irrigation by a flood retention and storagedam, new diversion weirs and improved irrigation infrastructure. The proposed project in Wadi Hassan will result in significantly increased availability of surface water for spate irrigation and thus also increased infiltration. The Wadi has a base flow serving a limited irrigated area (surface unknown).

- 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 Hassan and Wadi Bana. In the Abyan delta 25,600 ha (Bana) and 6300 ha (Hassan) are cultivated; it is unknown how many hectares partially or fully depend on groundwater irrigation from the shared aquifer. Depending on the design of 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 6300 hectares of farmland fully or partially depend on the Wadi Hassan for spate irrigation in the Abyan delta. 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

- Public water supply from groundwater: groundwater from the Abyan delta is a major 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.

#### Natural resources

- Over-seasonal storage of water through recharge of groundwater: water which infiltrates without being directly consumed by 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 in the project area 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.

- Sediment transport and deposition: forces of erosion are strong and vegetation cover is minimal in the upstream catchment. 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 the reservoir silts up very rapidly.
- Maintaining underground fresh-saltwater balance in coastal zone: there is permanent flow of fresh groundwater towards the sea, thus forcing heavier seawater downstream and maintaining a layer of freshwater. Over-exploitation 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.

#### Biodiversity

- Providing habitat for disease transmitting organisms. Schistosomiasis, transmitted by freshwater snails, as well as malaria, transmitted by mosquitoes breeding in freshwater, are endemic to the project area. The creation of a permanent reservoir may enhance the reproduction of freshwater snails and mosquitoes. This depends on the type of vector species and their ecology. The risk of infection greatly depends on availability and reliability of public water supply and vigilance of primary health care services.
- Miscellaneous services provided by the reservoir area: the area of the proposed reservoir is sparsely covered by natural vegetation with associated wildlife. Most probably this area is used for wood collection and grazing of sheep. It is unclear whether any valued or threatened biodiversity will be affected.
- Coastal fisheries: the wadi spate flows reach the Gulf of Aden, thus providing an important influx of sediments and nutrients in the coastal sea. The proposed project will lead a reduction of 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.

### **4.3.3 Development of alternatives**

*The purpose of developing alternatives is to investigate whether any solutions exist that are environmentally sustainable, socially acceptable and economically feasible. Comparing such alternatives, including the autonomous development (or "do nothing") alternative, provides relevant and transparent information for decision making.*

The Commission recommends to develop the following alternatives:

**1. Alternative A – ACE design:** Hassan Dam including diversion weirs, this is the existing design in which the purpose is short-term storage of irrigation water cum flood control. 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:** Hassan Dam including diversion weirs, in this alternative there is a flood retention dam with orifices that hydraulically control (reduce) the flow rate of the spates. This design is proposed 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 to control the flow and partially divert this into the upgraded main canal systems. No dam is 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 above alternatives with the reference situation should provide the justification for the selection of one of these 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 in the entire basin, 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 the 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: (i) describe changes in ecosystem services (ii) identify affected stakeholders, (iii) assess the social and economic impacts of these changes in ecosystem services.

Mitigating measures to prevent or reduce negative environmental or socio-economic impacts of the identified alternatives must be described as part of the alternatives and taken into account in the analysis.

- 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)
- Breeding of disease transmitting organisms: expected vector breeding site in relation to human presence near breeding site results in number of potentially exposed people.
- Loss of surface area for grazing; loss of fuel wood production (in cubic meters fuel wood).
- Change in productivity of commercially exploited fish stocks (total catch and catch per unit effort).

Table 1 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 delta;
- 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;
- farmers making use of the proposed reservoir area (for grazing or wood collection)
- citizens in the Abyan delta using ground water 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 to make a weighted comparison between alternatives, based on costs and benefits: (i) cost benefit analysis and (ii) multi criteria analysis. To capture the diverse nature of the different changes 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 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) stimulate to provide arguments for according effect scores, help to compare the different effects 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 interviewees 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.

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 (+ is more. – is less; this is not a value judgement), based on expert judgement by the Commission.

Ecosystems service	Autonomous development	ACE design	MAI-Aden design
<b>Agriculture</b>			
Water supply for spate irrigation	?	Climate change may lead to increased spate flow.	+ Operational rules unknown; evaporation from future reservoir depends on operation. ++ Clear-cut improvement of spate irrigation.
Groundwater for irrigation	-	Overexploitation probable, leading to lowering water tables.	? Unclear what the net result is of evaporation from reservoir and improved spate irrigation. + More water available for irrigation. Balance needs to be found with public water withdrawals.
Agriculture	0	Agriculture remains sub-optimal; displaced people cannot return to their legally owned land.	+ Reclamation of abandoned land. ++ Reclamation of abandoned land. More lands can be irrigated compared to ACE design because of reduced evaporation losses.
<b>Public water supply</b>			
Public water supply	-	Over exploitation 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.
<b>Natural resources</b>			
Underground storage	-	Quality may deteriorate due to lack of sanitation and over-exploitation by agriculture.	? Unclear what the net result is of evaporation from reservoir 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.
Sediment transport	0	No changes expected	-- Rapid sedimentation in reservoir; short life time. - Slower sedimentation in reservoir.
Maintaining underground fresh-saltwater balance	?	Unclear	? Unclear +/- Improved infiltration will halt sea water intrusion, unless freshwater withdrawals remain unsustainable
<b>Biodiversity</b>			
Miscellaneous services reservoir	0	No change	-- Total loss under permanent reservoir - Some loss due to short inundation and sediment deposition.
Breeding of vector organisms	0	No change	+ A (semi-)permanent reservoir will promote snail-breeding 0 As long as prolonged stagnant water is avoided there will no marked change.
Coastal fisheries	?	Unclear	- Reduced run-off to sea affects productivity - Reduced run-off to sea affects productivity

## 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 stakeholders 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 the buildings in the proposed reservoir area are inhabited, the Commission recommends using the World Bank Operational Policies 4.12: Involuntary settlement, when the area will be flooded.

#### 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.