ENVIRONMENTAL SOCIAL IMPACT ASSESSMENT (ESIA) SUMMARY

Project Name	**:**	Thwake Multi-purpose Dam Project
Country	**:**	Kenya
Project Number	**:**	P-KE-E00-009
Department	**:**	OWAS
Division	**:**	OWAS 2

1. INTRODUCTION

1.1 Thwake Multipurpose Dam is a project under the Tanathi Water Services Board (TAWSB) and entails harnessing of the fluctuating flows of the Athi River and the seasonal water from Thwake River. The dam will provide water supply for domestic, livestock, irrigation, hydropower and even industrial activities in the beneficiary districts. It will largely serve areas in Makueni and neighbouring districts but also certain parts of Kitui based on topography.

1.2 The current access to clean water in Kenya is estimated at 90% in urban areas and 44% in the rural areas while the national average stands at 57%. At the same time, provision for safe sanitation stands at a national average of 80% (95% urban and 77% rural). This makes Kenya a "chronically water scarce" country. Water availability currently stands 647m^3 per capita and is projected to fall to 245m^3 per capita by the year 2025; noting that the international minimum is 1,000m^3 per capita. Kenya's water resources are also highly vulnerable to climate variability which often results in floods and droughts; inadequate storage capacity currently limits the ability to buffer against the water shocks or shortages.

1.3 Among the worst hit by water shortage is the greater Makueni and Kitui Districts that are among the notably arid and semi-arid land (ASAL) areas receiving annual average rainfall of between 200mm – 900mm and 800 – 1200mm per year in the lower and higher zones respectively. The project areas get an annual average rainfall of 500mm per year that is also unevenly distributed over time with long periods of dry weather. As a result, sources of water are unreliable, far apart and of poor quality.

1.4 Thwake Dam was first proposed for construction in 1953 during the colonial days and again in the 1980s. However, the project was never undertaken. Significant numbers of intervention projects in water and sanitation have been undertaken in Makueni district and other areas in the southern part of eastern province, but the problem of water shortage continues to worsen particularly with regard to its sustainable availability. The proposed multi-purpose dam is being designed to serve the greater Makueni district with Kalawa, Kathonzweni, Kibwezi and Makindu as the main target areas. Other areas to benefit include sections of Wote, Nguu and Mutito Adei areas.

1.5 The scope of the ESIA included

- Discussions in association with TAWSB, NEMA and other affiliated lead agencies to confirm the scope of the environmental issues and studies for this proposal.
- Environmental studies (desk and new field investigations and community consultation as required) to identify anticipated environmental impacts of the

proposed project.

- Identification of potential mitigation measures and discussion of these with TAWSB, the engineers and others so as to analyze practicality and likely cost.
- Finalization of recommended mitigation measures required during design, construction and operation of the project
- Development of cost estimates of the mitigation measures.
- Preparation of a project-specific Environment Management Plan / Mitigation Management Action Plan that meshes with AWSB's overall Integrated Environment Management Plan.
- Assistance to TAWSB in submission of findings to NEMA and subsequent discussions with NEMA and other agencies as required during their assessment procedures.
- Carrying out of a Social Economic Survey
- Carrying out of a census of population to be affected by the project and preparation of desegregated data.
- Identification of socio- economic impacts of the project to the stakeholders.
- Carrying out of an aerial survey of the project area and cadastral survey of the land parcels to be affected and accompanying list of the registered land owners
- Determination of the land to be acquired and the tentative compensation values for both land, permanent, semi-permanent and temporary structures and both cash and subsistent crops.

2 PROJECT DESCRIPTION AND JUSTIFICATION

2.1 Description: Thwake Multipurpose Dam has been identified by TANATHI Water Services Board (TAWSB) as a strategic facility to supply water to the semi-arid greater Makueni District and the adjoining areas downstream. Following feasibility studies of covering the entire district, it was established that water is a priority to all the residents in terms of livelihoods and social requirements. The overall ecosystem will also get transformed to the benefit of the communities. The dam is proposed to be located immediately downstream (~1km) from the confluence of Athi and Thwake rivers in Mavindini Division (on the Makueni side) and Kanyangi Division (on the Kitui side) while the flow back will extend into Kathulumbi Division of Mbooni district to the northwest of the dam site. The proposed dam will cover an area of approximately 2,900ha spanning Makueni, Kitui and Mbooni districts with a catchment area spanning about 10,276km2 reaching as far as the Ngong hills, Kikuyu escarpments and the lower reaches of the aberdares. The project is designed to serve among other locations Mavindini, Kanthuni, Kitise, Kithuki, Kathonzweni and Mbuvo in Makueni district and other areas within Kibwezi district downstream of the dam site as well parts of Kitui district that are favoured by the topography of the project site.

2.2 Justification: Residents in the greater Makueni District and the region in general, are forced to walk distances of up to 10km in search of water for livestock and domestic use. The little water found is mostly of inferior quality effectively risking the people's health and hygiene. This is clearly depicted in the reported cases of water borne ailments (diarrhea, intestinal worms, bilharzias and skin problems). Therefore the proposed dam is a necessary intervention that will address water

scarcity and in turn open up the area for development and improve the socio economic status of the involved areas. The dam will open up the area for development in terms of activities such as fishing, tourism and the fact that the dam axis may provide a causeway that will open up the area by providing social and economic access between Makueni and Kitui Districts. The overall ecosystem of the project area stands to get transformed to the benefit of the communities

3 POLICY, LEGAL AND ADMINISTRATIVE FRAMEWORK

3.1 Environmental Impact Assessment is a tool for ensuring new projects and programmes incorporate appropriate measures to mitigate adverse impacts to the environment and peoples' health and safety as well as enhancing sustainable operations with respect to environmental resources and co-existence with other socio-economic activities in their neighbourhood. Recent GOK efforts aimed at formulating a clear policy strategy has culminated in the enactment of a new legislation on water management. The Water Act 2002 is aimed at harmonising and streamlining the management of water resources, water supply and sanitation services (see outline and sample extracts in annex IV). Necessary policies and legislation that ensures annual environmental audits (EA) are carried out on every running project, activity or programme and a report submitted to National Environmental Management Authority (NEMA) for approval and issuance of relevant certificates. According to the Kenya National Environment Action Plan (NEAP, 1994) the Government recognized the negative impacts on ecosystems emanating from industrial, economic and social development programmes that disregarded environmental sustainability. Following on this, establishment of appropriate policies and legal guidelines as well as harmonization of the existing ones have been accomplished and/or are in the process of development. The NEAP process introduced environmental assessments in the country with among the key stakeholders being industrialists, business community and local authorities. This culminated into the development of the Policy on Environment and Development under the Sessional Paper No. 6 of 1999.

3.2 The EIA regulations are applied in accordance with the provisions of the Environmental Management and Coordination Act (EMCA) of 1999. Kenya passed the EMCA in 1999. The main function of the EMCA is to provide for the establishment of an appropriate legal and institutional framework for the management of the environment and implemented by the National Environmental Management Authority (NEMA). The proposed project shall be conducted under the guidance of Government of Kenya laws including policies, regulation, legal and institutional framework including;

- The Environment Management and Co-ordination Act, 1999
- Environmental Management Regulations
- The Factories Act (Cap. 514)
- The Water Act 2002
- Water Rules
- The Public Health Act (Cap. 242)
- Physical Planning Act (Cap286)

- Local Government Act (Cap. 265)
- The Land Planning Act (Cap. 303)
- Land Acquisition Act (CAP. 295)
- The Penal Code (Cap. 63)

3.3 In addition, the relevant AfDB policies, guidelines, procedures and safeguards below supplement the National Environmental Legislation:

- African Development Bank (2000). *The African Development Bank Group Policy on Good Governance.*
- African Development Bank (2001). *Environmental and Social Assessment Procedures for African Development Bank's Public Sector Operations*.
- African Development Bank (2001). *Gender Policy*.
- African Development Bank (2001). *Handbook on Stakeholder Consultation and Participation in ADB Operations*.

4 DESCRIPTION OF THE PROJECT ENVIRONMENT BASELINE CONDITIONS

4.1 General Overview:

Makueni District is within the ASAL areas with limited rainfall, relatively elevated temperatures and high levels of evaporation. As a result, vegetation is generally withered though soils are reported to be fertile. Generally, most parts of Makueni District lie within a water scarce zone with very limited water resources. Kaiti, Thwake, Thange, Uani, Muoni, Tawa, Kiboko and Kiangini contain rivers with very low flows that traverse the area with mainly seasonal tributaries. Suitable sites suitable for earth dams are few and far apart with inadequate catchments while groundwater potential is generally poor in most locations due to poor recharge except for low lying areas and river flood plains. The project area is basically agricultural (though limited by inadequate rainfall), with both cash crops (coffee, cotton, horticulture, etc.) and food/subsistence crops (maize, beans, pigeon peas, cow peas, cassava, sweet potatoes, etc.).

4.2 Topography and Physiography

The dam project area is located on relatively undulating terrain with a general slope running in a north-easterly direction and an elevation of between 600m above sea level in the southeastern to 1,900m above sea level in the northwestern. Among the notable physical features dominating the area and the adjoining districts include Unoa Hills (1,280m above sea level), Malivani Hills (1,340m above sea level) and Nzueni hills at (1,403m above sea level). Further north are highlands constituting surface water sources among them Nthagu, Kitondo and Iuani Hills where seasonal streams originate flowing south and east eventually draining into Kaiti River and eventually into Athi River.

On the Kitui side, Yatta plateau stands high at an average of 1,170m above sea level and creates a major physiological barrier between the larger Makueni and the larger Kitui districts. The plateau runs in a northwest – southeast direction with Athi river flowing in the same direction to the south sits on hard basements that also

determines the drainage trends of the area. Among the outstanding physiological features on the Yatta plateau and within the immediate proximity of the dam project area include Kanyangi hill (1,160m a.s.l.), Kilisa hill (1,146m a.s.l.) and Ndandoni hill (1.056m a.s.l.). This is in addition to numerous depressions and valleys as well as notable peaks.

Basement activity has dominated history of the area and has controlled the geomorphologic evolution as well. The rocks of the area (mainly tertiary strata) rest directly on the Basement system and generally have a gentle easterly slope. Most of the land surface and related landforms has been interfered with by human economic and settlement activities over the years through massive excavations, charge of drainage pattern and clearing of vegetation. Notably the eastern direction of the area is dominated by a gentle slope, while other direction is fully dominated by slope intercalated by ridged valleys.

4.3 Drainage

The project area falls within the greater Tana and Athi drainage basin which includes mostly the central and eastern parts of the country. Management of water resources in this drainage mainly falls under Tanathi Water Services Board that sits in Kitui Town, though the upper sections of Athi river basin are under the Athi Water Services Board sitting in Nairobi. The drainage pattern of the greater Makueni District (now comprising of Makueni, Mbooni East, Kibwezi, Nzaui and Kathonzweni) is highly influenced by the Athi River and its tributaries (Kambu, Kaiti, Kiboko, MtitoAndei, Thwake, Thange, Uani, Muoni, Tawa and Kiangini among others) rising from the central highlands running eastwards toward the Indian Ocean as the Galana/Sabaki River. The flow route of the river in the area follows the topography trends. Due to the flat terrain, clear catchments and un-cohesive soils, flush rainfall has the potential to flood or wash down infrastructure (roads and bridges) and, therefore, there is evidence of drainage structures (culverts, drifts and bridges across major river streams). Furthermore, farmers and landowners have internalized soil control measures including terracing.

The Yatta Plateau is the main influencing physiological feature to the north of the dam area on the Kitui side. While Athi River runs southeasterly direction on the southern edge of the plateau following its alignment, part of the watershed and tributaries are to the north of the plateau and join Athi River far downstream of the plateau. Among the stream is the Tiva river and its main tributary Mwitasyano river (seasonal) that traverses Kitui Influencing general drainage towards Athi river.

4.4 Hydrology

Thwake dam falls within the Athi Catchment drained by the Athi River basin and its tributaries. The hydrology is, therefore, influenced by the flows from Nairobi's river system (Nairobi, Ngong, Mbagathi, Ruaka, Ruiru, etc.) in the upper reaches of the catchment that spans as far as Ngong hills, Kikuyu Plateaus and the lower slopes of the Aberdares. Nearer the project area, are notable rivers (most of them seasonal) including Thwake, Tawa, Kaiti, Iuani and Kalawa rivers upstream of the

proposed site while Kiboko, Makindu, Muoni, Kiangini, Mbanya, MtitoAndei, Kibwezi, Kambu and Thange rivers discharge into Athi River downstream of the dam location. From the Kitui side, the streams discharging into Athi River include seasonal rivers Tiva and its tributary Mwitasyano and their smaller streams. Tsavo and Voi rivers join the river far downstream of Kitui district in TaitaTaveta district. Physiologically, the hydrology is influenced by the rainfall potential in Mbooni hills, Nzaui hills, KiimaKiu, Muumandu Hills, Kilungu hills and Iuani hills to the west of the project area where most of the streams originate from. The Yatta plateau alignment determines the flows to the main Athi River, and limiting inflows and surface runoff from the Kitui side into Athi River. It would also limit flow of water into the Kitui from the dam site.

Due to the stream network combined with effective drainage and gentle slope, Makueni and Kitui districts has not reported cases of significant flooding. There were no ready records on flow trends of the rivers for use during this study due to low level hydrological monitoring resulting from their seasonal nature. All the streams contribute to the Sabaki river system flowing down to the coast.

4.5 Water Resources

Major sources of water in the region include earth dams, boreholes and seasonal rivers (it is only Athi River that is permanent). Only about 29% of households in Makueni district have access to adequate water in dry seasons and 41% in wet seasons (similar situation experienced in the neighbouring districts. Many of the sources that provide water are unsafe and only 18% to 22% of the population have access to safe water in the dry and wet seasons respectively. Distance travel to water sources range from 5 – 10km (Makueni District Profile, AMREF 2000).

Athi River is physically coloured (brown) due to inflows from the catchments upstream and other pollutants from as far as Nairobi city, as well as upstream urban settlement effects. The observed physical water quality showed high levels of turbidity and suspended matter associated with the catchment status. It is also expected that the water could have high residual levels of agro-chemicals from the potential areas upstream, which include industrial pollutants' residuals arising from industrial activities in Nairobi City and Athi River towns. Sampling of river water was carried out on the Athi River for analysis. Sampling points were selected at strategic locations upstream and downstream of the proposed dam site. The analysis was carried out at AgriQ Quest Limited (NEMA Certified), a water quality laboratory. Among the water quality aspects analysed include,

(i) Low dissolved oxygen,
(ii) High nutrients (N, P, K) as nitrates, phosphates,
(iii) High suspended matter and turbidity (colour)
(iv) Elevated dissolved solids,
(v) High alkalinity but relatively neutral,
(vi) Could be high in calcium and sodium contents (the two elements determining sodium absorption ratio (SAR),
(vii) Heavy metal residuals (Fe, Mg, Mn, Cr, Pb, Ni, Cu, Cd, Co, Bo, Al, etc.)

(viii) Biological content including faecal coliforms, algae and other aquatic micro-flora.

Households in Makueni and the adjoining districts (Mbooni East and Kitui West) are dependent on two main categories of water sources as per 4.6 and 4.7 below.

4.6 Surface Water Sources

The main surface sources of water in the project area (Thwake, Muoni, Kaiti, Kalawa, Kiangini, Mbanya, Thange and Uani rivers among others) flow west – east general direction and has sources from Mbooni Hills in the North while other tributaries originates from Kikima and Kiu hills to the East. The rivers and their tributaries do not only influence surface water sources in the area but also groundwater recharge capacity. Most of the rivers are semi-permanent (seasonal) draining into Athi river system while most of the tributaries are seasonal.

Specific sources included KambiyaMawe and Kikumini dams and Kaiti River as the notable surface water sources for Wote Division. Sources in Kalawa division include Kyamakuthi, Mkuku, Yumbuni and Kiatirieni earth dam as well as access to the seasonal Kalawa stream, Thwake river and Athi river with the latter being the only permanent source. Kathonzweni division benefits from about 9 earth dams provided by various groups including the Red Cross (Ituka and KwaMusele dams), CDF initiatives, World Vision, Catholic Church and the Ministry of Water. Kikuu and Athi River are also accessible whenever there is surface of sub-surface flow. Finally, notable sources in Nguu division include Nthunguni and Mwingati rock catchment dams as well as the seasonal Muoni and Kikuu rivers.

During dry seasons, small sand holes of between 0.5m and 2m are used by the local consumers and often by water vendors to extract water from the riverbeds. More than 50% of water consumers in the urban centers and the District in general depend on surface and sub-surface water sources. A significant number of households have installed rainwater harvesting systems (direct from roofs) and communal rock catchments systems. Where rock catchments have been provided, storage tanks and water kiosks have also been installed under the management of the same communities. A good example is found at Mathangathi village in Mavinding Division.

4.7 Groundwater

Groundwater is perhaps the most reliable source of water in Makueni district, though exploitation is limited by unsustainable depths, poor yields as well as the associated costs. For example, Wote Water and Sewerage Company extracts water for public supply from a borehole constructed in 1947 while a host of many other private and institutional boreholes exist in various parts of Makueni district. Wote Division has the highest ground water yield and also has the most boreholes in the area in terms of number and presence, with over 25 boreholes as compared to an average of less than five in other divisions. There are more boreholes in the lower zones including Kibwezi, Kitui and Mutomo districts.

4.8 Biodiversity

4.8.1 Vegetation

The project area depicts a homogenous mix of plant species adapted to dry conditions and low rainfall experienced throughout the year. About 80% of the area anticipated to be inundated has a rich accumulation of life and dead biomass that will not be allowed to be covered under water due to the implications on water quality thereafter. Human activities have significantly eliminated natural vegetation for agriculture and settlement, but indigenous plants are still notable in most areas. River basins are the worst hit by the reclamation due to availability of water. Forested areas are confined to the hill tops (approximately 2% of the forest cover) while lower areas have been cleared to pave way for commercial, residential and institutional activities. At the site, elevated areas (Kathukuni hill, Kilisa hill slopes and Kanyangi hill) are among zones with very high biomass accumulation comprising of indigenous trees and shrubs.

The greater Makueni district has a total of 5 gazetted forests and 4 un-gazetted forest areas covering 25 km2 and 5 km2 respectively. In addition, it seems efforts in encouraging landowners to plant trees for farm forest or other noise with close 30% willingly do it. Key forest products in the region include timber, poles, fence posts, charcoal and wood carvings. The five gazetted forests (Nthangu, Mbooni, Makuli, Kibwezi and Kilungu) are estimated to produce over 3,000m3 of timber in addition to volumes of firewood every year. Makueni District (and most of Eastern Province) has been undergoing massive agro-forestry and the results are visible, though the tree species are mainly exotic. Successful zones in this regard include Mavindini, Wote, Kathonzweni, Nguu, Mbooni, Kilome and Kaiti among others.

Among the major notable plant species include:

i) Grasses – Chlorisgayana, Common star grass and Themedathriandra,
ii) Poisonous weeds – Solanumincanum and Daturastramonium,
iii) Acacia species – Acacia tortilis, Acacia melifera and Acacia Karki
iv) Shrubs – Banalities aegypttica and Lantana kamara,
v) Horticultural crops like pawpaw, mangoes, maize, oranges, and bananas among others,
vi) Indigenous trees like Croton megalocarpus and Exotic trees

4.8.2 Animal Species

Historically the area had a wide variety of wild animals. These include the Elephants, African Buffalo, Grey Duiker, Black backed jackal, lesser kudu, spotted hyena, olive baboon. The animals are concentrated there due to increasing human settlement and agricultural activities. There have been cases of human wildlife conflicts involving the Hippos and crocodiles, the baboons and velvet monkeys are a nuisance as they are notorious crop raiders. Hyrax and squirrels can be observed all over the area. The fish in the area are mainly found are Common Carp Cyprinuscarpie, Claris spp, Barbusspp, Momyrusspp, Labeospp

and the eel anguliaanguila. The proposed project is expected to attract additional aquatic animal species to location (hippos, crocodiles, snakes, etc.).

4.9 Geology and Soils

4.9.1 Geology

The geology of Makueni and the neighbouring districts is characterized with Achaean gneisses of the Basement system. These are the oldest rocks in the area comprising of quartz-felspathic gneisses and biotite gneisses beneath the recent soils. The project area overlays a Basement System, which in the low lying areas is characterized by low groundwater, yields. The base rock is observed to only recharge fast when it is adjacent a riverbed that provides direct infiltration of water. This explains the great depths attained to strike reliable aquifers. It is also notable that boreholes drilled on Basement rocks running in parallel trends within short distances hardly interfere with each other due to the special morphological strata in the area that limits lateral flow of underground water. This is the kind of base rock running across Athi River at the point proposed for the dam embankment.

4.9.2 Soils

Most areas around the Makueni and Kitui Districts are generally covered by deep sandy alluvium and red sandy soils in addition to patches of black cotton soils and murram that exist at the project site. Typical soils are sandy (eroded from the base sedimentary rock) and contain little organic matter and hence have low fertility. Valleys and river flood plains, however, have notable productive soils due to accumulation of silt and minerals though they are limited by lack of adequate rainfall. Though most areas have been cleared of vegetation for agricultural purposes, and soil conservation initiatives seem to have been integrated in the land use practices through construction of terraces in almost all cultivated land. There is, however, still notable siltation (soil loss into river beds) in most rivers in the area. Soil fertility is high in most areas, but productivity is hampered by poor rainfall.

4.10 Rainfall

The hills to the north and central parts of the District highly influence the climate in Makueni District. These higher zones are cool and wet and receive 800mm – 1,200mm rainfall per year whereas the low lying areas are hot and dry receiving 200mm – 900mm rainfall per year. The project Districts receive scarce rainfall throughout the year with an average of 500mm per annum spread over two seasons, a situation that contributes to the serious scarcity of surface water sources in the area. Rainfall is also unevenly distributed over time and space with long periods of dry weather. The long rains occur in March/April while the short rains occur in November/December. Low rainfall is attributed to the trends in winds from the ocean towards the central highlands and high temperatures. Due to the rainfall fluctuations and long dry spells, the generation of silt from the catchments (especially from the Thwake river basin) is relatively high. High flash floods; therefore, bring down heavy loads of silt (sand) towards the location of the dam

(tonnes of sand were observed in the area). From Table 2, it can be observed that the maximum rainfall occurs in November-December, March-April and May. June-September has the minimum rainfall.

4.11 Temperatures

Makueni and Kitui Districts in general experiences homogenous climatic conditions characterized by high temperatures during the day measuring up to 32oC and low temperatures at night at an average of about 25oC. During the dry season between May and October extreme heat is experienced in the low lying zones while the high altitude zones experience relatively cool temperatures. The high temperatures experienced in the low lying areas cause high evapo – transpiration and moisture losses from soils and plants

5 PUBLIC PARTICIPATION

5.1 Public participation followed AfDB requirements and was mainly achieved through direct interviews, observations, questionnaire administration, holding stakeholder and public meetings. Those consulted included Tanathi Water Services Board; opinion leaders within the community; local politicians; local members of the Provincial Administration consisting of the District commissioners; District officers; area chiefs and their assistants. Other people interviewed included representatives from relevant government ministries and departments including Ministries of Lands; Environment and Mineral Resources (NEMA); Public Health and Sanitation; Water and Irrigation; Gender, Culture Sports and Social Services; Water Resources Management Authority (WRMA), Kenya Forest Services, Kenya Wildlife Services and the Makueni District Steering group.

5.2 The local consultative meetings were conducted at the following markets:

i) Miksi market in Mavindini Locations, Katithi sub-location,
ii) Katithi Market in Mavindini locations, Katithi sub-location,
iii) Syotuvali market in Kathulumbi Location, Syotuvali sub-location,
iv) Kanyangi market in Kanyangi location,
v) Kanzokeani market in Kathonzweni Division

5.3 Stakeholders Views and Opinions

There is strong feeling that mitigation measures against negative impacts should be formulated and implemented with strict monitoring. The foreseen negative impacts included human – wildlife conflict, diseases (Malarial among others), displacement of animal watering points, insecurity, and disturbances of animals' migration to other areas. Among the key issues recommended to be addressed are:

i. Compensation should be done systematic and according to the law once survey and all land related cases for some parcels are sorted.
ii. Provide security to the neighborhood, dam site and the campsite
iii. Alternative livelihoods for those losing land should be supported for over an agreed duration.

iv. There should be expansion and increase of relevant communal facilities (schools, health centres, and water facilities among others) in the host communities to cater for the increased population due to immigration
v. All casual as well as some technical jobs should be reserved for the local population and there should be no importation of workers
vi. Irrigation canal should have sub canal
vii. The irrigation, farmers should form membership groups
viii. Give those compensated a grace period of 6 months to get another land

6 PROJECT ALTERNATIVES

6.1 Alternative Sites for Thwake Dam

According to the National Water Conservation &Pipeline Corporation, as compiled by the Ministry of Water, the Thwake project site is generally suitable with exceptional river water resource and suitable point of confluence of major rivers. Based on this information, several sites in the District were explored for suitability of Dam construction. The proposed site was selected following extensive studies taking cognizance of each of the various site attributes, namely environmental, social and sustainability, technology and commercial consideration, including the strength and stability of the water flows in the area, proven technology, benign environmental setting, low population density, security of the area, water availability and road accessibility. Consequently, sound justification and analysis conclude that the current proposed location of the dam appears to be the most suitable location because of e.g. low density of the population of the area and the steep to vertical configuration of the banks of the river in the area of the reservoir resulting in less impact than if the bank gradient was smoother.

6.2 Alternative Storage Option for Thwake Dam

Storage options were investigated for the proposed Thwake Dam. All the storage options were based mainly on one dam axis and other dam variables. The dam axis is located downstream of the confluence of Thwake and Tana Rivers. In the absence of a design of the proposed dam, the evaluation of the alternatives is limited to the reservoir storage, reservoir yield and the volume of earthworks quantities. The assessment has evaluated the hydrology of the Thwake and Tana Rivers downstream of the confluence of the two rivers.

6.3 Alternative Ancillary Facilities for Thwake

In addition to the alternative dam sites considered previously the current Feasibility Investigation is looking at alternative transmission line routes to closest urban centre such as Konza city among others as well as worker camp locations. These alternatives have been included as far as possible in this ESIA report to ensure social and environmental considerations are included in the investigation of these alternative Project components. However, further environmental assessment will need to be undertaken for the ancillary facilities during final design. The alternatives that have been considered include controlled releases of water from the dam and provision for outlet to supply the

neighbouring emerging city like Konza upon the final design. Besides the issues of costs and yield that led to the current choice, on the public health point of view the analysis indicates that the water quality will be better with the water treatment works located at Thwake and is consequently preferred. Further, the major health impacts are in relation to the location and construction of the dam, not so much the treatment works.

7 POTENTIAL IMPACTS

7.1 Sedimentation

Typically, dams and reservoirs intercepts close to 90% of sediments from the catchments.

Mitigation Measures include:

Sand check dams upstream and downstream of the dam, assisting communities at the dam site to get organized into groups for an economic disposal of the accumulated sand ahead of the dam construction. Ensuring that economic interests of downstream sand users are considered.

7.2 Water Quality

Water stored in a dam or reservoir is subject to undergo certain physical, chemical and biological transformations. Thwake dam location will be faced with residual faecal and organic matter from pit latrine, graveyards and waste holding sites from the displaced homesteads and social locations. This would particularly impact on the health of the consumers and their animals. Nutrients (nitrogen and phosphorous) are expected from the geological emissions, organic decompositions and surface runoff discharges from settlement areas and markets around the dam. This could create potential for eutrophication of the dam water hence complicating treatment of the water. Turbidity and suspended matter from the entering flows, surface runoff discharges and organic reactions among other sources. This situation will lead to limited light penetration that has got direct linkage to biological quality of the water.

Biomass accumulation in the dam area could render high humic (organic concentration) levels in the dam water and further downstream. It also has a potential to increase the nutrients and other minerals associated with plant decaying matter. Limited water mixing, aeration and light penetration reduces available oxygen resulting into anoxic conditions at the lower layers of the water. Anaerobic conditions in the lower layers of the water generate carbon dioxide, methane, hydrogen sulphide and create low pH scenarios. Due to the lowered pH, the geologically held iron and manganese and other heavy metals are likely to be released into the water effectively changing the water quality. Implications on water quality would be felt by the water consumers in the immediate location of the dam as well as social and ecological dependents of Athi River downstream in terms of habitat pollution, people's health and cost of water treatment at various stages.

Mitigation Measures

Instituting a broad water quality monitoring system, clearing of vegetation materials (live and dead) at the dam site before the area is excavated and inundated, maintaining appropriate records on water quality as required by the law, avoiding inundation of pit latrines and graveyards, encouraging proliferation of aquatic macro-fauna along the periphery of the dam to ensure natural aeration of the water, identifying specific point sources of water pollution (cattle pens, market centers, agrochemical use points, etc.) for isolation and management.

7.3 Water Loss

The project could increase through exposure to weak geological points and also increased surface area. The fractures and fissures provide a potential for infiltration of water into the sub-surface and possibly creating springs on the lower areas. The water loss pathways effectively imply;

(i) Unaccounted for water losses from the dam structures such as fissures in the base rock and hence unachieved desired objectives,
(ii) The scenario could also affect weaknesses to housing foundations downstream of the phenomena,
(iii) Micro-climate moderation (lower temperatures and higher humidity) through increased atmospheric moisture arising from evaporation,
(iv) Potential losses at consumer points through wastage and leakages.

Mitigation Measures

(i) Geological profiles throughout the area proposed for inundation should be established to identified areas of weaknesses and appropriate strengthening measures incorporated,
(ii) Sub-surface water infiltration trends on affected areas should be established and monitored over a period of time with respect to effects on houses and other structures,
(iii) Indigenous trees and shrubs that have low water dissipation capacity should be encourages around the dam buffer zone to minimize loss of water through evapotranspiration processes,
(iv) Ensure enhanced maintenance of the distribution pipelines,
(v) Introduce economic and financial initiatives towards water saving and responsible utilization at consumer points.

7.4 Species Diversity

Construction of the dam implies removal of existing vegetation and/or possibility of submerging of others. Riparian aquatic vegetation could develop on the new water/land transition zones with new species introduced and flourishing of the existing species (grasses, reeds, cyperus spp., etc.), completely new ecosystem could also be established

Mitigation Measures

Undertaking a separate inventory of the unique biodiversity within the affected areas for purposes of preventing extinction. Providing an ecologist to oversee

monitoring and management of ecological changes around the dam ecosystem, engaging Kenya Wildlife Services in monitoring and establishing community interests and values in the evolving ecological setting and enhance economic benefits from the same.

7.5 Hydrology

Depending on the dam design, the flow regime of Athi River could change for considerable distance downstream. Implications downstream will be;

(i) Reduced average high water levels downstream the basin,
(ii) Constant distribution of silt deposition (land fertility for downstream farmers) will be confined on a narrower flood plain since flood flows will be reduced,
(iii) On the other hand, current sub-aquatic ecosystems will be compromised on the higher flood plain zones of the river basin thus slightly changing the basin characteristics (this change in trend has not been quantified at this stage),
(iv) One advantage is the reduced channel erosion during high peak flows, reduced water quality (turbidity and suspended matter) and delta protection further downstream at the river mouth.

Mitigation Measures

Ensuring compliance with the water resources regulations at all times. At least 30% of the base flow should always flow in the stream to sustain ecological and social requirements downstream, reactivating gauging stations around the dam and downstream to monitor effects of the dam to the river basin over time.

7.6 Positive Social Impacts

The positive impacts anticipated from the project include;

(i) The standard of living of the beneficiary residents will improve such as to include income generation and productivity, housing, health, etc.,
(ii) The distances traveled and time spent in search of water will be reduced hence the beneficiaries (especially women and children) using the energy and time on economically and socially viable activities for the families,
(iii) Areas suitably situated to receive water for irrigation will not only help the local communities in sustaining food but also all the residents of the neighbouring districts,
(iv) The dam will also moderate the micro-climatic conditions of the immediate surrounding areas through increased humidity and/or cooling effects,
(v) Enhance the agricultural potential and productivity of the target areas as well as promoting recreation activities,
(vi) Overall increase of the total population and density. This will provide ready markets for goods and services and reduced rural-urban migration as people get employed in the upcoming opportunities in the area.
(vii) Raising the population growth and density rate resulting from natural growth and immigration that further enhances the availability of labour and provides ready markets for goods and services thereby spurring economic growth of the area
(viii) Reduced rural-urban migration as people get employed in the upcoming opportunities in the area.

(v) Upgrading of certain roads, necessary for the construction and maintenance of the dam, will contribute to a better transport and travel networks. This will have positive social and economic impacts in the area.

7.7 Negative social Impacts

They include displacements and re-settlement to alternative locations; increase in human-wildlife conflicts cases especially from the increase in populations of aquatic animals notably crocodiles and hippopotamus; trauma due to the relocation of graves; disruptions to subsistence fishing activities; health and safety of the residents from possible enhanced vector breeding (mosquitoes, snails, etc.); attraction of wildlife to the area and water contamination; accidental drowning etc..

Mitigation Measures

They include initiating public education and awareness; implementing an all-inclusive participatory Land Acquisition and Resettlement Action Plan (LAP & RAP); adopting economic activities that co-exist with wildlife such as eco-tourism; provide counseling services and spiritual support to those affected by the inundation and reburial activities.

7.8 Positive economic Impacts

In addition to water supply, the dam has numerous economic benefits to the local residents such as to include fishing, tourism, significantly increase the price of land. The project will be a major boost to realizing the vision 2030 and achievement of the MDGs through eradication of extreme poverty and hunger by enhancing income sources and food security. Farm management is likely to improve as possibilities for capacity building are likely to accompany increased potentiality of the land. This will result to increased crop yield and food security. Enhanced crop yield and food security resulting from change in farming with more reliance on irrigation, as opposed to reliance on rainfall, and increased use of inputs including certified seeds and fertilizer. Further, farm management is likely to improve as possibilities for capacity building are likely to accompany increased potentiality of the land.

By providing direct and indirect local employment, the project will ease the direct resource dependency pressures in the district's sectors especially agriculture thereby easing soil erosion. Provision of water from the proposed dam has the potential to enhance development and growth of local markets as more economic and social interests arise. More important is the opportunity to improve sanitation and hygiene in these markets as opposed to the currently potential threat of diseases in almost all the markets. Reduced poverty levels, increased incomes and improved livelihoods will result from the project. Dam construction and maintenance will increase consumption from the local markets, emergence of other associated economic opportunities and activities including tourism, fishing, trade, production of high value crops and transport among others. Further, these will increase the Gross Geographical Product (GGP) of the area as well as the tax base for the government.

7.9 Negative Economic Impacts

Sections of the river banks (specifically Thwake) seem to have a special value to the livestock. Goats and sheep chew the earth (whitish deposits) along the banks and it is likely that this value may not be found anywhere else away from the river flood plain. Some access roads will be inundated breaking means of internal communication from one community to another. It is however, expected that alternative routes will be established as part of the project. There will be loss of prime land especially that on the riverine. Those with farms next to the river will be denied access to it and therefore there will be substantial loss of high value and productive land farmland on the riverine.

Mitigation Measures

Establishment of a program to enable affected communities to benefit from the economic potential of the resources in the area before displacements. This would include controlled burning of coal and making briquettes, cutting wood for construction, harvesting building materials (sand and stones) and any other movable natural resources. Compensating and resettling people prior to commencement of the project. Undertaking detailed risk assessment of the dam to downstream ecosystems, supporting communities to form organisations that can sand harvest and market products such as fish, crops and livestock.

8. ENVIRONMENTAL HAZARD MANAGEMENT

8.1 Risks for this project could include

- dam breaking,
- spillways giving in,
- raised storage tanks collapsing,
- overflow onto upstream roads and bridges,
- accidental drowning of residents and their livestock.

The risks will be dealt with as part of the risk management plan.

10. MONITORING PROGRAM

Project Activity	Key Impacts	Areas of Concern	Management Action Plans and Responsibilities	Timeframe and Cost Estimates (KShs.)
Preparation Activities • Surveys • Camp site setting • Material holding site setting	Social conflicts	• Dam site and its immediate surroundings, • Identified transmission pipeline route • Katumbua hill slopes • Selected camp site,	• Notify all affected land owners before surveying their land, • Involve the local administration and other social groups in recruitments	Preparatory stages No direct cost implications
General preliminary Construction Activities o Land acquisition, o Catchment alignment	Acquisition process of required land for the dam construction Acquisition of extra land for buffer zone and camp sites from the landowners, Negotiating with land owners for identified construction cam sites, Limiting access to water for residents the dam distance upstream of the dam site.	Dam site and immediate surroundings Katumbua hill slopes Identified transmission pipeline (dam site to Katumbua hill (8km) via Katithi market, Identified locations for sand traps upstream (estimated 1 ha. for each every 5km along Kalawa, Thwake and Athi rivers)	Negotiate additional land required with neigbouring landowners, Undertake a comprehensive land acquisition and resettlement action plan (LAP & RAP) as a basis for compensations, Compensate appropriately any land acquired for the main dam, buffer zones, water treatment plant, sand traps, the pipelines and storage tanks, Sensitize landowners on necessary land use changes for the protection of the dam. **Responsibility:** NWCPC, MWI, provincial Admin. Contractor	Preparatory stages **LAP/RAP could cost ~KShs. 3,850,000.00** **Compensations estimated at ~KShs. 500,000,000.00**
Site clearing			Confine vegetation removal to	

Project Activity	Key Impacts	Areas of Concern	Management Action Plans and Responsibilities	Timeframe and Cost Estimates (KShs.)
Vegetation removal, Biodiversity degradation , Access to the river and livestock watering point.	Riverine vegetation removal, Damage to related aquatic biodiversity, Disruption of existing access to the river by the residents, Blockage of livestock watering and mineral eating locations	Entire dam site (Katithi, Mavindini, Syotuvali, Kathulumbi, and Syomunyu sub-locations) Thwake – Athi confluence Thwake water point about 5km upstream Thwake – Kalawa confluence	the surveyed dam extent only, Plan for vegetated buffer zones with suitable indigenous tree species around the dam and along the banks of the rivers, Provide for approve direct access to the river upstream and downstream of the dam, Involve community on dam clearing activities. Allow landowners disposal off trees and other vegetation on their land through controlled commercial charcoal burning and briquette making, Removal for offsite disposal all plant matter and organic residual for future water quality safety. **Responsibility:** NWCPC, MWI Contractor NEMA and MWI for surveillance	Initial construction period No direct cost implications
Site clearing Removal of houses, sanitary facilities and cattle pens,	Pollution of water from human waste residuals, Pollution at waste disposal sites Cultural aspects of graves relocation,	**All** affected settlements on relevant sections of Katithi sub-location in Mavindini, Syotuvali sub-location in Kalawa and Syomunyu sub-location in Yatta Division. Settlements along the pipeline	Undertake a controlled and supervised decommissioning of pit latrines (current and abandoned) on the affected settlement locations, Undertake a procedural relocation of all identifiable	

Project Activity	Key Impacts	Areas of Concern	Management Action Plans and Responsibilities	Timeframe and Cost Estimates (KShs.)
	Future effects to water quality from manure residuals	route Settlements on Katumbu hill slopes	graves to locations pre-agreed and identified by each of the relevant families, Allow the landowners to dispose off manure from cattle pens at market rates, **Responsibility:** TAWSB, MWI and Contractor Public Health and NEMA for surveillance	
Construction components Earth moving	Siltation of river downstream, Lubricants and oil spills from construction machinery, Trenching for the transmission pipeline Spoil disposal.	Dam site (relevant sections of Mavindini (Makueni), Kalawa (Mbooni East) and Yatta Division (Kitui West). Katithi market and its surroundings, Katumbua hill slopes and settled foots, Athi River water immediate downstream of the dam site Construction camp sites and access roads	Carry out construction during the dry season, Any oil spills from machines to be contained for safe disposal, Control earth moving to avoid siltation of the river beds Construction to stick to the schedule or shorter period **Responsibility:** Contractor, Supervisor, TAWSB NEMA and MWI for surveillance.	During the construction period **No direct cost estimate on this item**
Construction components Dam formation	Safety of the workers and adjacent communities could be threatened, Possible intrusion to the local communities	Dam site (relevant sections of Katithi sub-location in Mavindini, Syotuvali sub-location in Kalawa and Syomunyu sub-location in Yatta Division).	Maintain all construction equipment in good operating conditions, Provide workers with appropriate personal protective gear and enforce application of	Attention on this throughout the construction period

Project Activity	Key Impacts	Areas of Concern	Management Action Plans and Responsibilities	Timeframe and Cost Estimates (KShs.)
	private life, - Migration into the project area (from within project districts and other parts of the country) - Noise and vibrations from construction machinery - Negative social interactions (cultural interference, immorality, etc.	- Settlements along the pipeline and foothills of Katumbua hill - Settlements around construction camp sites, - Settlements and land use activities around material sites and spoil dumping areas,	the same at all times while at work - Construction work to be undertaken during day-time only, - Provide appropriate sanitation facilities and waste holding bins at the workers camps - Earth moving and excavations be under damp conditions. Dry dusty materials be stored covered,	~KShs. 3m for public education and awareness, ~KShs. 5m for HIV/AIDS and other communicable diseases control campaigns
Construction components Machinery, materials and waste management	- Dust emissions and depositions into settlements and cultivated land, - Emissions from construction machinery into the atmosphere, - Noise from construction activities - Waste discharges from construction camp sites - Material sites management,		- Provide an awareness and sensitization forum for the workers as well as the neighboring communities, especially on communicable social infections such as HIV/AIDS, TB, etc., - Material sites be fenced up for the safety of the neighbouring communities, Responsibility: Contractor and supervisor. NWCPC, NEMA and MWI for surveillance	
Water Abstraction and Use	- Wastage of water at consumer points and distribution network,		- Encourage beneficiaries to give priority to domestic and livestock,	

Project Activity	Key Impacts	Areas of Concern	Management Action Plans and Responsibilities	Timeframe and Cost Estimates (KShs.)
	Low ability and willingness of the communities to maintain hygiene around the dam sites.		communities on the need to boil or disinfect the water before use if obtained directly from the dam. Encourage residents to use the treated water	
Dam Operations User Safety and risks downstream,	Injuries of the operators and visitors, Safety risks of a dam break to downstream aquatic ecosystems, social and economic features. Safety risks of settlements and farmlands along the transmission pipeline, Risks to safety of the settlements at the foothills of Katumbua hill Risks of drowning into the dam to children, the aged and livestock	Downstream of the dam extending down to the Sabaki river mouth at the coast, Occupied dam neighbourhood Settlements along the transmission pipeline Settlements at the foothills of Katumbua hill	Undertake a comprehensive risk assessment study or the dam as part of the pre-commissioning stage, Maintain a fence around the dam with provision for limited and controlled access to the dam water, Enhance close surveillance by the community, especially those living on risk prone areas, Sensitize the communities on dam safety issues associated with the dam. Provide clear emergency preparedness strategies.	Continuous attention ~KShs. 500,000.00 per year on safety and emergency preparedness
Dam Operations Social and economic issues,	Wastage of water, Illegal water application, Illegal water vending (especially if obtained	Areas to be served,	Collaborate with other players in the region on sanitation, health and hygiene awareness creation,	Continuous attention

Project Activity	Key Impacts	Areas of Concern	Management Action Plans and Responsibilities	Timeframe and Cost Estimates (KShs.)
dependants, Water use trends and accountability, Facility Ownership	from the dam), Sand harvesting from the dam area and upstream, Tree harvesting Access to biodiversity resources in the area.	River beds upstream of the dam (Athi, Thwake, Kalawa and other streams)	Develop water use guidelines and costing structures for all consumers and beneficiaries, Sand harvesting to take place from authorized locations only (e.g. sand interception dams),	**~KShs. 300,000 for surveillance activities.**
Dam Operations Institutional Aspects	Non-compliance with water abstraction regulations, Natural Resources Utilization, Water use linkages among the beneficiary communities,	Areas with potential deposits of sand (river beds upstream of the dam in Mavindini and Kalawa divisions)	Comply to the provisions of the Water Resources Management Authority, Comply with sand harvesting regulations, Organize communities for effective and sustainable utilization of natural resources associated with the dam. Establish appropriate water user associations in the areas neighbouring the dam, Establish a specific monitoring system for the dam and its water	Initiate action upon commencement of construction and enhance during operations **~KShs. 300,000 for institutional strengthening (Could vary annually)**
Catchments' Management	Changing land use practices, Enhanced vegetation,	Kalawa divison, Mavindini division and Kanyangi location.	Encourage immediate landowners to take responsibilities of the dam safety, Immediate landowners to be	A continuous activity

Project Activity and	Key Impacts	Areas of Concern	Management Action Plans and Responsibilities	Timeframe and Cost Estimates (KShs.)
	Influenced sanitation trends in the neighbouring homesteads	No significant notable changes in the far reaches of the catchments	motivated into maintaining buffer zones along the river and the dam itself banks, Guide landowners in the catchment change their land use practices.	**No immediate cost estimate**
Decommissioning Phase	Removal of construction camp sites (housing, toilets and washrooms, waste dumps, etc.), Removal of construction residual material holding sites, Effects of material borrow pits left open Disposal effects of wastes and debris.	The respective locations	The contractor to prepare a decommissioning plan of all construction installations and associated sited at least 3 months prior to end of construction.	During construction **No direct cost**
	Removal of part or all of the water treatment plants Demolition of the water distribution tanks, Demolition of the dam structure, Removal of the transmission pipeline	The dam and treatment works locations	Notify NEMA at least one year before the intention to decommission Undertake a decommissioning audit at least six months before the activity and provide a decommissioning plan, Undertake the decommissioning following the decommissioning plan and under supervision by NEMA, .	At decommissioning stage and surveillance thereafter (could be over 50 – 60 years upon commissioning assuming nothing h extraordinary happens to the dam) **No direct costs**

Budget

The project is estimated to cost approximately ksh. 9.2 billion and construction is estimated to take three years spread as follows:

i)	Dam, spillway and draw-off tower	KShs. 5.23 billion
ii)	Water supply	KShs. 0.526 billion
iii)	Hydropower component	KShs. 1.96 billion
iv)	Allowance for land and property compensation	KShs. 0.343 billion
v)	Preliminary and contingencies	KShs.1.76billion

TOTAL KShs. 9.2 billion

The construction period is estimated to take 3 **years**

9.1 Monitoring Parameters

The environmental and social monitoring will involve a continuous surveillance of performance of specific functions during the construction and operation phases of the project. Among the aspects to be monitored will include the following;

i. Construction

(i) Health and Safety particularly of the construction workers and the neighbouring communities,
(ii) Social linkages and interactions with the construction works,
(iii) Interaction with key sensitive environmental features including hydrology, aquatic life forms, soil erosion, vegetation loss, air quality, etc.,

ii. Operations

(i) Safety aspects of the dam,
(ii) Downstream hydrology
(iii) Biodiversity development,
(iv) Land use trends,
(v) Economic features.

9.2 Monitoring Schedule

Environmental/Social Aspect	Monitoring Indicators	Frequency	Remark
Construction			
Environmental pollution during	Air quality	▪ Continuous visual observation, ▪ Measurements quarterly	Mainly dust from earth moving and emissions from the equipment

Environmental/Social Aspect	Monitoring Indicators	Frequency	Remark
construction (Air, Noise, Water, etc.)	Noise and vibrations	▪ Continuous surveillance ▪ Measurements on quarterly	Controlled from equipment
	Water quality	Once a month	Mainly downstream sediment levels
	Soil loss	Continuous surveillance	Extent of erosion in the immediate catchment
Ecological disruption	Vegetation types lost	Quarterly during driving construction period	This will provide the nature of plants species for compensation purposes
	Animal species and loss of habitats (fish, crocodiles, hippos, etc.)	Initial and quarterly through the construction period	Specific habitats need to be marked before construction
Social disruption	Loss of farm lands	Pre-construction activity	
	Compensation and relocation	Pre-construction activity ▪ Review at construction commencement ▪ Review at commissioning stage	▪ It would be expected all compensation and relocations are completed before construction is commenced
	Alternatives to institutions lost (schools, health centres, markets, etc.)	Before commencement of works	This aspect to be addressed alongside the resettlement process
	Acceptance at host areas for displaced persons and adaptability	Before construction period	▪ Constitutes part of the resettlement process ▪ Important to track potential social conflicts
Commissioning			
Waste disposal	Debris at points construction	Upon completion of works	It is a onetime assessment
	Successful decommissioning of construction camps	Upon completion of works	Site rehabilitation and evaluation will be necessary
Operations			
Environmental pollution (air, noise, water quality and flows)	Air quality	Half yearly sampling	Dust emissions, emissions from equipments.
	Noise and vibrations	Half yearly	Machine operations (mainly localized)
	Water quality	Half yearly measurements	Upstream and downstream the plant
Ecological trends	Invasive weeds	Annual survey (speciation)	This will identify new species and provide mitigation measures
	Wildlife habitats and breeding areas	Annual survey (speciation and counts)	Continuous opportunities to be established
	▪ Evolving habitats and species dynamics ▪ Influencing factors	Annually initially then every 3 years	New aquatic conditions expected to evolve gradually

Environmental/Social Aspect	Monitoring Indicators	Frequency	Remark
Hydrology	Flows in the main river stream	Monthly (or during heavy rains)	This is am for challenge for the whole seven folks dam system
	Sediment transportation	Annual measurements at dam entry	This task is necessary for entire cascade system
	Dam capacity variations	Every 2 years	Also a major challenge to the cascade system
Safety from potential dam break	▪ Safety risks to immediate residents and their livestock ▪ Safety risks to downstream residents ▪ Potential features at risks	Safety risk audit every 3 years	Safety audits should also be an integral part of the entire cascade system
Social	Security and safety	Quarterly	▪ Involvement of the stakeholders and local communities would be necessary ▪ Safety of residents from wildlife and risks of drowning
	Access to water (domestic and irrigation)	Half yearly	Safety of residents from wildlife while accessing water
	▪ Land use changes ▪ Cultural trends	Annual surveys initially then every 3 years	An important determinant of social trends
Economic trends	Value of dam to residents (support to livelihoods, fishing, tourism, irrigation, etc.)	Half yearly.	This is an important factor on the CSR front.

11. CONCLUSION

It is also concluded that the project magnitude will be significant such as to impose impacts to the physical and biological environment as well as the social, cultural and economic setting of the area. The negative impacts, however, are identifiable and can be mitigated through design and administrative measures. However, the overall positive impacts of the project far outweigh the negative projects through the mitigation measures outlined for the project.

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