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

-Yemen-

x x / 076-xxx / ISBN xx

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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 Surdud, see Appendix 1 for a map of Wadi Surdud.
Wadi Surdud is one of the seven major wadis, which rise in the central highlands and flow westward across the Tihama towards the Red Sea. The catchment area of Wadi Surdud upto Al Kadan above the point where the Wadi flows into the Tihama is 2500 km2. The catchment up to the proposed dam site is 2370 km2. The length of the Wadi course from its source to the proposed dam site is about 70 km. At Al Kadan, approximately 90 km from its source, the Wadi flows into the Tihama plain, generally flowing another 30 km, before being completely dry. Only during exceptional floods (frequency not documented) the water flows into the Red Sea.
The Surdud dam project is a multi-purpose flood control and irrigation scheme for Wadi Surdud. The anticipated agricultural development project is located in the coastal part of the Surdud basin lying the Tihama plain. The project area can be defined as the flood plain of Wadi Surdud. The most important part is the area of 17,200 hectare which has the right to irrigate using Wadi flows and the area that will be flooded by the reservoir. It is stated that the main objectives for rehabilitation and development project are[1]:

- diversion of water to the land in controlled quantities;
- reduce scour damage to the field and the canals;
- reduce water losses and wastage;
- increase the area of land receiving irrigation water;
- increase recharge to decrease the rate of depletion of ground water re sources;
- improve reliability of water supply.

Therefore the following works will be constructed:
Package I and II

- a storage dam (main dam - height 52 meters) in Wadi Surdud for storage and flood mitigation;
- diversion weirs in Wadi Surdud for diversion of flood water into irrigation canals in a controlled manner;
- access roads to diversion weirs and feeder roads to villages;
- inspection roads along the canals for accessibility to the area and structures;

Package III

- water supply system for 52 villages.

The Abu Dhabi fund has agreed with the Government of Yemen to secure funding of a part of the total estimated costs US $ 113.5 Million, for the construction of these works.

1.2 Request for advice and objectives

At the request of the Minister of Water and Environment of Yemen dated 14-07-2007(see Appendix 2), this advice is prepared by the Netherlands Commission for Environmental Assessment (hereafter called “the Commission”)[2]. In a verbal explanation the Minister

[1] 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.
[2] 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

asked the Commission to review the existing EIA reports for the dam planned in Wadi Surdud and, if necessary, provide guidelines for supplementary information.
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, that falls under the 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, the working group visited Yemen from 28 September – 6 October 2007. Wadi Surdud was visited during a one day field visit. Appendix 4 provides the program of the visit.

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 dam 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 approximately one year ago. The Ministry of Water and Environment has received these reports informally, but never received a formal request for approval of ToR and/or review[3]. 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 has been formally submitted.
The Commission does not take a position but underlines that the legal procedure should be followed. The Commission has decided to take the information available (see below) at present as the point of departure for review:

- Ministry of Agriculture and Irrigation. Updating the feasibility study and detailed design for Surdud Dam project:
  Final report - Phase 1 (May 2004)[4]:
  Volume 4:
  - Development of infrastructure
- Construction schedule and organisation

3 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.

4 Volume 1, 2 and 3 have not been made available to the Commission.

- Environmental Impact Assessment
- Socio-economic aspects
- Economic appraisal

Final report – Phase 2 (November 2006):
Volume 1: Executive summary
Volume 2: Survey and investigations
Volume 3: Detailed design of dam and appurtenant works
Volume 4: Detailed design of irrigation and road works
Volume 5: Development of infrastructure – village water supply

For the review of the EIA reports no use could be made of an existing approved ToR. 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).

The Abu Dhabi fund for development does not require environmental or social safeguards (www.adfd.ae) and has not subscribed the Equator principles[5].

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 Guidelines for integrated water resources management www.cap-net.org

2. MAIN REVIEW FINDINGS

2.1 Main conclusion

The Commission noticed that the EIA chapter for the Wadi Surdud project does not meet the EIA requirements as stated in (i) the Environmental Protection Law of 1995; and is does not comply with (ii) the EIA Guidelines by the World Bank nor those by the Commission on large dams (2000). Even when taking into account the additional information provided in the feasibility study, the information remains insufficient.

[5] The "Equator Principles" are a financial industry benchmark for determining, assessing and managing social & environmental risk in project financing www.equator-principles.com

The Commission noticed the following essential inaccuracies that directly influence the justification of the project. All water of Wadi Surdud river basin is used and re-used until all water is consumed before it could reach the Red Sea. Under such conditions, any additional water consumption in the upstream part of the river basin results in a decrease of water for downstream users. The proposed Wadi Surdud Dam will create a reservoir from which about 4 Million Cubic Meters (MCM) of water per year will evaporate. Hence, downstream water availability will decrease by this volume, resulting in increased water scarcity. This loss will have social as well as economic consequences that are not described.

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 study, which 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.

- Information on expected water resources development activities in the upstream catchment have not been included. Yet, numerous small dams have been built in recent years. Discussions on the export of water for Sana'a are prominent; Wadi Surdud is seen as a potential source of water. These developments (autonomous development) will influence the availability of water at the proposed dam site.

- The IRR of the project is calculated at 10.3 and the annual benefits is estimated at US $ 40 Million. These figures are not justified. The internal rate of return should be based on all costs and benefits created by the project. The appraisal documents do not provide accurate information on a number of costs associated to the project, such as:
  - costs associated to the loss of water that will affect the non-target downstream farmers;
  - costs associated to the relocation of farmers depending on agriculture in the reservoir area.

  As a consequence, the IRR provided does not give meaningful information.

- Alternatives, other than the proposed storage dam, that might also solve the problem(s) and achieve part of the objectives, are not elaborated. As a consequence no comparison of alternatives and no comparison with the autonomous development have been made. Therefore, decision makers can not judge whether the most sustainable solutions are proposed, according to the three pillars of sustainability (environmental-, social- and economic aspects).

- Operational rules for management of the dam and diversion weirs have not been described. As a consequence it remains unclear how much sediment will accumulate in the reservoir. It has not been indicated which and how many downstream water users will loose its resources due to 4MCM/year evaporation from 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[6]) 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 reservoir area and irrigated area have been informed or consulted, or whether they participated in the design of the projects.

- Representatives of the upstream communities that will be affected directly by the reservoir of the dam, informed the Commission that they have not been consulted directly. How compensation of individuals and compensation of the affected communities is foreseen is not described in the report nor communicated with the people in these communities.

2.2 Main recommendation

The Commission recommends to remedy the essential shortcomings and therefore provides guidelines for a new EIA (see chapter 4). Because the shortcomings are that fundamental, it is recommended to prepare this new EIA report in accordance with the EIA requirements as stated in the Environmental Protection Law (1995) for the Wadi Surdud project. A river basin plan is necessary to develop and assess the alternatives in the EIA study as proposed by the Commission. 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:
The groundwater balance of the Wadi Surdud catchment in the area downstream of Al Kadan (Figure 1) was determined by Van der Gun and Wesseling (1991). According to these authors, a total amount of 99 MCM/y flows into the Quaternary Alluvium, while 183 MCM/y flows out of the Quaternary aquifer. So, there is a net water imbalance, indicating that the storage of the aquifer is being consumed. This imbalance is a problem, since there is no long-term sustainability of water resources in the Wadi Surdud Tihama area, leading to adverse social and economic effects.

[6] Douglas L. Vermillion & Said AL-Shaybani (2004). Small dams and social capital in Yemen. How assistence strategies affect local investment and institutions. IWMI Research Report Nr. 76. Colombo, Sri Lanka.

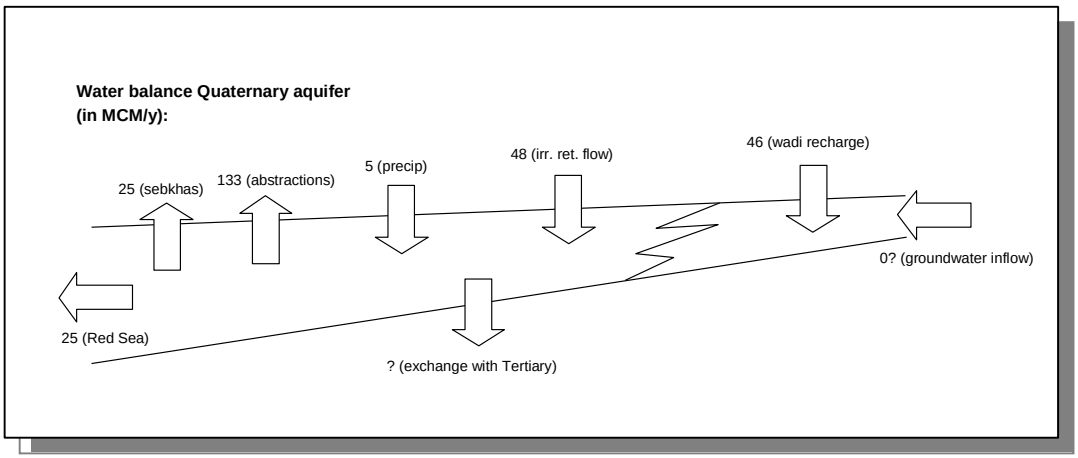

Figure 1: Water balance of the Quaternary Alluvial aquifer, which is considered to be the most important aquifer in the area downstream of Al Kadan (Van der Gun and Wesseling, 1991).

However, the components of the groundwater balance are not sufficiently known, and therefore our knowledge with regard to groundwater flow processes occurring in the Quaternary aquifer is far from complete. There are two arguments in support of this observation:

- The volume of water flowing from the Quaternary aquifer into the Tertiary aquifer or vice-versa is usually discarded, but in essence this amount is not known;
- Groundwater level data of two wells in 2006 (Table 1) are similar to groundwater levels in the same wells in 1993 (Van der Gun et al., 1995). This might suggests that groundwater levels have remained stable for the last 14 year, and that over-abstraction of the aquifer –causing groundwater level declines- might not have been occurring at such an alarming rate as mentioned by Van der Gun and Wesseling (1991). However, it is clear that data from two wells are by far insufficient to come to conclusions.

Table 1: Groundwater level data of two wells in the Tihama plain and part of Wadi Surdud. Data apply to the year 2006 (NWRA data, received in the field)

Map sheet	Name well	Elev.(m)	Coordinate		G.W.L. (May)	G.W.L. (Aug)	G.W.L. (Nov.)
			UTM-north	UTM-east			
1543C2	WRAY 3A	190	1681696	291103	51.76	52.31	51.56
1543C1	WRAY 4A	135	1690694	307952	pump	34.90	32.89

The Commission has not been able to obtain sufficient information on actual or perceived problems in agricultural production in the project area, because of limited information supplied and unwillingness of some key respondents to meet the Commission.

3.2 Proposed project and impacts

With regard to Package I and II of the Project, the Commission noticed that the impacts of the proposed project as presented in the available project documents are incorrect and even misleading.

Environmental aspects

1. The construction of the dam will only increase the total water deficit of the Wadi Surdud area downstream of the proposed dam. At present, surface water inflow is already more than fully used and re-used, while the creation of a lake behind the proposed dam will increase water loss due to evaporation. The yearly amount of evaporation from the lake was estimated by ACE consultants to be around 2.0 to 2.5 MCM. However, two remarks have to be made here:

- the monthly values used by the consultants (Sheet 1-8 in Annex 2.1 of Volume 3 of the Final Report Phase 2) are consistently lower than the monthly evaporation values used in Table 2.1 (same report), of the Ad-Dahi meteorological station, while the Bani Yusuf records should not be used. This because the Bani Yusuf is at an altitude of 1560 meters above sea level (the proposed dam site is at 350-400 meters above sea level).
- the area of the reservoir used to determine evaporation losses by the consultants (again Sheet 1-8 in Annex 2.1 of Volume 3 of the Final Report Phase 2) is consistently lower than given in Fig. 2.9 of the same report.

The Commission estimated that the total evaporation loss from the lake is in the order of 4 to 5 MCM/yr, which is twice the amount calculated by the consultants. This is based on the following data: the reservoir is situated at Normal Conservation Level of 386 meters above sea level, a reservoir area is 1.8 km^2 (based on Fig. 2.9 of Sheet 1-8 in Annex 2.1 of Volume 3 of the Final Report Phase 2), and the evaporation figures of 2356 mm/year from Ad-Dahi meteorological station. Such a large volume of water is **simply lost** from the entire water balance of the Wadi-Surdud Tihama region. To put this loss in the right perspective: compared to the total amount of water used for spate irrigation, situation 1991 (around 10.7 MCM/yr; Table 6.4, page 64, van der Gun and Wesseling, 1991), an estimated evaporation loss of 4 to 5 MCM/yr directly results in a reduction of about 40% of water available for spate irrigation, situation 1991. This reduction will have social as well as economic consequences that need to be described.

2. The Quaternary sediments near the foothills mainly consist of coarse, permeable alluvial fans (Figure 1). Therefore, a major part of water released from the dam, will infiltrate in these alluvial fans and recharge groundwater. The Commission estimates that in the case of controlled and delayed release of water from the dam, extensive aquifer recharge processes will take place, thereby drastically reducing the availability of water for surface water irrigation.

Package III of the proposed Project

With regard to Package III of the Project, the Commission identified the following problem:

When new village water supplies are being installed including the construction of village groundwater wells, the abstracted groundwater may be subject to both microbiological and organic chemical pollution. With regard to microbiological contamination of groundwater and in order to provide the villages with safe drinking water, well site

selection should be based on the assumption that chlorination of abstracted groundwater does not take place. Organic chemical pollution of groundwater may take place in the vicinity of irrigated areas due to leaching of pesticides and herbicides. A proper assessment of the present extent of microbiological and organic chemical pollution patterns in the shallow Quaternary aquifer is deemed necessary.

Social aspects

"Noah people were punished by flood because they disobeyed him, but we did not disobey anyone so why should we be flooded?"

These were the exact words of Sheikh Fadl, a key person in the Surdud upstream area. Together with his fellow farmers, they mentioned to talk on behalf of a 5000 people community: a community that was never consulted nor asked about their opinions, perceptions or needs as regards to the Surdud Dam project. Sheikh Fadl and the other farmers cannot imagine that any financial compensation will ever make up for their loss of approximately 300 hectares of fertile lands, fruit trees, their houses or their community. They compared losing their lands to losing any part of their bodies, it can never be repaired.

They resented being bypassed by government officials and requested to be talked to directly instead of other sheikhs who are not a direct stakeholder in the area and who they believe, have negotiated compensation amounts with officials on their behalf.

Of the total farming community downstream of the proposed dam depending on surface or groundwater coming from Wadi Surdud, about 30% will, according to the feasibility report, directly benefit from the proposed dam project. Given the fact that all water is already consumed, this implies that the rest of the farming community, the majority, will experience minor or major water losses as a result of the project.

4. GUIDELINES FOR EIA

4.1 Approach and scope of the study

The Commission assumes that the main objective of the proposed dam is to increase agricultural production through to improved water availability. The Commission calculated that this objective cannot be achieved because 4-5 MCM of water will be lost yearly due to evaporation from the reservoir created by the dam. To tackle the problems in Wadi Surdud downstream of Al Kadan, alternative solutions have to be studied in an EIA. To be able to develop these alternatives a water balance and a basin plan are required.

Therefore, the Commission recommends to develop a Wadi Surdud basin plan and a water balance as part of that plan and subsequently an EIA in which the alternatives are developed and impacts of the alternatives will be compared.

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 sectoral 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 the area downstream of the site where the main dam is constructed at Al Kadan, including the Sebkhas and the coastal area. And the area

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

The study area for the EIA is the entire water basin of Wadi Surdud, including the quaternary aquifer and coastal area along the Red sea as far as affected by Wadi Surdud. It is recommended to use the boundaries of the Surdud basin (Region 3.3) as presented on the map: Water resources management regions (NWRA, 1999).

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

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 Surdud, for practical reasons defined as the area overlying the quaternary aquifer charged by Wadi Surdud, downstream of Al Kadan (the site where the first weir was projected).

The Commission recommends to use the ecosystem services provided by Wadi Surdud (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. As a consequence the study area will be significantly larger than the project area, encompassing the entire upstream catchment area of Wadi Surdud.

Since any intervention in the water resources system in the project area will have downstream consequences, the study area necessarily also encompasses the coastal stretches influenced by Wadi Surdud or its associated aquifer.

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 information minimally required is a water balance for the entire basin, including a distinction between present upstream versus downstream water uses, planned future interventions, and their consequences for the water balance. This provides necessary data on the present and future availability of water at Al Kadan.

However, when decision making has to take into account the trade-offs between upstream versus downstream development of water resources, including the social, economic and ecological consequences of such decisions, a basin plan is needed. Such a basin plans defines the priorities in water resources development within the boundaries set by the overall availability of water within the basin.

The Commission recommends that such a basin plan will be drafted for the Wadi Surdud basin before any major investment decisions are taken[7].

The water basin plan should provide the following information:

- 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 and the part downstream of the proposed dam;
- water use and water consumption for each of the identified stakeholders (water users) as listed in section 4.4 b.

Following the approach of the UN Millennium Ecosystem Assessment (MA, 2003 [8]) Wadi Surdud and its associated quaternary aquifer 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 subsoil avoids evaporation losses and provides opportunities for agriculture. It is unknown how much water presently reaches the Wadi Surdud dam site and

[7] 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.

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

further downstream. The data used in the feasibility study date back decades. In recent years small dam construction in the upper catchment has intensified, most probably resulting in decreased availability of water due to higher evapotranspiration (reservoir evaporation losses and intensified agriculture) in the upper catchment region. Spate irrigation in the project area has been largely taken over by groundwater irrigation. The project aims at enhancing spate irrigation by improved infrastructure.

- Water supply for irrigation through groundwater pumping: groundwater is pumped for irrigation. The present rate of groundwater exploitation is assumed to be unsustainable, as stated earlier, implying that the level of exploitation exceeds the annual recharge from rains and river floods. According to the feasibility study presently over 30.000 people active in agriculture in the Tihama plain depend on water originating from the Wadi Surdud, predominantly from groundwater, supplemented with spate irrigation and some rainfall.

- Agriculture on fertile floodplain soil. The deposition of sediments has created soils suitable for agriculture in the river valleys and in the Tihama floodplains. Presently some 30.000 farmers fully or partially depend on the Wadi Surdud for spate or groundwater irrigation in the coastal plain. In the area foreseen as reservoir farmers depend on 300 ha of cultivated land, based on permanent base flow irrigation.

Domestic water supply

- Public water supply from groundwater: groundwater is the main source of public water supply. Intensifying land use, lack of sanitation, and the use of agrochemicals are threats 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 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. Lack of sanitation and recycling of water 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 river valleys, where finer sediments have create 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. Maintenance of terraces is said to be neglected in the upper catchment which may lead to increased erosion and an increased sediment load of the wadi.

- Maintaining underground fresh-saltwater balance in the 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 and gradually moves inland.

Biodiversity

- Providing habitat for biodiversity: the area of the proposed reservoir is rich in bird species. In a relatively barren surrounding, the lush green environment with a permanent flow of water provides an important bird habitat.

- 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 an reliability of public water supply and vigilance of primary health care services.

- Maintaining the sebhka wetlands along the coast: the quaternary freshwater aquifer reaches the surface near the coast. Evaporation near surface groundwater has created saline marshlands of importance to migratory birds along the East Africa – West Asia flyway.

Fisheries

- Influencing coastal fisheries: in earlier days the spate waters from the Wadi reached the Red Sea thus providing an important influx of sediments and nutrients in the coastal sea. Nowadays, this only seldom happens. The Commission has not looked into this matter in any detail. However, from a national water management perspective it is relevant to have some estimate of the influence of reducing the flow of all wadi's to the coastal seas. It may have a significant impact on productivity of fisheries resources. For the present study we suggest to leave this aspect untouched.

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 proposed by the Ministry of Agriculture and Irrigation**. Alternative 1A: This can be the construction of weirs and a storage dam as proposed by the Ministry of Agriculture and Irrigation. Site selection of the dam has to be justified. Operational rules for the dam have to be provided.

   Alterative 1B: The Commission recommends to consider also the pro posed construction of diversion weirs without a storage dam. In this alternative, spates could be diverted effectively while no water is lost due to evaporation from the storage reservoir.

2. **Alternative for sustainable water use**. Sustainable water use in the entire basin should be the guiding principle for this alternative. For the development of this alternative one could think of the following building blocks:

- Allocation of water to the different users. This implies that water will be taken form one user and given to a (new or more productive) user. This involves a change in the traditional water allocation and which might conflict with existing water rights.
- Increased water efficiency in the delta by applying the improved irrigation approach as applied in for example the World Bank ground water and soil conservation project[9].
- The only opportunity to increase the available amount of water is the construction of a desalinization plant for public water supply. For reasons of energy efficiency such a plant is preferably built in combination with a power plant in, for example, Hodeidah.

3. **Alternative economic development**. There are indications that presently little or no water is "lost" in the study area, and groundwater sources are allegedly "mined" (i.e. water extraction exceeds yearly recharge), leading to the observation that water resources management is unsustainable. As a consequence, it may be impossible to develop alternatives from a water sector perspective only to return towards a sustainable situation. Given the autonomous development probably leading to intensified upstream water use and thus reduced availability in the project area, one should also consider an alternative in which cultivated land is taken out of production and new job opportunities for farmers have to be developed in other sectors. A linkage with the desalinisation and energy plant mentioned under alternative 2 to solve domestic and industrial demand for water and energy is suggested.

4. **Autonomous development** as a reference situation / alternative also providing the base line information for the water basin plan. 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 region, 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;
   - extraction of water from the spring zone in Wadi Surdud for Sana'a 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.

[9] The Ground water and soil conservation project is a World Bank project approved in 2004 aiming to assist the government of Yemen in promoting ground water conservation in farming areas and increasing surface and ground water availability. the project has been evaluated positively in 2007.

4.4 Impacts of the alternatives

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.
- Breeding of disease transmitting organisms: expected vector breeding site in relation to human presence near breeding site results in number of potentially exposed people.

Biodiversity

- Maintaining biodiversity: change in habitat of species with internationally recognised status (red listed)
- Maintaining sebkhas wetlands: change in quality or surface area of wetlands.

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 Tihama zone 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, 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 (CBA) 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 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.

Table 2: This table provides an overview of a qualitative assessment of the expected impacts of autonomous development (without project) and the proposed dam project on the reservoir site and the area downstream of the dam, expressed as changes in ecosystem services (+ is more, - is less; this is not a value judgement). It provides an example how alternatives can be compared and is based on expert judgement by the Commission.

	Autonomous development		Alternative 1A: Proposed project (dam + weirs)	
Agriculture				
Water supply for spate irrigation	-/+	Upstream development will reduce availability. Climate change may lead to higher rainfall.	++	Spate irrigation will be enhanced for an estimated 9.000 farmers.
			--	Reservoir will lead to additional evaporation of water and decreased water availability for downstream users
Water supply for irrigation through groundwater pumping	-	Overexploitation already probable, leading to lowering ground water tables.	--	Evaporation losses and enhanced spate irrigation near the reservoir will lead to reduced infiltration further downstream. About two-third of the population depending on agriculture will experience deteriorating conditions (about 20.000 people).
Agriculture on fertile floodplain soil	0	No change	--	Loss of 300 ha of productive land in the reservoir area.
Domestic water supply				
Public water supply from groundwater	-	Overexploitation and lack of sanitation are a threat to groundwater quality	+/--	Project aims at improving public water supply; however, water quality parameters not taken into account in the presented project, leading to public healthy risks. Overall groundwater situation will deteriorate as a result of the other project components.
Natural resources				
Over-seasonal storage of (ground)water	-	Quality may deteriorate due to lack of sanitation and over-exploitation by agriculture	-	Evaporation losses and enhanced spate irrigation near reservoir will lead to reduced infiltration further downstream. Reduced inflow of freshwater may further deteriorate groundwater quality
Sediment transport and deposition	?	Increased sediment load is expected due to decreasing maintenance of terraces in upstream catchment. Sediments are value for land improvement. Impact of increased sediment load on hydrology is unclear.	--	Lifetime of dam is limited to due sedimentation in reservoir; or extremely costly sediment removal operation required. Not taken into account in the feasibility study.
Maintaining underground fresh-saltwater balance	-	Overexploitation of freshwater will lead to further saltwater intrusion.	--	Loss of water will aggravate the situation, especially at the downstream part of the wadi where wadi flow will be reduced by the project.
Biodiversity				
Maintaining biodiversity	?	No information available	-	Reservoir will destroy rich and diverse habitat. The new habitat will be less favourable.
Vector breeding	0	No change expected. Quality of health services determines the severety of the associated health problems	-	Reservoir will create breeding ground for snails and maybe mosquitoes. Unclear if people will be directy affected as people will be relocated (where?).
Maintaining sebhka wetlands	?	No information available	?	No information available

4.5 Mitigation

Mitigating measures to prevent or reduce negative environmental or socio-economic impacts of the identified alternatives must be described as part of the alternatives.

4.6 Public participation, compensation and resettlement

Public participation

Assuming that the proposed alternatives will be developed, assessed and compared as part of a basin plan, it is recommended to use good practice guidelines for participation and awareness raising of all affected stakeholders in the development of the basin plan. It is obvious that besides the identified stakeholder gender issues should be considered from the start.

In any case stakeholders should be informed and involved during the following phases in order to get the necessary commitment for the implementations of the projects:

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 added towards the EIA report.

Compensation and resettlement

In case of the alternative 1A – proposed construction of dam and diversion weirs – the following is recommended because people have to be resettled:

- All people that will be affected directly by the reservoir have to be well informed actively about there rights and opportunities by an independent party. They could be supported by an NGO. Information sharing is the first priority principle for

participation. In many cases opposition to a project arises due to lack of information or mis-information.
- The needs of especially the farmers that will be replaced should be identified including their needs for social services, drinking water supply etc.
- A resettlement plan has to be included in the EIA report and should be discussed with these farmers. The resettlement plan has to be set within a national policy framework, in case this is not available yet.
- The procedure for compensation should be developed and should be explained and become publicly available. In the compensation plan a distinction should be made between community and individual compensation. All affected people should compensated even those without a land title.

For resettlement 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.