The Act has wide ranging powers; of direct relevance to this EIA are the following Sections:

- Section 47-49 allows for the proclamation of environmental planning areas which would be managed by the Environmental Council and for which an environmental management plan would be prepared.
- Section 51 allows for the minister to declare an Environmentally Sensitive Area.
- Section 56 allows for the declaration of an area as a protected wetland.
- Sections 106 – 113 state that it is an offence to emit pollutants, emit noise or discharges in excess of the standards prescribed.
- Section 141 requires any person undertaking an activity to comply to environmental standards and criteria.
- Section 151 allows the Council to require any person to reinstate the environment to a state as near to the original as possible.
- Section 178 ensures the public right to environmental information and to participate in decision making.

### *3.3.2 Environmental Impact Assessment Guidelines and Audit Regulations (2005)*

The guidelines provide the legislative framework for the impact assessment process from screening of project to review. Report format and qualifications of parties to conduct an ESIA are well elaborated.

### *3.3.3 Wildlife Conservation Act (1974)*

The principal legislation governing wildlife utilization in Tanzania is the Wildlife Conservation Act of 1974. This Act provides the Director of Wildlife with powers to oversee the overall management of wildlife in the country. The Director is in charge of game reserves, game conservation areas, and open lands, while the Tanzania National Parks Authority (TANAPA) is in charge of the national parks (Lawyers' Environmental Action Team (LEAT).

The key points of the Act regarding the powers and responsibilities of the Director of Wildlife are:

- Section 3, which establishes the office of the Director of Wildlife who is appointed by the President.
- Section 9, which provides that no person may carry out hunting activities in the game reserve and game-controlled areas without permission from the Director of Wildlife.
- Section 12, which states that no person may graze animals in the said areas without having applied for and received permission from the Director.
- Section 32, which gives the Director the power to grant licences for the capture of animals for zoological, educational, or scientific purposes or for any purpose he deems in the public interest.
- Section 41, which gives the Director broad powers to issue Presidential Licences to hunt, capture, and photograph animals on conditions laid down by the Director, whether or not such animals are protected by any other provision of this Act or any other written law.
- The Director is empowered to refuse, in the public interest, to issue licences and certificates, or to grant permission to any person. The Director also has the power to cancel any licence, permission, or permit.

### *3.3.4 Wildlife Conservation (Wildlife Management Area) Regulations (2002)*

There is an ongoing review of the status of the Game Controlled Areas and, in conjunction with the WMA Regulations, recommended change in status of some these areas. These changes potentially include change to the Lake Natron GCA.

### *3.3.5 The Forest Act 2002*

The Forest Act delineates the forest types and their management/ ownership. For any development that would impact the forest such as extraction/ exploitation of products, an assessment of impacts is necessary. This can be included in an overall ESIA depending on the nature and location of the development.

The Act sets out penalties and forums for conflict resolution if these should arise.

### *3.3.6 National Museum of Tanzania Act (1980, Act No 7/80)*

The National Museum of Tanzania is a body corporate established by Act of Parliament. It is a scientific educational and cultural institution charged with the duties of collecting, conserving, displaying, and researching on all materials relating to Tanzanian's cultural and natural heritage.

### *3.3.7 The Land Acquisition Act 1967*

Under the Land Acquisition Act, 1967, the President may, subject to the provisions of this Act, acquire any land for any estate or term where such land is required for any public purpose.

Land shall be deemed to be acquired for a public purpose where it is required, for example, for exclusive Government use, for general public use, for any Government scheme, for the development of agricultural land or for the provision of sites for industrial, agricultural or commercial development, social services, or housing or; where the President is satisfied that a corporation requires any land for the purposes of construction of any work which in his opinion would be of public utility or in the public interest or in the interest of the national economy, he may, with the approval, to be signified by resolution of the National Assembly and by order published in the Gazette, declare the purpose for which such land is required to be a public purpose and upon such order being made such purpose shall be deemed to be a public purpose; or in connection with the laying out of any new city, municipality, township or minor settlement or the extension or improvement of any existing city, municipality, township or minor settlement; etc.

Upon such acquisition of any Land the President is compelled on behalf of the Government to pay in respect thereof, out of moneys provided for the purpose by Parliament, such compensation, as may be agreed upon or determined in accordance with the provisions of the Land Acquisition Act, 1967.

The President may also revoke a right of occupancy if in his opinion it is in public interest to do so. Accordingly, the land for which a right of occupancy has been revoked reverts back to the Government for re-allocation pursuant to the existing need(s).

### 3.3.8 Local Government Act, 1982

The Local Government Acts 7 & 8 (1982) gives authority to local governments to regulate matters that are local. Despite the authority of local governments the bylaws should not derogate any principal legislation.

### 3.3.9 National Land Use Planning Commission Act 3/84

In addition to the Local Government Act another act that regulates land use is the National Land Use Planning Commission Act. This Act creates the National Land Use Planning Commission with the main function to prepare regional physical land use plans, formulate land use policies for implementation by the government (Central and Local) and to specify standards, norms and criteria for the protection of beneficial use and maintenance of land.

### 3.3.10 Land and Village Lands Act, 1999

Land Act 4 (1999) and the Village Land Act (1999) replace previous legislation on land, consolidating all provisions by the earlier legislation. The current Acts divide land into public land (Village land), reserved land (land set aside for conservation e.g. National Parks etc.) and hazardous land (that poses danger if developed e.g. 60m from rivers, mangroves etc.).

### 3.3.11 The Town and Country Planning Ordinance

Under the provisions of the Town and Country Planning Ordinance also the President is empowered to acquire any land for a project of public interest. The 1956 ordinance after its revision in 1961, states:

Where it appears to the President that it is necessary to acquire any land within a planning area for the scheme applicable thereto and agreement for the acquisition thereof between the Local Authority and the owner of such land cannot be reached, the President may acquire such land under any law relating to the compulsory acquisition of land.

Without prejudice to the generality of the provision of subsection (1) of this section, the power of the President hereunder shall extend to the acquisition of land which has not been developed in accordance with the scheme applicable thereto which, in his opinion, it is necessary to acquire in order to secure its good development or the proper, orderly and continuous development of a planning area or any part of it or the good development of neighbouring land.

Without prejudice to the provisions of any law relating to the compulsory acquisition of land, the purposes for which land may be acquired under the provisions of this ordinance shall be deemed to be the public purposes.

### 3.3.12 The Land (Assessment of the Value of Land for Compensation) Regulations, 2001

These regulations provide criteria for the assessment of compensation on land, as per market value for real property; disturbance allowance is calculated as a percentage of market value of the acquired assets over twelve months; and transport allowance calculated at the cost of 12 tons hauled over a distance not exceeding 20 km.

The other criteria includes loss of profit on accommodation based on business audited accounts and accommodation allowance equivalent to the rent of the acquired property per month over a 36 month period.

### 3.3.13 Fisheries Act (2003)

The Fisheries Act of 2003 repealed and replaced the Fisheries Act (1970) make provision for sustainable development of fisheries and aquaculture activities taking into account of their possible negative environmental implications.

Of importance to the present project, the Act highlights the strategies for protection and maintenance of the genetic and species diversity as well as protection of trans-boundary aquatic ecosystems.

### 3.3.14 Water Acts and Regulations

This section relates to Water Utilization and Control Act, Amendment and Regulations; Urban Water Supply Act and Waterworks Ordinance; Public Health Sewerage and Drainage Ordinance; and Tanzania Bureau of Standards Act. In the case of water utilization and control of water pollution, at least six different laws have relevance (LEAT).

A water right (WR) must be acquired or use of the water is illegal. A water right is defined as a "right to divert, dam, store, abstract and use water." No water may be used except in accordance with the grant of a water right. A WR serves several purposes. First, it allows the authorities to be aware of the quantities of water being taken from and available from water sources. Second, it provides a framework for allowing authorities to control pollution discharges.

The process for acquiring a WR requires an applicant to apply to the relevant Water Officer for the right to take water. The District Agricultural Officer, District Executive Director and the Regional Water Engineer are then required to make a report regarding the application. The Water Officer must then consult the relevant water board and consider the reports of the above. The public is given the opportunity to object to the application by filing objection at relevant water board. The process for objections is laid out in GN 233, 1975.

Specific standards exist for production of certain products which are certified under the Tanzania Bureau of Standards (TBS) Act. Where the process involves water use, the relevant TBS production standards which address water use will apply.

Discharge Of Effluents/Water Back To Receiving Waters: Standards are established under WUCA for effluents and receiving waters and it is an offence not to abide by these standards before and during discharge into water courses, receiving waters or sewers. If a WR is granted for a mining, forestry, power or industrial purpose, the following narrative standards apply. Users shall:

- Return the water to the same water body or other water body as authorised by the Water Officer
- Return the water substantially undiminished in quality
- Not pollute the water to the extent of directly or indirectly causing injury to public health, livestock or fish, crops, orchards, gardens which are irrigated by the water, or any product which uses the water in its production process.
- Treat the water to meet the [numeric] water quality standards specified below.4
- Third, for commercial, industrial and trade waste systems, no discharge from these sources is allowed into receiving waters without a "consent" granted by the Water Officer. The public has the right to object to granting of a "consent".

Consent to discharge also includes consent to discharge into underground strata. In practice, however, issuance of a WR is deemed to be a consent and no separate "consent" requirements exist. There are numerical standards for the receiving waters themselves (water quality standards), based on the particular category of the receiving water into which the effluent is discharged. Maximum permissible concentrations for different chemicals and compositions are given for the three categories, which are as follows:

- Water suitable for drinking water supplies, swimming pools, food and beverages manufacturing industries, pharmaceuticals manufacturing industries, or industries requiring a water source of similar quality.
- Water suitable for use in feeding domestic animals, in fisheries, shell cultures, recreation and water contact sports.
- Water suitable for irrigation and other industrial activities requiring water of standards lower than those of water in category 1 or 2.

Several provisions of the laws also relate to monitoring of performance. For example, it is required that "returns" (reports) be made by WR holders to the Water Officer setting out the nature of wastes or effluents provided by his use of water. The WR holder shall also install or facilitate the installation at the point of discharge all machinery and other facilities necessary for the taking of samples and the collection and treatment of effluents. In addition, the Water Officer is given powers to require submission of "information" from holder of WRs, and may enter and inspect any premises. Surprise sampling is carried out by the Laboratory Division at Ubungo and includes sampling, analysing, checking water upstream/effluent downstream, etc.

The TBS has also prepared several standards for "sampling methods" of pollution. For example, standards exist for sampling of industrial effluents and for micro-biological examination of effluents. Under their authority to issue product specifications and process standards, TBS may also make surprise inspections.

Enforcement;. where a Water Officer finds a WR holder to be in violation of the standards or conditions of the WR, he may serve a notice of "default" on the WR holder, and give the holder an opportunity to rectify the default. If no improvement occurs within the specified time, the Director of Public Prosecutions may prosecute the WR holder in court for an offence under the relevant Act. In addition, the WR may be revoked or diminished for failure to comply with conditions of the right.

## 3.4 Strategies, Action Plans and Planning

Cognisance of planning activities is needed, particularly community natural resource management programmes, Ramsar Planning and physical development plans such as roads and dams (e.g. the, Ewaso Ngiro South Multiple Purpose Project and the Mta wa Mbu – Loliondo road). Additional planned developments give rise to the risk of cumulative or synergistic impacts when added to this project.

### *3.4.1 Lake Natron Ramsar Management Plan*

The Lake Natron Ramsar Management Plan is to commence 2007. This will be a three year management planning process which will focus on (pre appraisal report prepared by Sangale *et al*, 2001):

- Increasing the baseline date on Natron;

- Raising awareness of local communities concerning the opportunities posed by a Ramsar site, wise use approach, ecosystem approach and supporting policies and legislation to assist in implementing these approaches);
- Zonation of land use for resource management, the preparation of village and zone management plans for sustainable resource management;
- Identification of wise use pilot projects such as
    - promoting incentive measures to encourage wise use,
    - Community Based Wildlife Management Areas development for the Natron basin, (3) Eco-tourism project development,
    - Game hunting phased out in the Ramsar site,
    - Sustainable livestock production
    - Bee keeping,
    - Sustainable agriculture,
    - Sustainable mineral resource abstraction,
    - Sustainable management of fuel wood.
- Establishment of a revenue collection system
- Establishment of suitable institutional arrangements for the wise use of Natron Ramsar Site including trans-boundary collaboration.

Earlier studies by Kobb (K Consult, 2001) recommended the following for the Natron system:

- Designation of the area as a Ramsar site to make it more difficult for national and trans boundary projects with significant environmental impacts to be initiated.
- Publicise the unique character and ecological importance of the Lake and promote its tourism potential.
- Improve security to allow tourism to thrive and to improve quality of life for the Lake's inhabitants.
- The basin should be left as a refuge for wildlife and hunting cease in the Ramsar site.

### *3.4.2 Conservation Plans and Community Managed Areas and Village Land Use Plans*

Community Initiatives: The community at Engare Sero has established a post of "Wildlife and Tourism Officer" who is responsible for monitoring wildlife resources and tourism activities. This is a result of the community receiving royalties from some of the camps established in vicinity of the village.

The Engaruka Village (the site of the Engaruka irrigation ruins) has established a gate levy for tourist vehicles using the main road passing through their village. Tourists are charged USD5/person.

### *3.4.3 Physical Development Plans*

**Road**s
Upgrading of the road from Mto wa Mbu via Engaruka and Engare Sero to Loliondo (feasibility completed in 2000, detailed design ongoing for TANROADS).

**Rail**
Proposed rail link from Arusha to Mwanza.

**Hydropower**
Ewaso Ngiro River (South) Multipurpose Project in Kenya which consists of hydropower plant and agricultural developments (plan prepared for the Kenyan Power Company by a consortium of

companies in 1993). This project is currently on hold partially due to concerns raised by Tanzania.

TANESCO is in the pre-feasibility Stage to develop the waters of the Peninj River for a 30 megawatt power station. Such a development will have secondary infrastructure requirements such as power lines etc also.

**Arable Agriculture**

Communities at Pinyinyi, Moinik and, to a lesser extent at Engera Sero, have been supported to develop their arable agricultural potential through the development of irrigated agriculture. Similarly there is expansion of arable (rainfed) and irrigated agriculture in the catchments of the western tributaries to the Lake.

# 4 SOCIO-ECONOMIC AND CULTURAL ENVIRONMENT

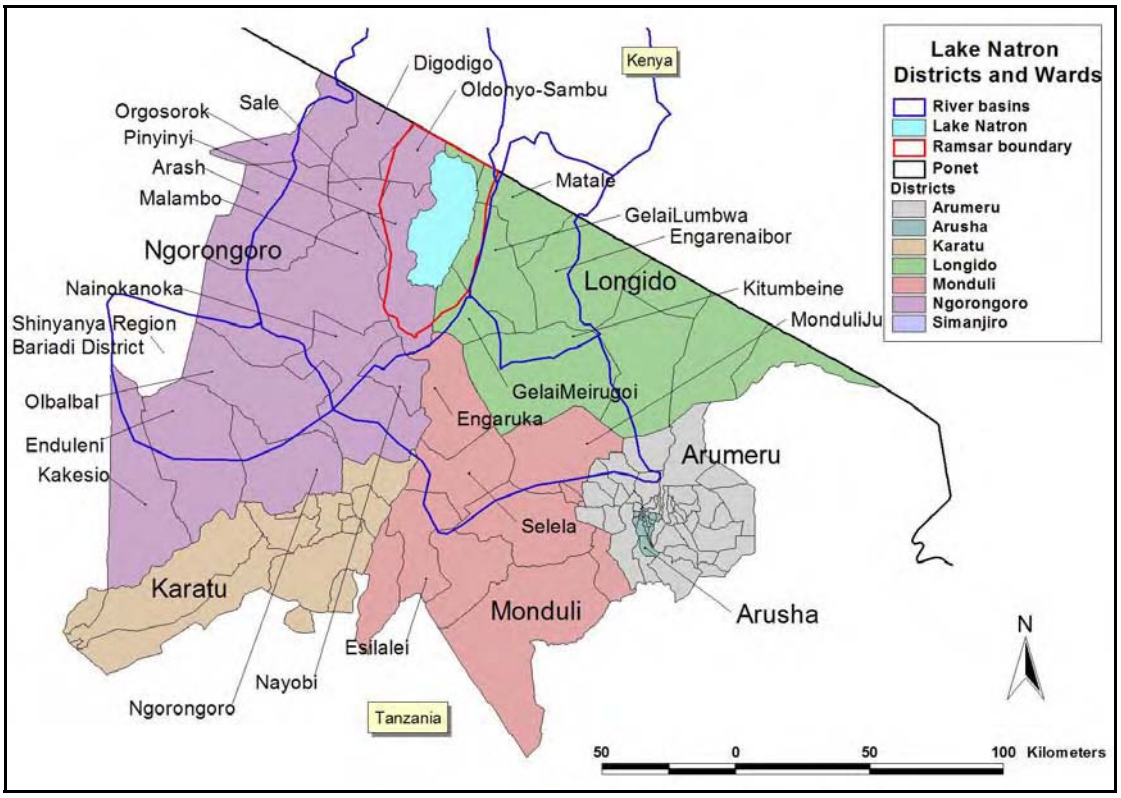
## 4.1 Administrative Areas and Gazetted Land Use

Lake Natron lies between the Districts of Longido on the east side of the Lake and Ngorongoro on the west. Access to the area from the south goes through a third district, Monduli.

In Ngorongoro District, Pinyinyi is the only ward within the Lake Natron area and for Longido District, Gelai Lumbwa and Gelai Bomba make up the wards concerned. In Monduli District, Esilalei, Selela and Engaruka are the wards that provide access to the Lake Natron GCAs (See Figure 4-1).

In the North the Districts of Longido and Ngorongoro are bordered by Kenya and the larger catchment basin for the Lake lies in Kenya.

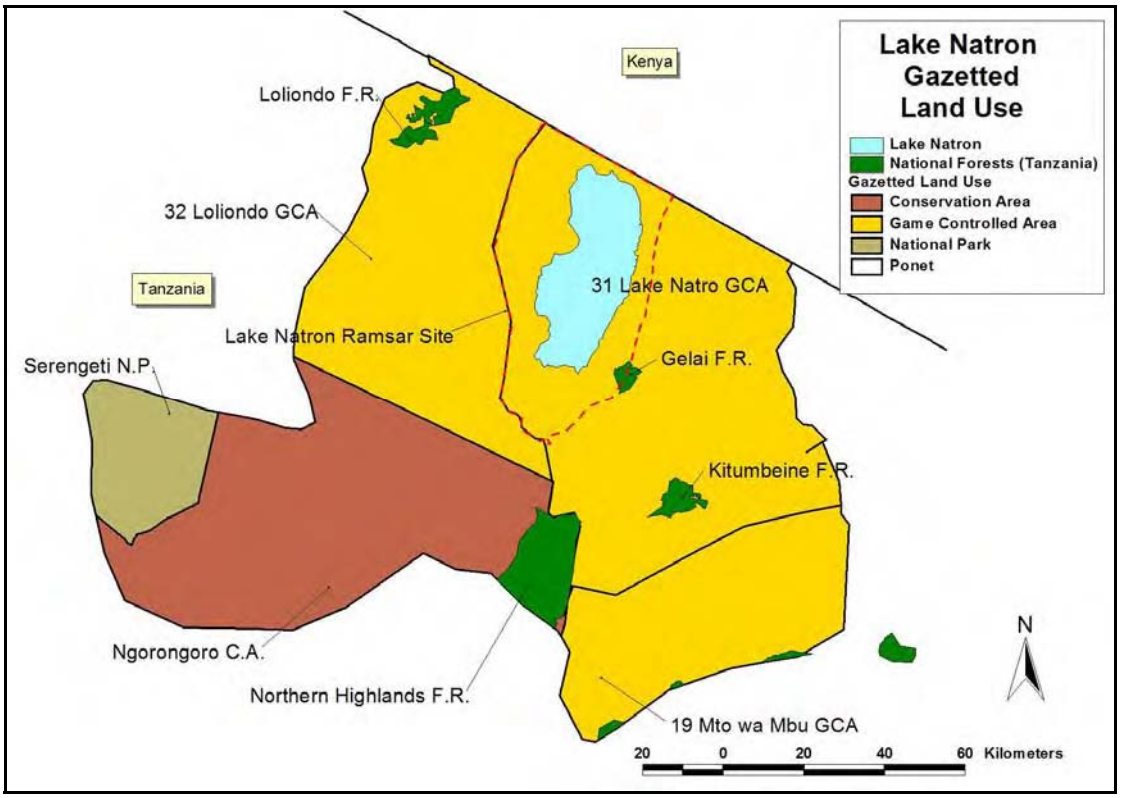
**Figure 4-1: Administrative areas of the Lake Natron and surroundings**




The area around Lake Natron is leased out in two main hunting blocks; Loliondo which covers western plateau and Lake Natron GCA. These are further sub-divided into North and South. Tanzania Game Trackers hold the lease for the Lake Natron North GCA and operate a commercial hunting operation. Lake Natron South is managed by TAWICO.

The Ramsar site boundary crosses two of the District (Ngorongoro and Longido), defining an area that is not linked directly to the existing administrative boundaries. The gazetted (Ramsar and GCAs) land use for the Lake and the land to the west is mainly for conservation and tourism (Figure 4-2).

**Figure 4-2: Gazetted land use of the Lake Natron and adjacent catchments**




In addition to the gazetted land use, there is widespread pastoralism and some rainfed, irrigated arable agriculture and a number of settlements. The Ramsar site falls within the GCA and uses the western boundary of Lake Natron GCA. To the east the Ramsar boundary follows the watershed from Oldonyo Lengai to Gelai and then northwards to Kenya separating the Kipingaine Swamp from the Lake.

## 4.2 Demography

The villages that are within the project area include Engare Sero, Pinyinyi, Alaililai and Londo Losirwa (also known as Magadini). The majority of the population surrounding Lake Natron are the Masai and the Batemi (Sonjo). The Sonjo are mainly found in villages on the western shore of the lake; Engasero, Pinyinyi with some at Engaruka Village. The Masai are the majority and predominate in almost all villages in the project area. Some minority groups such as the Rangi, Chagga, Pare, and Waarusha are found in strategic villages where agriculture, trade and tourism are common.

### Engare Sero Village

Engare Sero village (Pinyinyi ward) is inhabited by tribes from all over Tanzania due to its location at the base of the escarpment and historical activity based here but the dominant tribes are Masai, Chagga, Mbulu and Sonjo. There has been in the past a mining camp operated by the State Mining Cooperation (STAMICO) and this was the base of the township establishment, in subsequent years the tourist attraction for Lake Natron, Oldonyo Lengai and Engaruka ruins and waterfall have built the town to what it is. The village has three sub villages, Leprakash, Engare Sero and Monic. The village population is 4,283 with 2,011 men and the rest are women and children.

**Pinyinyi Village**

Pinyinyi (Pinyinyi ward) is most northern village on the western shore of Lake Natron with three sub villages of Pinyinyi, Masusu and Lorbilini. The population is 4,313 with 2,116 men and 1,323 women and 750 children. The ethnic diversity comprises of Masai, Sonjo, Kuria (from Musoma) and Chagga.

**Londo Losirwa/ Magadini village**

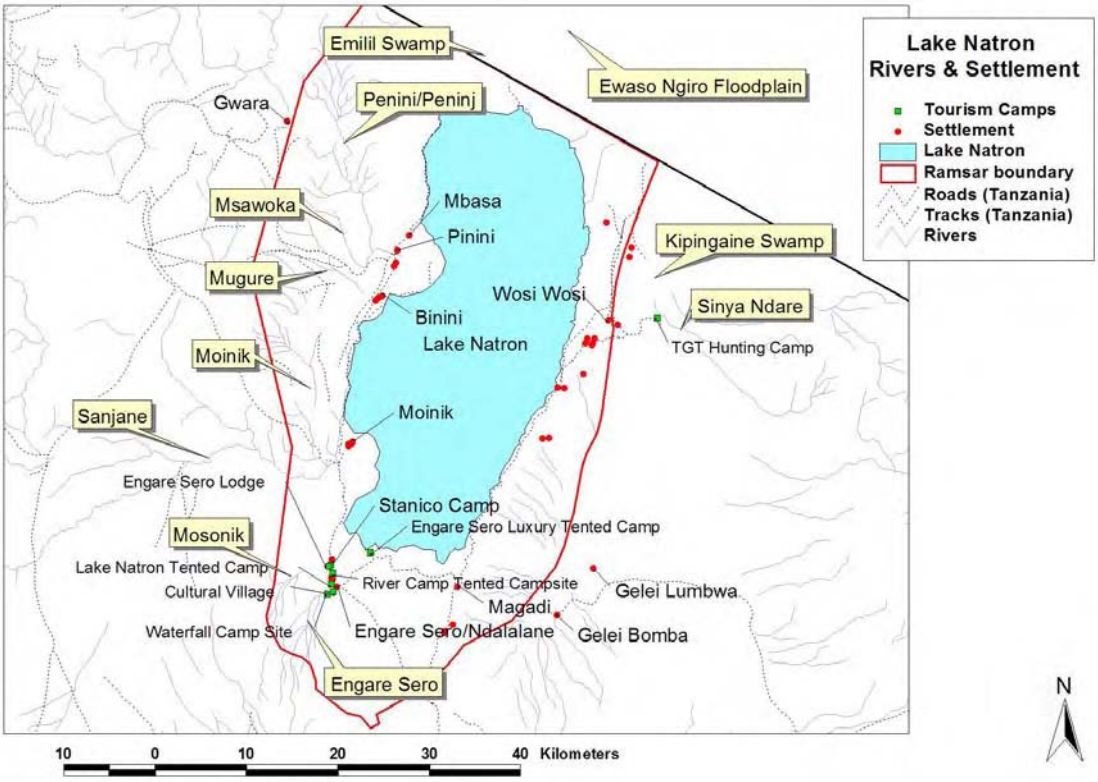
Londo Losirwa also known as Magadini village (Gelai Bomba ward) is located in a new district of Longido. It has three sub villages namely Opraa, Arman, Mariki. It has a total population of 2,400 of whom there are 1,054 men and the rest are women. This is a Masai dominated village.

**Alaililai Village**

Alaililai village is in Gelai Lumbwa ward and is inhabited by 2,586 people of whom 583 are men, 976 are women and 1,027 children. The average household size is recorded as 4 people below the national household size of 6 people. The total household number is 779, out of which 274 are headed by women. It was learned that women headed households are poorer than those headed by men. This is because women have limited access to means of production like land and cattle. Almost all the residents are Masai. This village has four sub villages Mlimani, Il sapukin, Naudo and Wosi wosi.

Of the sub villages in Alaililai, Wosi wosi is the only one within the area of intended project activity. The sub village has a total population of 475, with 102 men, 292 women and 171 children. There are 106 women headed households and the working population is approximately 50% (201) of the total population.

**Figure 4-3: Lake Natron showing the Ramsar boundary, major rivers and settlement**



## 4.3 Infrastructure

### *4.3.1 Accomodation*

The quality of houses in the project area reflects the level of poverty and/ or access to resources for construction. Most of house structures in the villages are made of wood poles plastered with mud and thatched roofs. There are few houses built with brick and roofed with corrugated iron sheets. At Alaililai 409 houses are thatched and 370 houses are made of mud, the only structure with iron sheet roofing is the Lutheran church. At Wosi Wosi all the houses are thatched.

Engaruka chini where the income level is seemingly better 800 houses are roofed with corrugated iron sheets and 500 houses are made of baked bricks while 50 are constructed using cement bricks. Of the 4200 houses 2200 are thatched. In Londo Losirwa there are more thatched houses than those with corrugated iron sheet roofing. And none of the houses are built with baked or cement bricks.

The villages of Engare Sero, Mto wa mbu and Selela have the most modern accommodation facilities in the project area with larger numbers of brick and corrugated iron roofed houses.

### *4.3.2 Transport*

Distances between villages are long and people travel by trucks, Lorries, private cars and donkeys to ferry goods. All these means of transport are privately owned.

At Engaruka village a bus operates between Mto wa Mbu and Engaruka twice a week when there are enough passengers. The poor condition of the road limits the number of vehicles operating this route. Thus fares high, travel times long and access to essential services limited. However, there are efforts to remedy the situation and the Government of Tanzania through its agency TANROADS has commissioned a study to upgrade the Mto wa Mbu to Loliondo road to bitumen standard.

## 4.4 Social services

Social services and related aspects are presented in relation to the three Districts and village specific information used to exemplify on the ground realities. For the District of Longido, information from Monduli District is used to reflect the existing status as most of the infrastructure for information gathering in the new District is still dependent on Monduli.

Social service provision in the villages concerned is poor as elaborated in the subsequent sections and Table 4-1 below.

### *4.4.1 Health and Sanitation*

**Health facilities**

Health services are poorly distributed and provided for in all three Districts. Hospitals, Rural Health Centres and Dispensaries do not receive regular maintenance especially those owned by the Government and as a result all seem to be dilapidated. The dispensary at Selela for example is poorly equipped with qualified staff, medicine and basic equipment.

Poor communication systems (bad roads, no telephones etc.) limit access to the sparse facilities. Communities in Ngorongoro District have only two hospitals to rely on (Wasso and Enduleni). The one at Wasso is closest to the project area. In the District, there are 16 dispensaries, no health

centre and 38 mobile clinics. The existing health facilities are poorly staffed, equipped, with low quantities of drugs and other supplies and thus inadequate to meet the demand.

In the immediate project area there is one dispensary at Engare Sero and another under construction at Pinyinyi. The accessibility to health facilities is on the average 22 kms, with the longest distance being 162 km as opposed to the recommended 0 to 5 kms for Ngorongoro District.

In Monduli and Longido Districts the situation does not differ from that of Ngorongoro. Monduli District had 32 dispensaries by the end of 1999. Five of the dispensaries are centred in urban centres and the rest are in villages. A number of the villages do not have dispensaries and so people travel long distances to access medical services. For example, Alaililai village does not a medical facility and so they have to walk 60 to 65 kms to Gelai Bomba for treatment.

**Prevalence of Diseases**

The top ten diseases in Ngorongoro District are malaria, acute respiratory infection, pneumonia, eye infection, diarrhoea, intestinal worms, Minor surgical conditions, skin infection; Sexual transmitted infections and Urinary tract infection.

In Monduli and Longido districts the ten most quoted diseases as quoted for Ngorongoro with the addition of non – Infectious Gastro-intestinal Diseases.

**HIV/ AIDS**

The magnitude of the problem of HIV/AIDS in the Districts is not readily established due to absence of monitoring system and voluntary testing and counselling centres. The pandemic however is recognised as a factor contributing to low agricultural and economic productivity in the area. One of the challenges for the pandemic is the reluctance/ hesitance of the Masai to adopt preventive measures. It is generally believed by these communities that HIV/AIDS is a normal disease that can affect anyone and is curable. Nonetheless, the Districts are making much effort to spread the HIV education to the Masai people and some progress is being made.

The areas served by the Districts are large and though there is some effort directed towards the pandemic it is minimal. The efforts include formation of Health and hygiene committees to deal with such health matters including HIV awareness campaign among community members of the Masai and Wa Arusha. A challenge for these committees is the low support from Districts officials due to inadequate transport facilities to facilitate monitoring of efficiency of VCT staff in the collection of and storage of data. Consequently, the data submitted to the district headquarter sometimes lack the required detail for planning purpose. None of the villages in the project area have VCT centres or Health and hygiene committees and so this facility is not available for them.

**Sanitation**

More than three quarters of the households in the project area do not have proper sanitation facilities such as pit latrines. Engaruka Chini reported to have only 60 pit latrines. In Londo Losirwa village out of 800 households only 250 have pit latrines with the rest having nothing. Pinynyi village none of the households have latrines.

The use of bushes and neighbours latrines is the general practice. Haphazard defecation has resulted in contamination of ground water sources, consequently into prevalence of water related and water borne diseases in the project area. Typhoid, amoeba and worms are rampant in the project area.

### 4.4.2 Education

The pastoral communities are generally reluctant to send their children to school, particularly girls. This is confirmed by statistics from Ngorongoro District council where it is reported that of the 49 Primary schools with a total of 16,752 pupils, 61% are boys and 39% are girls. The schools are poorly staffed as there is a registered shortage of 187 teachers. The situation does not differ in Monduli District or Longido District where the current teachers' ratio is between 1:65 and 1:236 respectively. Although it was reported that each ward has a primary school, these do not have adequate school facilities such as classroom, toilets and qualified teachers.

### 4.4.3 Water

The main source of water domestic consumption, livestock watering and irrigation is from surface water. Where water is scarce like at Wosi wosi sub village, women in particular travel many kilometres to access water. In these areas, households use less than the recommended daily amount of 25 litres per day per person and the entire household (6 individuals) consumes less than 4 (80 litres) buckets a day. Few households have adequate access to clean and safe water in the project area.

Villages like Engaruka where water is readily available have attracted many immigrants to settle in the village permanently. This is also a prime watering area during the dry season for herds.

In the dry season the pastoralists rely on constructed run off dams on the river beds for watering their livestock. Wosi wosi village depends on saline water from Lake Natron.

### 4.4.4 Energy Sources

There is no electricity in the project area and the few tented camps and institutions use generators. The majority of households depend on firewood for cooking and kerosene for house lightening at night. As a result of overgrazing and population increase it is thought that fuel wood is becoming scarce. Women and girls travel long distances to collect firewood in nearby bushes.

Deforestation in areas where there are woodlands is increasing. There have been some efforts to address the depleting fuel wood problem by SNV which provided training and support to the production of fuel-efficient stove some years back. In some areas (not within the immediate project vicinity) *Eucalyptus* trees have been planted for fuel wood.

### 4.4.5 Development Partners

There are three types of agencies that provide support to the communities; Non – governmental organisations (NGOs), religious organisations and private companies.

The NGOs operate mainly in settlements along the road from Mto wa Mbu. PAM is an agricultural improvement initiative working at Selela. It provides improved seeds to farmers as assisting them strategise and search for markets. ICA is an education based group that is involved in Masai girl education at Engaruka Chini. Other NGOs operating in the Engaruka are TaTEDO and KAKUTE (Kampuni ya Kusambaza Technolojia rahisi) both of which are directed towards the promotion of cheaper alternative technologies. KAKUTE promotes an affordable technology utilising *Jatropha* oil (Mbono) for the manufacture of soap, whilst TaTEDO deals with energy efficient stoves.

The Christian churches are another group of agencies that provide health, education support to people of the different villages. The Lutheran church is building a school at Gelai Lumbwa village.

INTERSAFARIS is a tour company (commercial) that supports some development in Engaruka village. Likewise the tented camps at Engare Sero participate in some village development through the contribution of village fees.

**Table 4-1 Social services available per village**

| Type of service/ Village | Primary school | Milling machine | Water | Mosque | Church | Shops | Medical | Transport |
|---|---|---|---|---|---|---|---|---|
| Selela | 1 | 4 | 15 | 1 | 4 | 4 | 1 | Foot, donkey |
| Engaruka chini | 1 | 3 | River | 3 | 6 | None | | Bus, truck, foot |
| Engare Sero | 1 | | | | | | 1 | foot, bus, donkey |
| Pinyiny | 2 | 6 | River | 2 | 3 | | | Foot, Donkey |
| Wosi wosi | 1 | None | Saline water from the river | None | None | None | None | Foot,donkey |
| Londo Losirwa | 2 | 8 | | 1 | 7 | 2 | 1 Health Centre | Vehicles, foot, donkey |

## 4.5 Household Income

Income levels vary tremendously, based on occupation, gender and even the basic interpretation of wealth. For the Masai wealth is not quantified by money but by ownership of cattle, wives and children. The majority who are livestock keepers and peasants have seemingly low incomes generated from selling their farm and livestock produce at low prices. Income values for business centres are easier to account for in villages like Selela village where the average income per household is estimated at 40,000 Tshs per month. In Wosi Wosi it was reported that, the household income is 25,000 Tshs a figure higher than Engaruka Chini where the average household income was registered at 10,000 Tshs and the houses are of better quality. These numbers suggest that the majority of the people live below the poverty line i.e. 1 USD per day, though it is not a readily established fact as impressed earlier. This conclusion could be made from observations on type of houses of these two villages. In most analyses housing is a wealth indicator and wealthier people normally own better houses than poor families, though in the pastoralist culture this may not hold true.

From a gender perspective, the distribution of income among men and women in the area is uneven. Men own all major means of production like land, livestock and capital while the women are considered as the labour force. However, in Engare Sero village, some women are engaged in income generating activities particularly the sale of beads and other handicrafts.

Food purchase is the main expenditure. This is higher during the dry season when food is scarce.

## 4.6 Land Tenure/ Availability

Up until the 1970's land allocation was done by village government. This system has since evolved and land purchased from individuals who have land to expose off or through customary law as inheritance. There remains however some amount of land under the village government authority. This land can be allocated to the needy but is generally for communal use.

Land is limited in the project area particularly arable land suitable for agriculture. Land along the rivers where irrigation agriculture is possible is considered prime and is all owned by individuals. Land far from the rivers is of less economic value as it is not productive. This normally designated for grazing and construction of public facilities such as schools and medical units. This selective system of land occupancy is evident in the location of the largest settlements in the project area being close to rivers.

## 4.7 Land Use

The three registered modes of land use in the project area, livestock keeping, agriculture and tourism have cumulative bearing on the ecosystem. The main use by the local communities is livestock keeping which utilises most of the land area. Agriculture is limited to the few acres where irrigation is possible along permanent river channels on the western lakeshore. Tourism both photographic and commercial hunting is conducted at specific locations around the lake.

### *4.7.1 Livestock*

Livestock keeping is a traditional and familiar source of livelihood for the majority of people in these three districts. The mode of livestock production is semi-nomadic characterized by a fixed home based with seasonal movement of livestock to exploit spatial and temporal availability of key resources like grazing, water, salt as well as minimal risk of diseases.

Typical livestock include Cattle, goats, sheep, donkeys and local chicken (See, Table 4-2). Livestock provide cash for food and biological manure; the communities regard livestock as a sign of wealth and security. The larger the herd one owns, the higher the status of the individual in society, quantity is more important than quality. A man who owns 50 or fewer cattle is considered poor. "Rich" men have a thousand or more. The cattle, though owned by the men, are considered to belong to the man's entire family. The family names the cattle and can recognize each animal's distinct voice.

Villagers at Wosi Wosi revealed that it was not uncommon to have 80 to 100 cows and/or 200 to 250 goats.

**Table 4-2: Livestock unit per village in the project area**

| Village | Losirwa | Selela | Engaruka Chini | Pinyinyi | Alaililai | Magadini |
|---|---|---|---|---|---|---|
| cattle | 8000 | 8,300 | 4,684 | 7334 | 4464 | 8,400 |
| goats | 4770 | 20,0000 | 3162 | 23736 | 8840 | 5,800 |
| sheep | 2330 | 18,1500 | 2261 | 12300 | 7455 | |
| donkeys | 310 | 980 | 416 | 500 | 1661 | 1,000 |

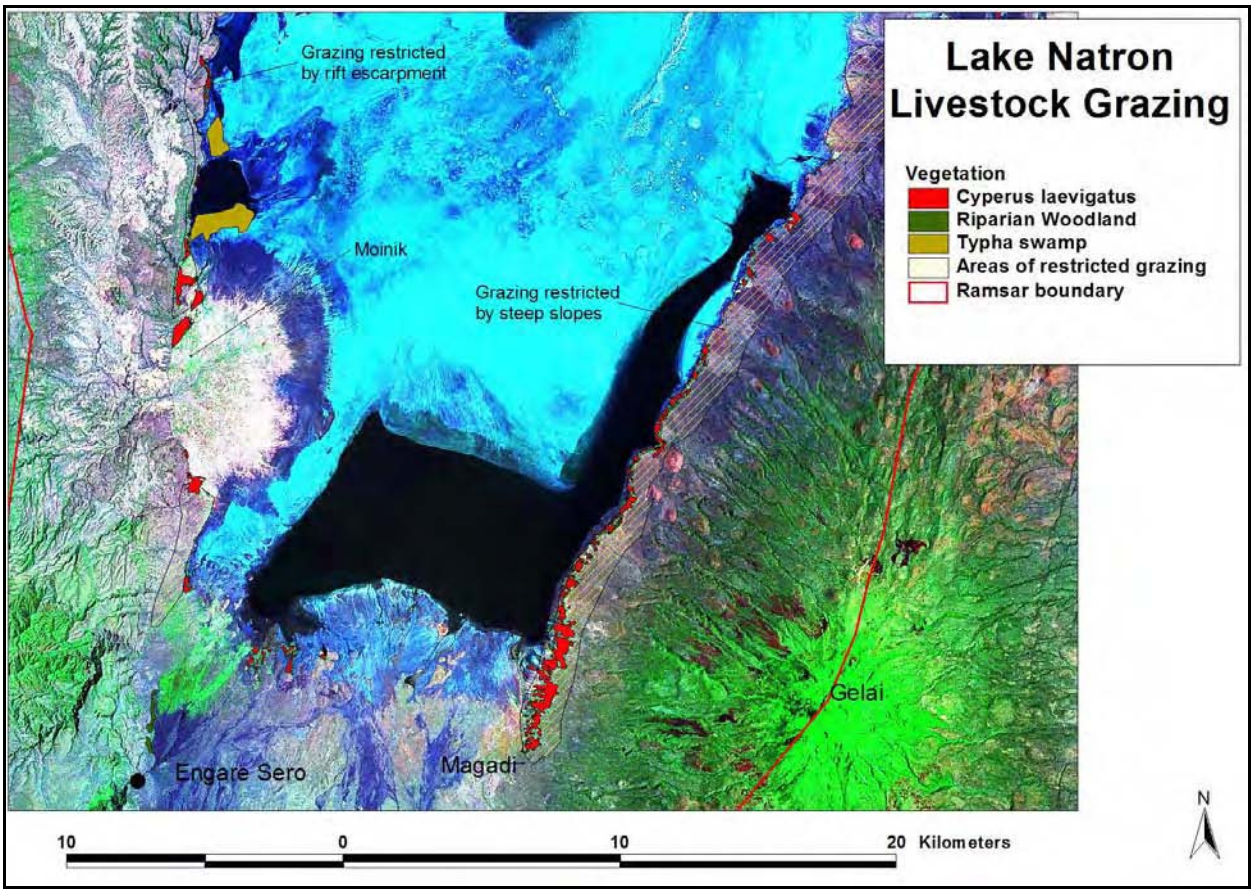
**Livestock Systems**

During the wet season there are few constraints on livestock movement but during the dry season livestock are limited by two resources; water and forage.

**Water**: During the dry season most of the fresh water springs dry up and pastoralists are forced to water their stock on the perennial rivers (Pinyinyi, Monic and Engare Sero) and at semi sodic springs (north of Monic and along the south eastern shores of the lake. Control of water resources by individuals and communities for irrigated agriculture and tourism have limited access to the scarce resources forcing large numbers of stock to water at concentration points. This results in social conflict and soil erosion.

**Forage**: At the height of the dry season, forage below the rift valley escarpment is limited to the *Cyperus laevigatus* sedgelands surrounding the sodic springs and the river deltas. These areas (ca 630ha sedgeland) are a critical resource, which is used by both wildlife (early mornings and evenings) and livestock (from mid morning till late afternoon). The separation in use is enforced to limit spread of disease from wildlife to livestock. Cattle are less dependent on this *Cyperus* forage as they are herded onto the plains daily or, moved for periods up into the mountain around the Gelei Forest Reserve or onto the rift escarpment. Small stock, though, are almost entirely dependent on the sedgelands during the late dry season.

**Figure 4-4: Location of important dry season forage areas**




The delta floodplains have been partially converted to irrigation agriculture or are cleared for rainfed arable agriculture. These multi use areas and riparian vegetation provided useful forage

(approximately 10.8km2). Only the Pinyinyi delta functions as a swamp providing good forage late into the dry season (approximately 760 ha of which at least 340 ha are now irrigated).

The grazing in the lake basin near the lake shore is restricted to the area between the lake and the escarpment or Gelai.

**Figure 4-5: People collecting water and stock foraging on heavily grazed *Cyperus* sedgelands and *Sporobilus* grassland near Magadi (SE end of lake)**

## Stocking Rates

Livestock densities in Livestock Units (lsu) for the Monduli (now Longido) district wards adjacent to the eastern side of the lake were (in 1984) on average 19.8 lsu/km$^2$ and had increased from 9.8 lsu/km$^2$ six years previously (Meindertsma and Kessler, 1997). Lake Natron Ramsar area falls into the arid – semi arid lands (Olpurkei) where carrying capacity in the dry season is about 0.2 lsu[1]/ha.

Our observed livestock density on the *Cyperus* sedgelands during the 2006 dry season was 0.5 lsu/ha and a further 2 lsu/ha for wildlife using the same sedgelands.

[1] Lsu = livestock units

### 4.7.2 Livestock Activities and Development

Expansion of irrigated agriculture on the river delta's and/or abstraction of the dry season water for use by plants will affect livestock water and forage availability leading to increased social conflict and poverty.

The *Cyperus* sedgelands along the sodic springs to the south and south east of the lake are heavily used by stock and wildlife during the dry season. Any major road or rail passing near these areas would result in high numbers of collisions with animals and disturbance to wildlife populations.

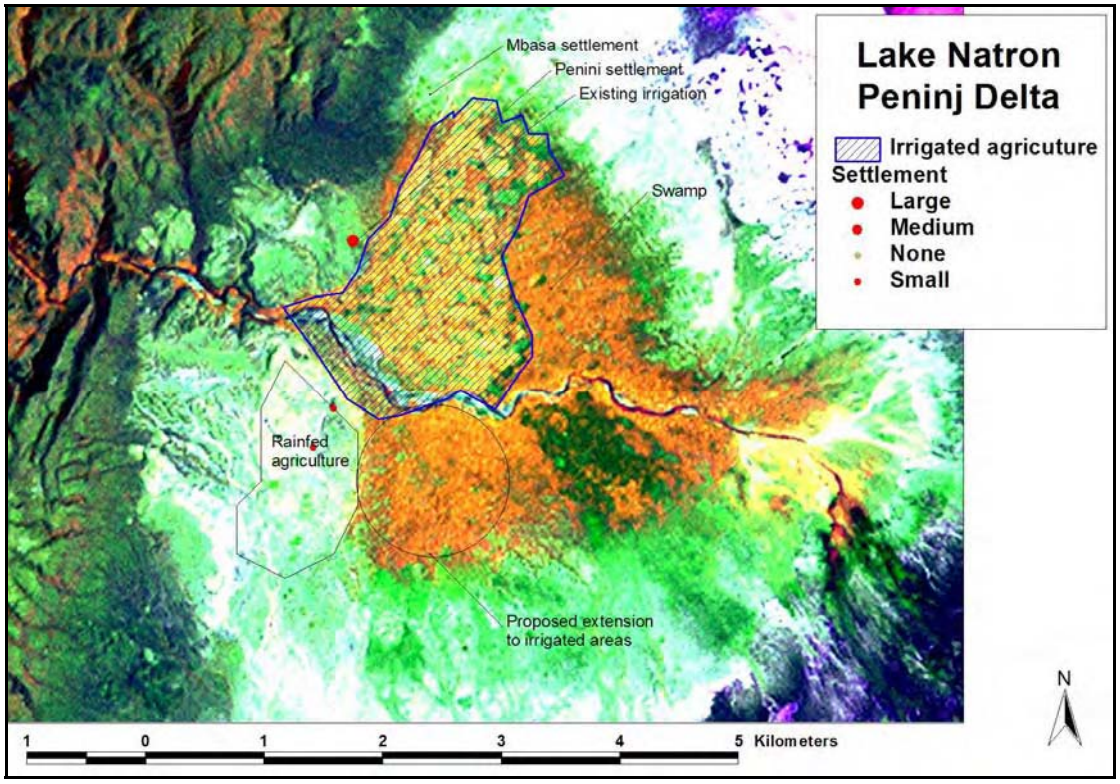
Any increase in arable agricultural, subsistence farming or pastoralism will increase the degradation of existing range and lead to loss of the critical dry season range.

### 4.7.3 Agriculture Systems

About 600 years ago there was already extensive and intensive irrigated agriculture and stock rearing based on the perennial flows of rift valley Rivers entering the valley floor. This occurred at Engaruka (5,000ha), on the waters of the Engare Sero and possibly the Pinyinyi and Monic. These developments ended about three hundred years ago and were replaced largely by Masai pastoralists (Sutten, 1990).

There is presently a mixture of rainfed and irrigated arable agriculture on the river delta soils of the Pinyinyi and Monic rivers and from fresh water springs near Engare Sero (See, Figure 4-6). The 2000-2001 landsat images indicate that there are about 340 ha of irrigation north of the Pinyinyi River and a further 113 – 200 ha north of the Monic River. There are also large areas of rainfed lands on the Pinyinyi, Mugure/Benini and Monic delta soils

**Figure 4-6: Irrigated agriculture on the delta of the Pinyinyi River**



Crops grown include paddy (at Selela), maize, groundnuts, beans, sweet potatoes as well as vegetables. The vegetables include onions, cabbages and beans. Some of the villages grow permanent crops including banana.

Production is primarily for subsistence with few villages producing surplus for sale. Maize and beans are major cash crops in the Districts especially for small scale farmers. In Ngorongoro District, it is reported that 15% of the district population have been involved in irrigation farming, the majority of farmers are found in Sale division (Pinyinyi ward is in this division). Farming is being intensified by in-migrants at and around Loliondo Township.

There is a strain on the livestock economy such that pastoralists are increasingly taking up cultivation to meet part of their grain requirements. Selela village reported to have 800 hectares under agriculture, the average farm size being 0.5 hectares. At Engaruka Chini the area under cultivation is 300 hectares and the average hectares cultivated per household is between 2 and 2.5 hectares. Similar to Engaruka, Wosiwosi farm size is 2 hectares. As a measure to increase the production from agriculture Selela and Pinyinyi are planning to rehabilitate canals for irrigation.

**Irrigation Agriculture**

At Pinyinyi irrigation agriculture predominates along the Pinyinyi River, here cultivation during the dry season depends on traditional irrigation canals. Crops cultivated include maize, sweet potatoes, cassava, banana, peas, pigeon peas, green grams, tomatoes, finger millet, water melon, groundnuts, onions, rice, and pawpaw.

Production is for markets in Kenya whereby middlemen transport the produce. Rice and finger millet are cultivated by few people due to frequent attack by birds. The farm size cultivated per household ranges between 1 – 1.5 acres for finger millet which produces 5 to 20 bags of 100 kilogram per sack per household. On average 1 acre produces only 8 bags, this is below normal production. Rice has a smaller farm area that is 0.25 – 0.5 acres per household. While farm land for maize per household is 1.5 of an acre, the harvest is between 5 to 7 bags per acre. This also is under production because generally 1 acre should yield 20 to 25 bags.

**Food Security**

The communities reported to experience hunger during the months of November and December, though there are grains stored in traditional storage facilities indicating insufficient production. Wosi Wosi sub village registered to experience food insecurity more than the other villages. It was generally expressed that villages in Longido District close to Lake Natron experienced longer periods of hunger than the other Districts. The most difficult period is from October to March during which men had to travel long distances up to Namanga and Arusha to look for food while women and children searched for drinking water.

Wosi Wosi has land area for farming activities unfortunately the land is unfertile. Villagers use to go to Gelai Lumbwa Mountains for farming. The main crops cultivated are maize and beans whereby one household harvest 3 sacks of maize per 1.5 to 2 acres; and 1 to 2.5 sacks of beans per acre. From December to March is when the farmers start preparing farms and planting seeds and from July to September is the harvesting period.

Existing agricultural problems and constraints include:

- Poor seed quality
- Inadequate farm inputs and the use of inferior farm implements such as machettes and hoes
- Drought/ floods – Floods is the main concern at Pinyinyi people as it limits expansion of farm acreage. On the other hand during the dry season the villages experience inadequate

water for irrigation. This results in conflict over the resources between farmers and between livestock keepers and farmers.

- Irrigation canals usually are blocked by debris carried down by flood. It takes time for the farmers to unblock the canals.
- Poor access to extension services causing dependency on traditional techniques of farming which are not high yielding and are labour intensive
- Low productivity of farms (poor nutrient load)
- Unreliable market for produce such as tomatoes banana and low prices for products
- Inadequate transport and high charges for transportation,
- Unfavourable weather for cultivation and destructive wildlife
- Crop diseases. Pesticides are not easily available one has to travel long distances to get them.

### *4.7.4 Forestry and Wood Resources*

Within the Lake Natron Catchment basin of Tanzania there are two official forest reserve areas; Gelai, which is a small water catchment and a District Forest Reserve, on the summit of Gelai Volcano. The other forest in the basin is the Loliondo District Forest Reserve located in the upper catchment of the Pinyinyi River.

The present expansion of irrigated arable agriculture, clearing of floodplain bush for rainfed agriculture and expansion of settlement is putting pressure on existing fuel wood and building wood resources. Any increase in population or intensification of agriculture will exacerbate this pressure. Gelai Forest Reserve is under pressure from dry season cattle grazing (and associated fires) and settlement.

The village governments have enacted by laws that prohibit people from bush fire. It is also prohibited to cut trees from nearby forest. Because of these by laws some families have opted to plant woodlots for home use. Some woodlots were observed at Selela and Mto wa Mbu villages.

## 4.8 Tourism

There are a good number of tourists that visit the Lake Natron GCAs area. Main attractions for photographic and Eco-tourism activities include Climbing of Oldonyo Lengai (The Highest active volcano in Africa); Walks up the Engare Sero River to the waterfalls; Cultural experience and visit to the cultural village; A number of different walks from the escarpment to the Lake; Bird watching safaris (High end tourism); Walking safaris to Gelai; Camel safaris from Arusha to Lake Natron and Archaeological visits to Engaruka agricultural artefacts. There are also some hunting companies that operate safaris especially on the eastern shore of the Lake.

**Tourist Accommodation**

Tourist accommodation is located at the southern end of the Lake around Engare Sero (Figure 4-3). The location allows for the best available road access and links to eco-tourism activities.
The following facilities are available, Camp sites with facilities for up to 70 campers, tented accommodation, luxury tented accommodation and Guest Houses. For the Camp sites there are no royalty agreements in place, the owners claim the entire fee for camping. With the tented camps there are agreements with the village for royalties to be paid.

### 4.8.1 Photographic/ Eco-Tourism

Since the improvement in the security situation of Natron, tourism has grown. Existing camps are operating and new comps have been established. There are three main types of tourism at present using the area, these are;

- Eco-tourism based out of Engare Sero or Mto wa Mbu
- Luxury lodge tourism (one camp established)

### 4.8.2 Value of Photographic/ Eco-Tourism

Photographic and Eco-tourism is generally restricted to the southern end of the Lake around Engare Sero. An estimate of its value based on the existing facilities with an occupancy of 50% in the high tourism season (June - February) and 25% occupancy in the low (September– January and January - March), for 2006/2007 rates; indicates that tourism generates approximately US$ 470,000/annum. This is a direct revenue estimate of earnings in the Lake Natron area and does not include multipliers.

The tourists buy a number of souvenirs from the locals such as arrow spears, beads from women and take Masai photos. The majority of these tourists come from America and Europe.

The registered tourists range from 5 to 10 a month. The tourists pay more than 5,000 Tshs at a camp site.

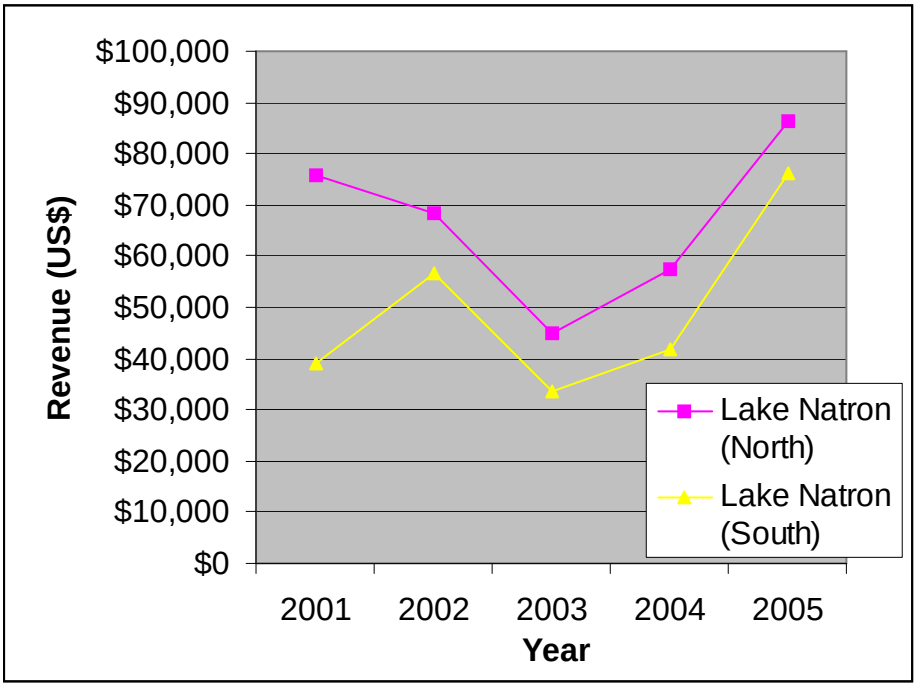
### 4.8.3 Sport/ Tourist Hunting

Consultations identified two companies with licences obtained from the central government (Wildlife Division). The villagers reported that the village governments are not involved in this arrangement and that the companies do not communicate with village governments.

The Division of Wildlife has two hunting blocks, Lake Natron GCA and Loliondo GCA. Loliondo falls to the west of the lake (above the escarpment) between the Lake and the Serengeti National Park. The Lake Natron GCA includes the entire Lake Natron.

The Lake Natron GCA is sub divided into two hunting blocks; Lake Natron North which is leased to Wengert Windrose of Arusha and operated by Tanzania Game Trackers and Lake Natron South which is leased to TAWICO. Income from the Lake Natron hunting blocks averages US$ 58,000 per year (See Figure 4-7). These returns were lower in the 2002-2004 period due to security concerns, but appear to be growing at about 8% on average. Total returns generated from hunting would be far higher than the lease fee as the companies are responsible to support development projects in their areas of operation and are required to pay tax and licence fees. Estimated direct returns to the District would be about US$ 70,000 (25% of fee plus developments similar to total fee charged) and to the nation as US$ 120,000 (remaining fee, licences at about, and taxes).

**Figure 4-7: Income Generated by the Lake Natron hunting blocks over five years (Source: Department of Wildlife)**




The type of tourism proposed under the Ramsar framework is low impact eco-tourism. There are a number of cumulative impacts associated with the potential development of tourism, these include, increase in vehicles and off road use, increase in immigration of service providers, social conflict, increased competition over habitats to be used for accommodation and recreation and increased solid and liquid waste production.

## 4.9 Other Sector Land Uses

**Mining**

The Lake Natron Basin has mineral resources which have not been exploited to a significant scale. Where practiced mining activity is at a very small scale. This might be attributed to lack of financial resources and technical capacity.

The Masai communities have traditionally extracted the trona from Lake Natron for sale and use by livestock. This is an activity carried out by women and provides significant input to the household income.

Bentonite is currently being exploited on a minimal scale from Gelai and around the Lake Natron shores. Magnesite occurs also around Gelai and is regarded as having medium financial return potential; this too is being exploited on a low scale.

### *4.9.1 Gender Concerns*

On the issues of gender sensitivity and equality in the project area, the study concludes that there is a low level of awareness in most parts of the rural areas whilst in semi-urban areas it was starting to register. This stand was based on the information obtained from public meetings conducted as well as the observations and secondary data from educational institutions. At the

meetings women were not free to contribute on issues which are pertinent to their daily activities because it is considered a sign of respect to keep quiet and listen to men who are regarded as the group with knowledge.

Furthermore, the division of labour puts demarcation and limit women in domestic tasks as opposed to men who hold leadership positions and security of the community. Women are also prohibited from right of ownership of properties. They are regarded as workers who provide labour for the properties of men even without any benefit. However, recently Masai women have started to engage in beads and handicraft business.

## 4.10 Archaeological and Cultural Heritage

### *4.10.1 Culture of the Lake Natron Basin Communities*

The communities in the Lake Natron Basin are largely pastoralist Masai who are continually trying to preserve their own ways in an increasingly modern world. The society is among the most well-known African ethnic groups internationally. They maintain many of their cultural traditions while engaging contemporary regional and global economic, social, and political forces. Decisions are made by the elders for each Masai group being patriarchical in nature.

They live on border of Kenya and Tanzania, moving their homes from time to time to follow their cattle, which is the main source of their livelihood. For the Masai, cattle are a significant part of their life; they drink cow's milk and blood as a sacred drink; they use the cows' dung to cover and seal their homes; they don't slaughter their cattle for food; but if a cow is killed, then the horns are used for containers; the hides are used to make shoes, clothing, ropes, and bed coverings; and the hooves and bones are made into ornaments. The Masai believe they are the rightful owners of all cattle, a source of many conflicts with other pastoral communities.

Second to the Masai are the Sonjo, they are farmers and cattle breeders and enemies of the Masai. They are the dominant tribe at Pinyinyi where they use an ingenious primitive irrigation system relying on the water from the escarpment (it is suggested that they are the first tribe in East Africa to water their fields by irrigation). Water is of significant value to them and they have controlled water rights where fourteen ‘wanamiji’ elders own the rights. Their origin is not easily established with a Bantu sounding language and nilotic features. There is a conscious reluctance by the tribe to adopt any new technologies.

**Cultural and historical sites**

The Oldonyo Mountains/ Engaruka ruins within the project area attract many tourists during the high season. In addition to the touristic value of these sites some of the Masai use the Oldonyo Mountains to conduct traditional ceremonies.

The communities have a number of modern religious structures and almost every village visited, had a church. Denominations ranged from include Roman Catholic, Lutheran, Anglicans and Assemblies of God to mention only a few. There were only two mosques recorded in the area, one at Selela and the other at Londo Losirwa.

### *4.10.2 Archaeology*

Lake Natron is a Soda Ash lake situated in the bottom of the Rift Valley basin (Gregory Rift) and surrounded by Rift Valley escarpments and volcanic mountains. The lake flats are surrounded by steep sloping hills with Plio-Pleistocene sediments rich in important fossils and artefacts as discussed below.

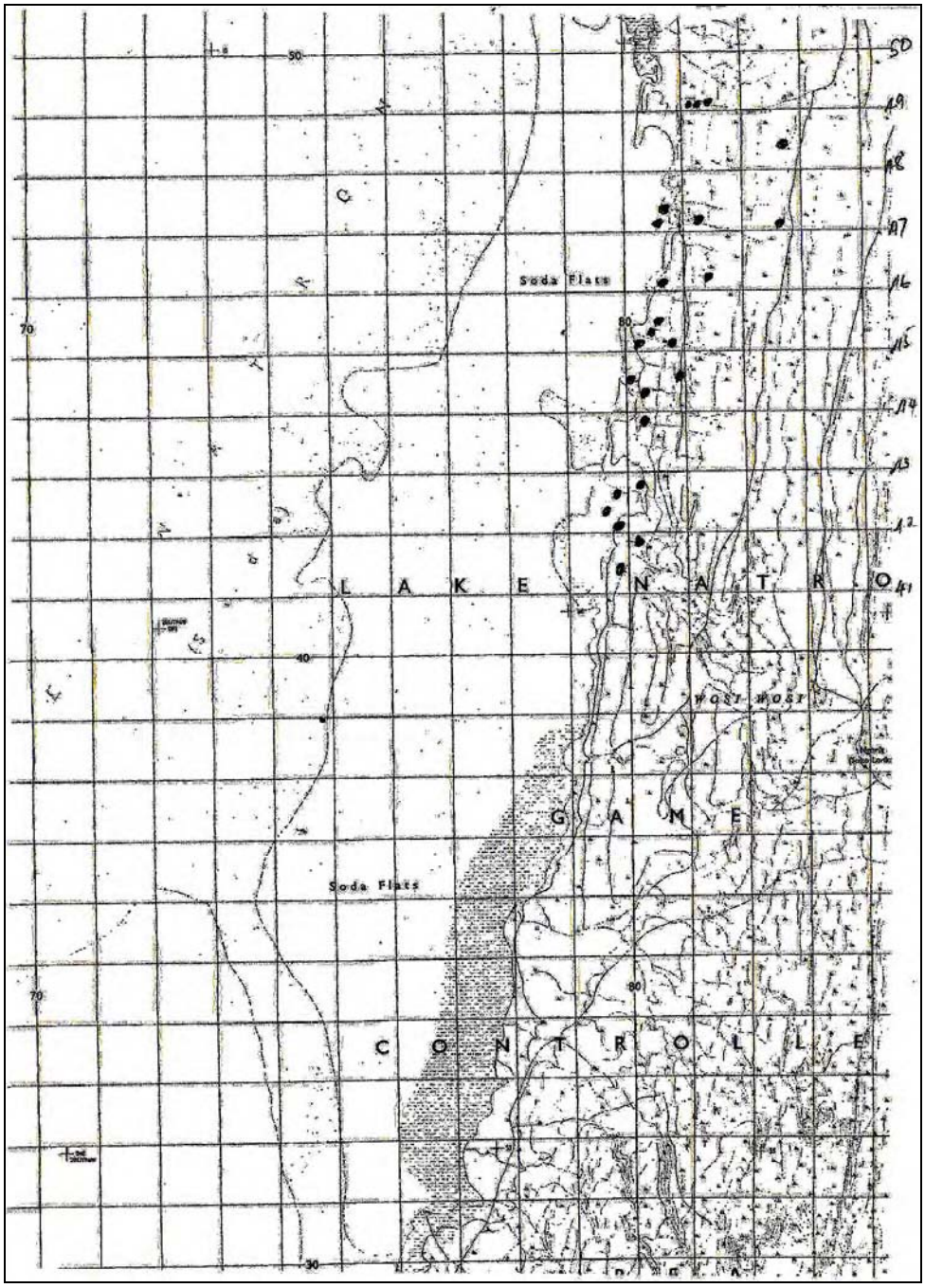
At Pinyinyi (Peninj), is a site which is best known for the Australopithecine mandible which fits the famous Olduvai *Zinjanthropus* skull (OH 5, *A. boisei)* as if they belonged to the same individual and also for containing the earliest Acheulean sites contemporary to Kenos Gradual sites in Ethiopia (Isaac & Curtis, 1974). Palaeoanthropological work at Pinyinyi was first initiated by R.E.F. Leakey and G.Ll. Isaac between 1963 and 1964 Isaac 1967). Between 1981 and 1983 an international team under the direction of Isaac investigated the area, followed by a hiatus until 1995, when a Spanish team resumed work in the area.

To date a total of 27 palaeontological and 8 archaeological localities have been discovered along the Western shore of the Lake. Most of the sites are located in the Humbu Formation, the lower member of the "Pinyinyi Group" at the top of the Plio-Pleistocene stratigraphical sequence. Archaeological materials and fossil bones appear unevenly distributed in the three main areas around the modern Pinyinyi River. Type section (Maritanane, Kamare & Kipalagu), Southern Escarpment (Bayasi, Karonga North South and East Mugure and Northern Escarpment (Mgudulu) are among the better known localities.

The Humbu formation is divided into two units; the Basal and the Uppers Sands with Clays. Research efforts have thus far concentrated in the Upper sands with Clays since the Acheulean and Oldowan sites were found in this unit. Though still controversial, the unit is dated to between 1.6 and 1.5 Ma (Isaac & Curtis 1974, Thoveny & Taieb 187). Normal magnetic stratigraphy suggests that it falls within the Olduvai subcron. The Acheulean and Oldowan sites are contemporary and co-occur in the Upper Sands with Clays of the Humbu formation. The co-occurrence of the two industries is also known at Olduvai Bed II. Like at Olduvai, most of the Acheulean sites are in fluviatile and proximal alluvial fan depositional environments, while the Oldowan ones are concentrated in a distal alluvial fan/lacustrine floodplain setting. Abundant fossil fauna are documented with the Oldowan sites near the lake, but bones are scarce in the Acheulean sites.

The Archaeology of the area to be impacted by the project has had no previous archaeological investigation. However, given the rich fossiliferous and artefact bearing sediments found on the western part of the lake particularly from Monic and Pinyinyi, the eastern lake flats were assumed also to contain archaeological and palaeontological relics spanning the Plio-Pleistocene period. The sites surveyed on the eastern shore and the location of test pits are shown in Figure 4-8.

**Figure 4-8: Location of the main finds and test pits excavated during the archaeological study**



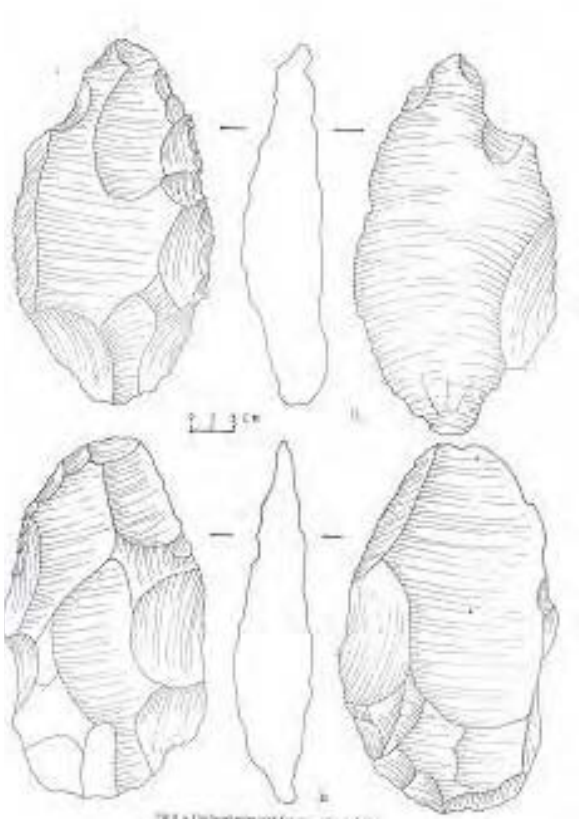

### *4.10.3 Archaeological Finds:*

The whole project site from the lake flat up to the first terrace and on to the Ngejeki Plateau is one expansive site but concentrations of artefacts vary from one locality to another depending on the relief. Localities on flat ground tended to have denser concentrations than those on slopes.

A variety of stone artefacts were recovered by surface survey and the limited excavations. A few of the artefacts are illustrated as shown here (Figure 4-9). As is discussed below the recovered data suggest a two distinct cultural industrial component, the MSA and LSA with a possibility of a late Acheulean component. The assemblage is reminiscent of comparable materials from the Lake Eyasi Basin and the western part of Lake Natron. Very few fossil remains were recovered

but this is seen more as a reflection the recovery strategies than denoting presence or absence of such relics.

**Figure 4-9: Artefacts from the Eastern shore of Lake Natron**



The project area has rich and diversified archaeological deposits spanning the MSA-LSA continuum and perhaps even earlier. Typical MSA assemblages include types such as diminutive bifaces, bifacial and unifacial points, core scrapers, discs, flake blades and a host of other artefacts. A host of new technical forms hitherto not reported in the literature have been found. These include a variety of casually and intermittently retouched ovate and cordiform pieces. LSA on the other hand is denoted by a variety of microlithic flakes and flake tools such as end and side scrapers, notched and backed pieces and a suite of geometrics. The core reduction technology combines bipolar and multiplatform core reduction technology producing both plain and Levalloisian flakes as well as blades, i.e. flakes that are at least twice as long as they are broad.

There are four types of raw material from which the artefacts are made; i.e. chert, metamorphosed sandstone and two types of lava, basalt and phonolite with the rare occurrence of obsidian.

The proposed project area was once a rich and very extensive archaeological site. However erosion over the years has taken a heavy toll of the heritage so that only a fraction of the heritage has survived. The Natron MSA industries are unique in terms of technological aspects attributes as well as the variety of typological forms.

## 4.11 Description of Social Conditions at the Proposed Site for the Soda Ash Plant

### *4.11.1 Demography*

The proposed project site is within the sub village of Wosi wosi. There are no settlements at the plant area or immediately along the route from Engare Sero. This is a sub-village of Alaililai village in Gelai Lumbwa Ward/Matale Ward of Longido District. The sub village is in the north-east of Lake Natron and borders Tanzania and Kenya.

The demographics for the sub village of Wosi wosi are presented in section 4.2 of this chapter.

### *4.11.2 Culture*

The community is Masai and during the consultations it was observed that, most of the villagers do not speak Swahili. The majority of the villagers are pagans.

### *4.11.3 Livelihood*

The main activity for the villagers is livestock keeping whereby they keep cows, goats, sheep and donkeys. According to the villagers consulted one livestock keeper could have 80 to 100 cows and/or 200 to 250 goats.

Wosi Wosi lacks suitable arable land for cultivation and only areas close to Gelai Lumbwa is farmed though with low output. Crops cultivated are maize and beans, and harvests range from 3 sacks of maize per 1.5 to 2 acres; and 1 to 2.5 sacs of beans per acre. The planting season is December to March is when the farmers start preparing farms and planting seeds and July to September is harvest.

### *4.11.4 Resource use*

The community of Wosi Wosi use soda ash from Lake Natron to mix with tobacco for smoke. The soda ash from the lake is also extracted sale to other communities.

**Figure 4-10: Magadi collection on eastern shore**

### *4.11.5 Social services*

**Education**

Wosi Wosi sub village has no primary school and so have to use the one at Gelai Lumbwa. There is however a nursery school.

**Water Supply**

The area has a dire problem of water. The community depends on water from hand dug wells constructed on the river bed. Daily water consumption within the area is 4 buckets per household.

**Health Services**

There is neither a dispensary nor HIV/AIDS education nor awareness campaigns.

**Energy**

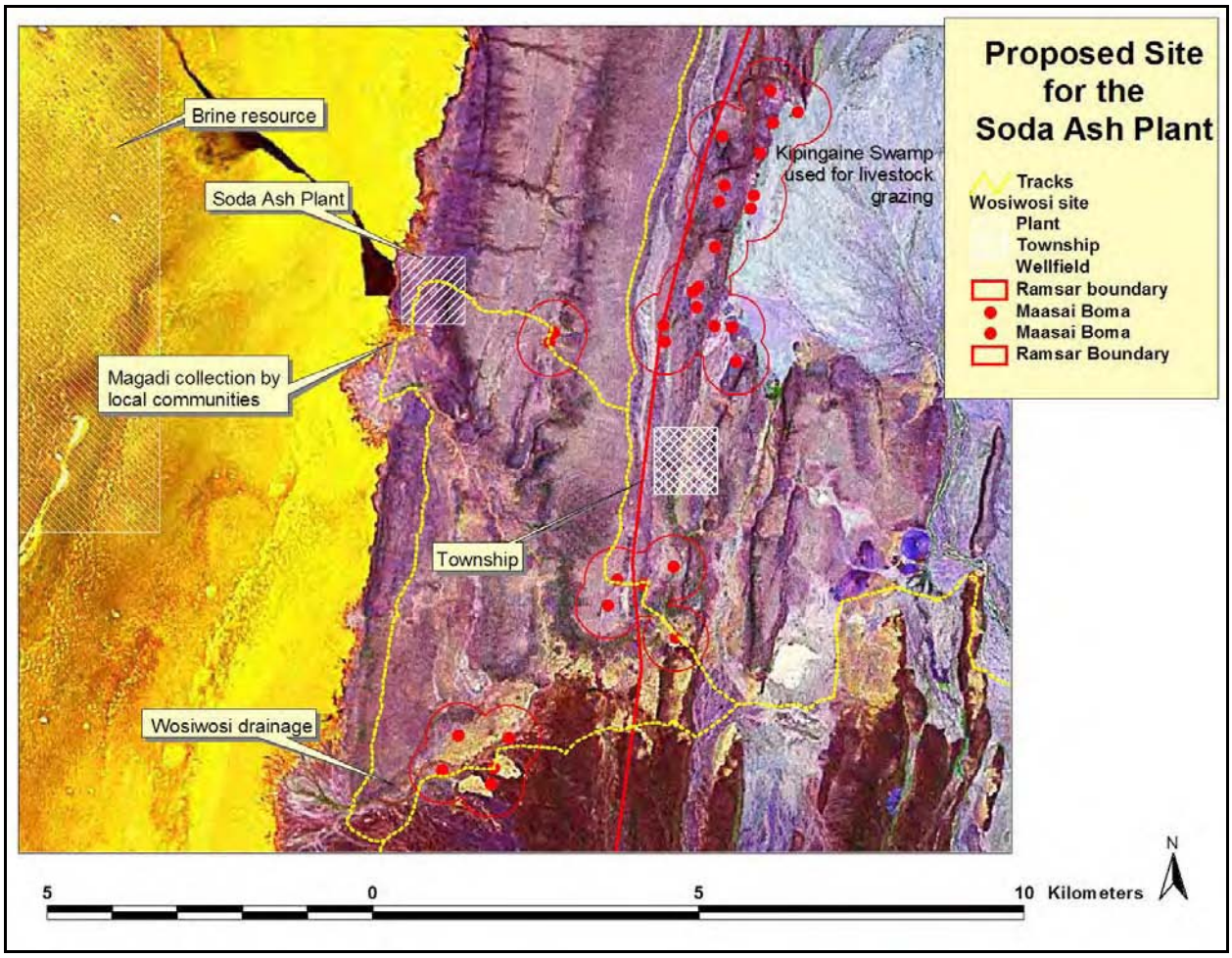
The main source of energy is firewood that is collected by women and girls from the bushes around the village. Deforestation is taking place at a relatively high rate.

**Transport**

Generally, the road network is in very bad condition, it is not passable during rainy season. Movement is by foot both for reason of the bad road and the basic reason for herding.

The pastoralists move where there is grazing and water and as such are not restricted by the national borders. Movement between Tanzania and Kenya depends on the availability of grass and water for livestock.

**Figure 4-11: Settlement near the site of the proposed Soda Ash abstraction plant**

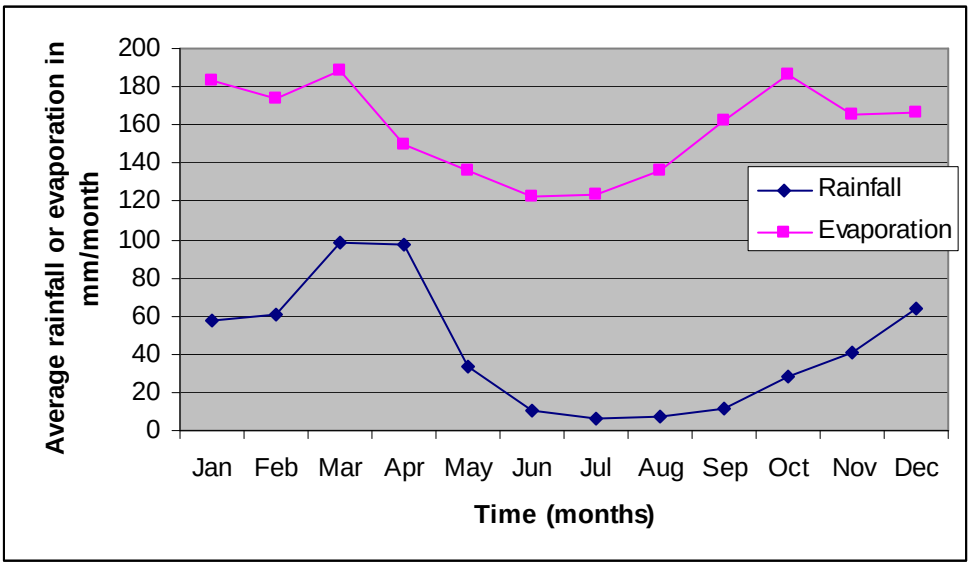


# 5 BIOPHYSICAL ENVIRONMENT

## 5.1 Climate

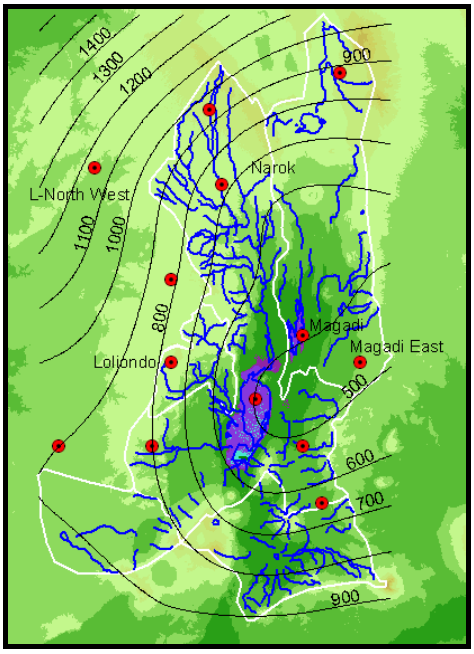
The catchments area of Lake Natron has a hot climate in low altitude areas and a cooler climate in higher altitude areas. Temperature ranges from 20°C to 35°C on average. Rainfall ranges from less than 500mm in low lands to 900mm at higher elevations. The lake Natron basin has a high level of evaporation making it one of the hottest and driest places in northern Tanzania. In January and February temperatures are often above 40 degrees Celsius.

**Figure 5-1: Average monthly evaporation and rainfall generated for Magadi (Source: CHARM (2007)**




The high temperatures coupled with low rainfall within the lower Gregory Rift create a negative water balance situation of about 1400mm at the Lake floor. The system relies on inflows from both rivers and springs to maintain perennial pools of water within the Lake.

**Figure 5-2: Isohyetal map of rainfall in the Lake Natron Catchment (source: Norconsult 2007)**



## 5.2 Geology and Soils

The geology and soils of the area are dominated by the volcanic activity and rift valley movement. The basin where Lake Natron is located was caused by block faulting of the Gregory Rift and is primarily composed of volcanic rocks such as phonolites, trachytes and basaltic lava flows. The lake is surrounded in the north, east and south by five Plio-Pleistocene volcanoes: Oldoinyo Sambu (2045 m), Shombole (1565 m), Gelai (2942 m), Oldoinyo Lengai (2878 m) and Embagai (3048 m). The Oldoinyo Lengai volcano is still active; it last erupted in in March 2006.

The area to the far north of Lake Natron forms a fairly level surface, it was created by Tertiary lava and ashes. A large residual hill mass called The Loita Hills rises to the northwest of this surface. To the west of Lake Natron, the surface level gradually declines from 1800 m, where there are a series of escarpments from the Serengeti Plain down to 610 m, which is the bottom of the Rift Valley. In some areas, Precambrian rocks are exposed and the surface is more uneven. A number of rivers have incised the escarpment tot eh west of the Lake for example the Pininj River has eroded the sediments along its course over the past 2.5 million years and has caused a deep gorge, approximately 350 meters in height, where the Pinyiny and the Mugure Rivers meet

The first tectonic activity that occurred in the Lake Natron area took place along the Gregory Rift sometime between 5 and 3.5 million years ago. This eruption elevated the Sonjo escarpment, which is located to the west of Lake Natron. The next volcanic activity, between 3 and 3.5 million years ago, formed the Mozonik volcano and the Shirere Hills, which are also situated to the west of Lake Natron. The next tectonic activity in this area happened a little before 2 million years ago and formed the Crater Highlands and the Gelai, Kitumbeine, and Oldoinyo Sambu volcanoes. These are all comprised of traquibasalts, basalts and basanites. Basalt lava from the Oldoinyo Sambu volcano compile a stratum, 400 meters thick, covering all of the areas surrounding the volcano in the lake basin.

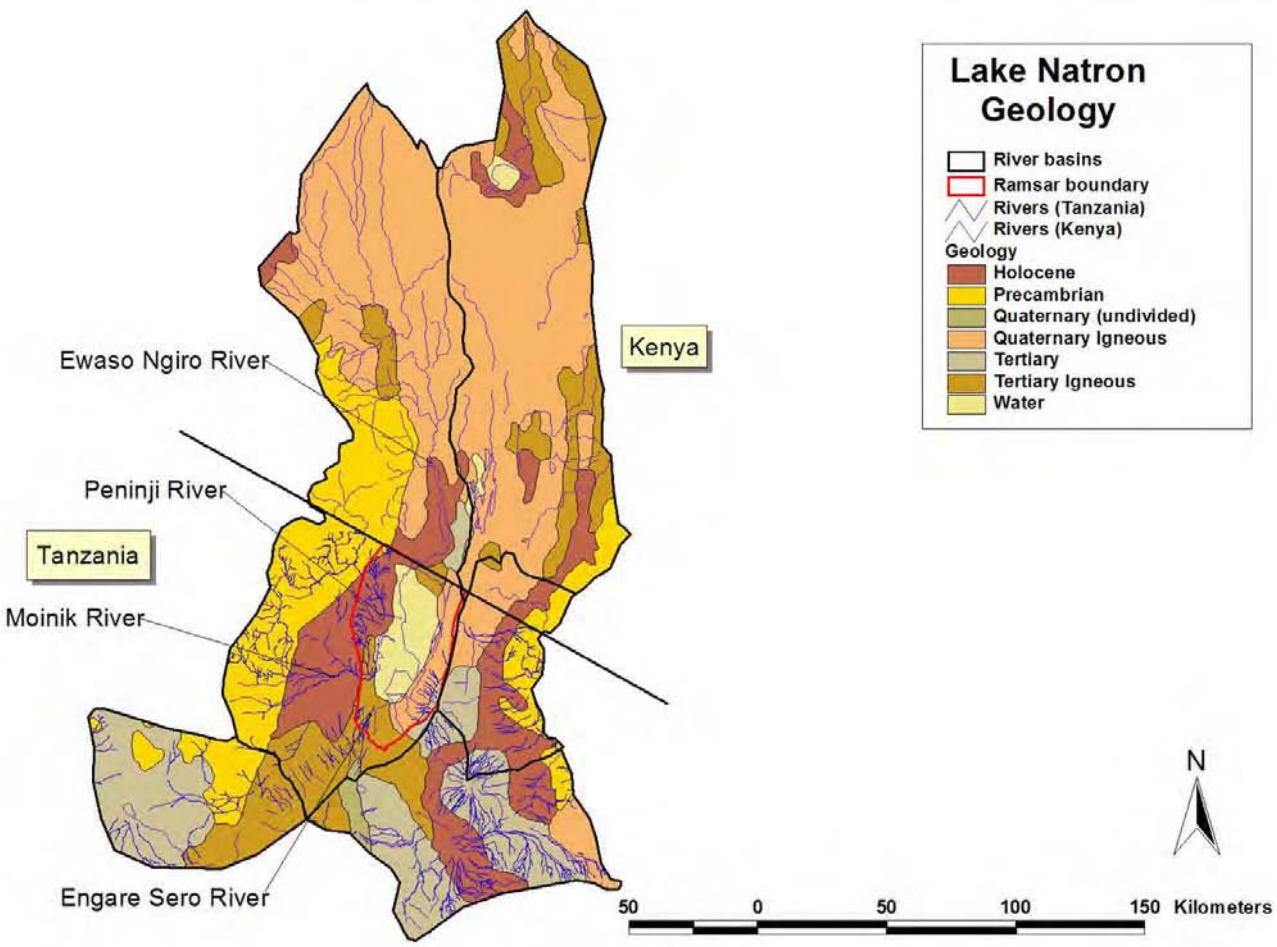
Between 2 million years and 1.35 million years ago, the Pinyinyi area was fairly tectonically stable. During this time that the sedimentation and the lacustrine formation of Lake Natron took place. The Sambu fault formed a small escarpment (20-35 m) which delineated part of the western boundary of the lake and was later covered by lake sediments during the Basalt Sands with Clays of the Humbu Formation. The paleo-lake was at least 35 meters higher than the present lake. This higher lake level was most likely caused by more humid conditions during that time.

At 1.5 million years ago, the salinity of Lake Natron was very low. The gasteropods, fossil fishes and plants recovered from sediments reveal a low amount of saline in the water and both the presence of calcium carbonates and magnesium. This changed at the end of the Early Pleistocene, corresponding to the Moinik Formation, the lake became increasingly more alkaline.

The geological sediments around the lake reveal that the Pinyinyi River was the main river feeding into Lake Natron 1.5 million years ago. An alluvial fan and a large floodplain appear to have been present where the river joined the lake. The fresh and hot springs that are currently present in various places around Lake Natron did not exist 1.5 million years ago. (Source http://www.ucm.es/info/preh/actividades/peninj/GEOLOGY1.htm).

This geology and history of flooding has created a landscape dominated by lake (lacustrine), volcanic (Haplic Solonetz), sedimentary (Eutric leptosols) and basment (Luvic and Chenozems) soils.

**Figure 5-3: Geology of the Lake Natron catchments and adjacent river basins**




### *5.2.1 Background to the Formation of Trona and Brine in Lake Natron*

During the last ice age 10,000 years BP the water level in Lake Natron was 656 masl (Marcel and Casanova, 1987) 50 meters higher than the present water level. Using the lake level fluctuations in the intertropical Africa, (Andersen and Borns, 1992) it can be seen that the water level has been receding until today.

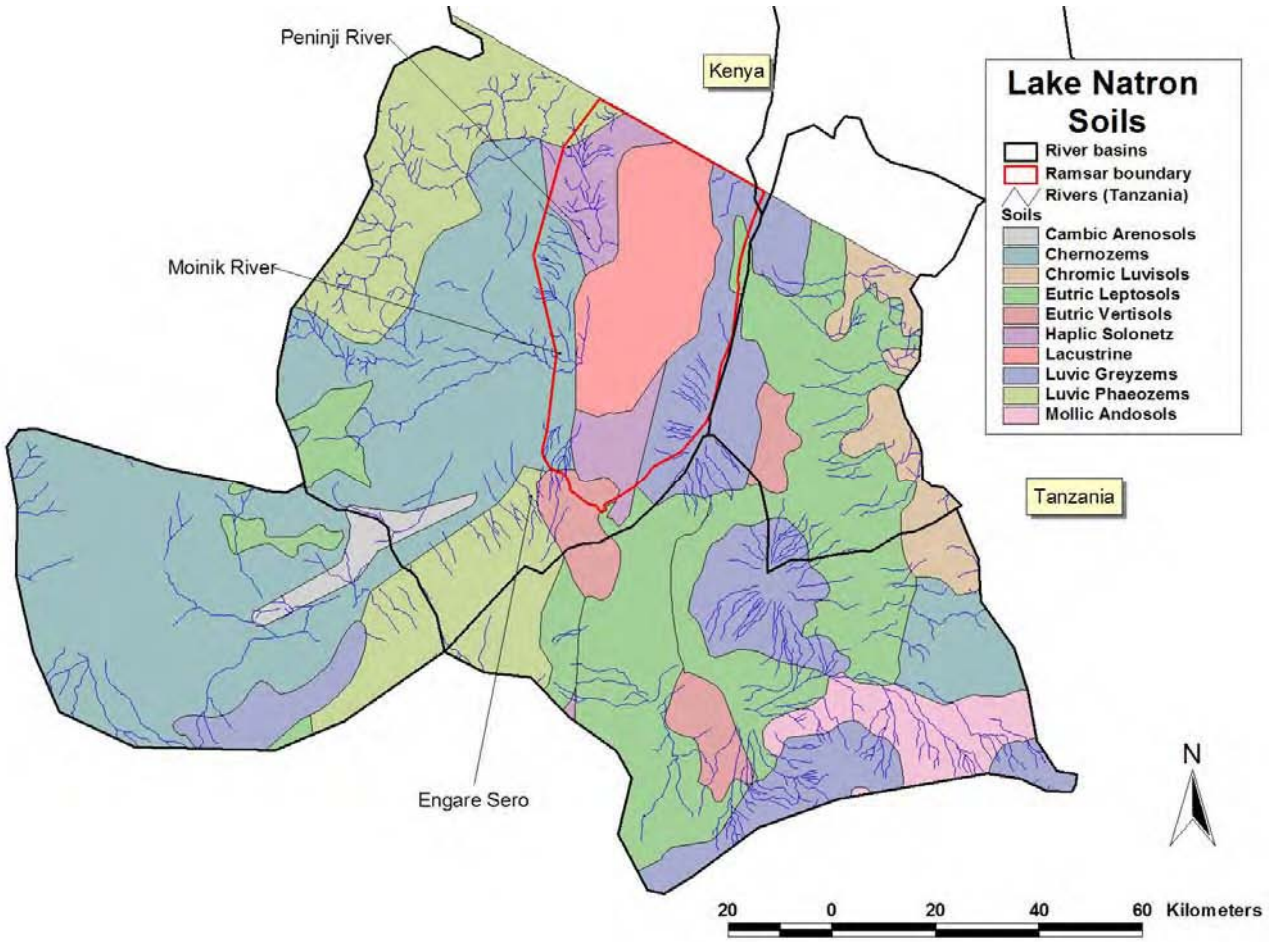
When the water level was 656 masl Lake Magadi and Lake Natron were connected and the water was fresh (Icole et al., 1990). It is postulated that the black mud encountered under the trona/brine deposit in Lake Natron is actually lacustrine sediments from the time when the Lake was fresh and could support plant life. The sequence above the mud is suggested to be the Evaporative series that has been created since the end of the last wet period. Jones et al. 1977 consider three major stratigraphic lake bed horizons; Evaporative series (recent); High Magadi Beds (~10000 BP) and Oloronga Beds (> 800000 BP). In Lake Magadi the evaporative series is estimated to range in depth from 7.5 to 28 meters with considerable variations. The evaporative series in Lake Natron is much shallower if the mud encountered indeed is old lacustrine sediments from the last wet period.

The following development has been postulated for the Lake Natron the last 10,000 years. As the water level starts to recede the water concentration becomes more and more salt and eventually trona precipitates. When the concentrations get so high that trona forms we reach the present day

situation where trona formation occurs during dry periods. Trona will form during dry periods until the lake is flooded and concentrations diluted. Dry periods following the wet period will enable a new layer of trona to be formed, layers of brine may be trapped under the topmost layer of trona.

When the layers of trona and brine again are flooded the trona will be saturated and can collapse. It was observed that the flood water on Lake Natron had a high pH and high solute concentrations, this is probably from mixing with brine under the trona rather than dissolving of the trona.

**Figure 5-4: Soils of the Lake Natron catchment**

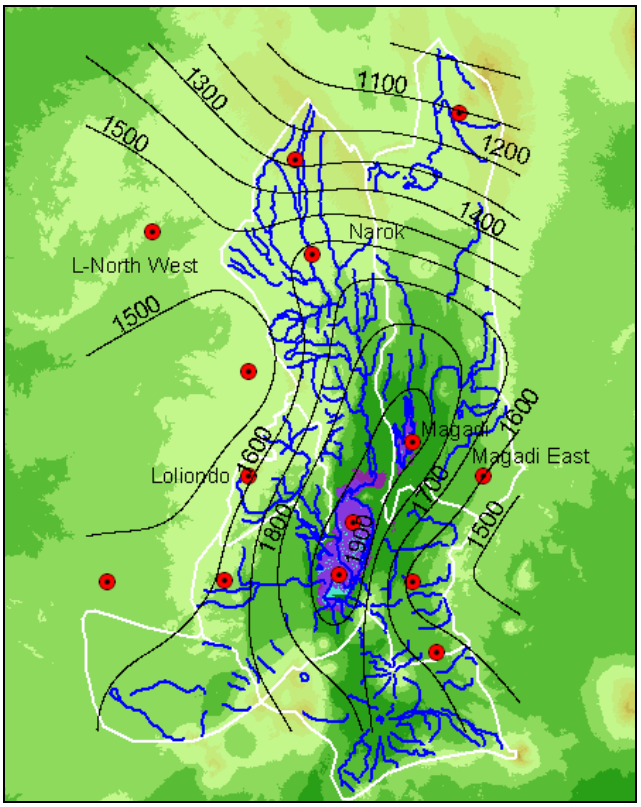



## 5.3 Topography

The Lake sits at the bottom of the Gregory Rift at about 610m. The rift follows a NNW-SSW trending alignment and is separated from the Magadi Lake by the Ewaso Ngiro delta. To the west the escarpment climes rapidly to about 1800m. To the east a ridge 700-750m (Ngejeki Plateau) separates the Lake from a wide swamp (650m).

The area is interpursed with a number of volcanoes Oldoinyo Sambu (2045 m), Shombole (1565 m), Gelai (2942 m), Oldoinyo Lengai (2878 m) and Embagai (3048 m) which dominate the landscape.

**Figure 5-5: Isohyetal of potential evapotranspiration (source: Norconsult 2007)**

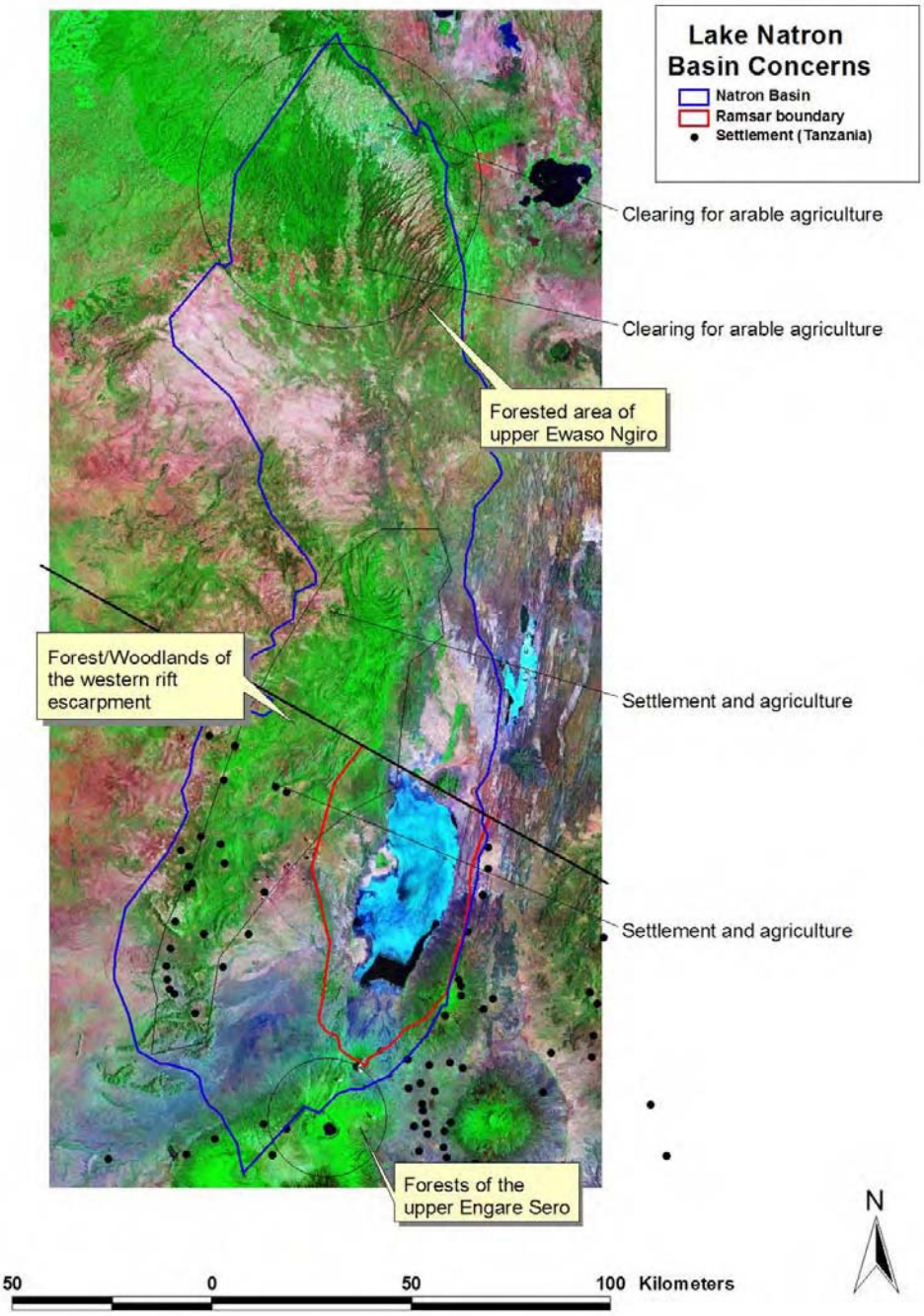



## 5.4 Hydrology

As indicated in the physical determinates, the hydrology has changed considerably over the last 10,000-6,000 years, changing the system from fresh to sodic. The waters of the perennial rivers flowing into the Lake are under threat. Land use in the catchments is rapidly occurring with deforestation and abstraction for irrigation ongoing.

Similarly the waters and land of the Ewaso Ngiro are also being developed with extensive clearing of woodlands for arable agriculture in the upper reaches in Kenya.

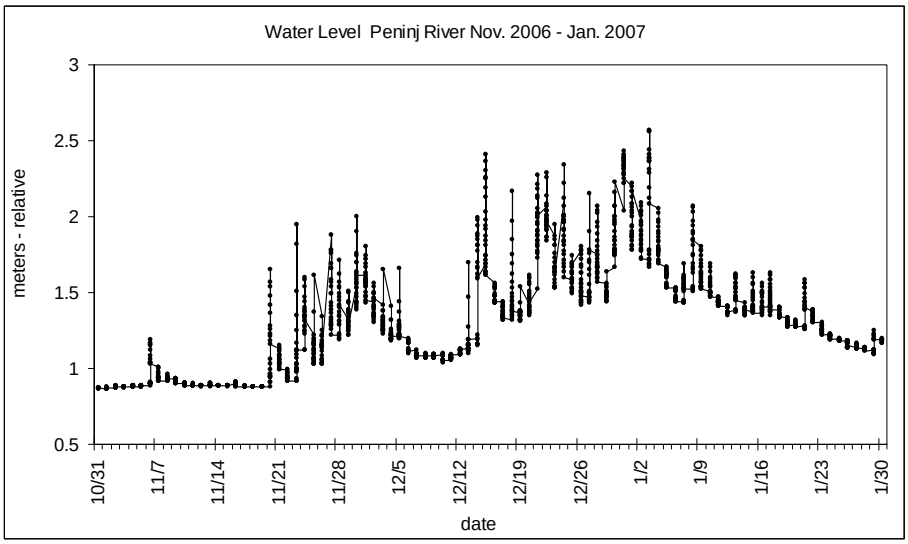
**Figure 5-6: Development in the upper catchments of perennial rivers feeding Lake Natron**




On the western shore of the Lake the Peninj catchment is the major one (1925 km$^2$). For this study daily discharges for the Peninj were generated from the rainfall time series and compared with the Peninj river water logger installed (2006-2007).

The logger reveals that the river stage rises and falls within hours typical for a catchment with quick runoff. The surface water component is more important than the groundwater contribution. It can be seen that in dry years like 1976, 1982 and 1992 even potable water supply from the Peninj is a problem. During the dry years the water shortage persists for several months.

**Figure 5-7: Observed hourly water level fluctuations in the Peninj river 2006/07**




On the eastern shore the main catchment is the Wosi Wosi. During the driest period (1976/77) the dry period lasts for more than a year and potable water supply is a problem.

Just south of the Ewaso Ngiro the fresh water influx is high and the concentrations may not reach a level where trona precipitation occurs. The lacustrine sediments are encountered here at the surface and no trona layers were encountered. The mud found was grayish/black suggesting that at least the upper mud is recently deposited in an oxic environment during recent flood events. From Ewaso Ngiro River water seeps into the old delta from the last wet period and feeds into Lake Natron both through streams and groundwater. The infiltration of water into the delta ensure that the seasonal water flux are less than the flow encountered at the Peninj, Moinik and Engare Sero where the present rivers have cut new river valleys in the old delta and do not recharge to groundwater to the same extent.

In the South there is fresh water influx from three sources and the situation is similar to that as seen in the North West at the outflow from Ewaso Ngiro but the sediment flux into Lake Natron are higher here due to surface runoff especially from the slopes and foot of the active vulcano Olyondo Lengai and sediment carried by the Monink and Engare Sera rivers. The high influx of sediments and fresh water gives a continuous open water body in the southernmost area and mud/silt flats that are at least 10 meters deep

## 5.5 Physical Determinants of Lake Natron's Ecology

As can be observed from the fossil river deltas and wave cut platforms located nearly 60 m above the present lake surface, the system has changed from a vast inland fresh water body less than 6,000 years ago to the present sodic lake today.

The continuation of this desiccation process would, in the long term, result in dry saline lake beds. There is one significant difference between the Natron system and other lakes that have fully dried out, the presence of sodic springs discharging large volumes of water into the lake and maintaining the perennial lagoons.

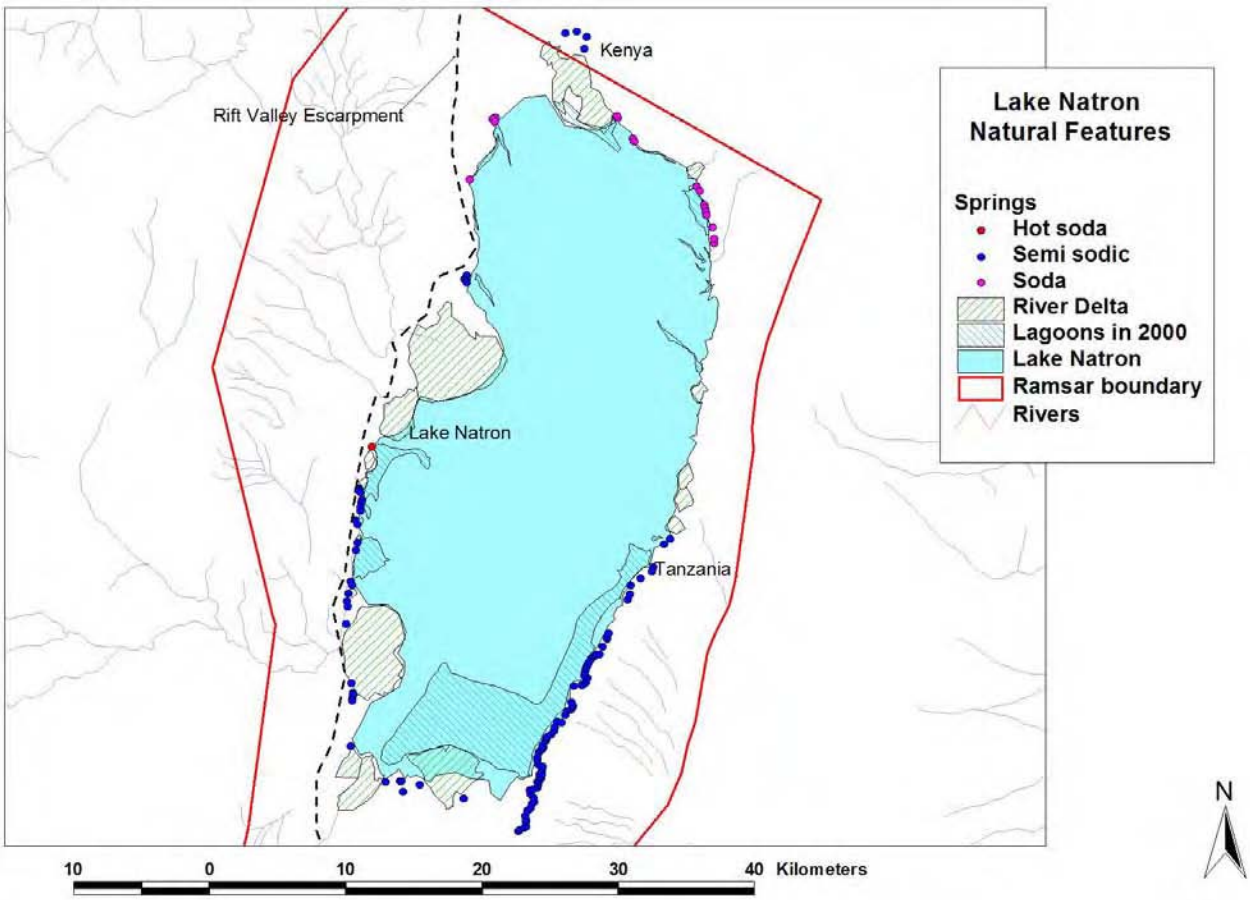
The volcanic activity of the Rift Valley has resulted in larva and volcanic ash covering the landscape and forming the sodic soils of the Natron lower basin. These soils and course grain sediments from the land in the upper catchment of the Peninj, Moinik, Sanjane (western areas),

Engare Sero (south of the Lake) and the vast catchment of the Ewaso Ngiro (northern), have entered the lake, forming much of the surface we see today. The course sediments can be observed at the active river deltas where the combination of fresh water and alluvial (non sodic) soils allow for human settlement. In the southern section of the lake where sediment levels and fresh water inputs are high, the muds are exposed at the surface and can be traversed on foot during the dry season. In the north and central areas of the lake the sodic levels in springs are higher and during the dry season a crystalline crust of trona cover the surface forming a seal to evaporation. The brine solution below the trona consists of brine in a mud slurry solution.

Spriggs (2001) points out that the waters of these saline lakes are extremely inhospitable, with a saturated salt solution of pH 9 to 10, and temperatures that reach up to 41°C near the mineral springs. These conditions are not constant, but change abruptly during the rains. Heavy rains temporarily flood the lakes with cold water and lower the pH dramatically. The mud flats surrounding the permanent water are just as inhospitable. Temperatures are extreme, winds are strong, vegetation is scarce and movement across this thick muddy environment is impossible for most mammals. As a result it is an extreme and highly variable environment with low species richness.

The areas of highest diversity and productivity are the river delta's, most of which flow sporadically in the wet season. The distribution of these delta areas and sodic springs are indicated in (Figure 5-8).

**Figure 5-8: Natural features of Lake Natron shoreline**



## 5.6 Aquatic Biology

The size and shape of the rivers and Lake change constantly in the cycle of dry and rainy seasons and between dry and wet years. The lake is also influenced by thermal springs due to its recent history of volcanic activity. The constantly flowing spring water is the main contributor to the formation of brine and soda crust in the lake. These hydrological dynamics of the Lake's springs add an extra dimension to the riparian ecosystem as well as to the water resource management issues.

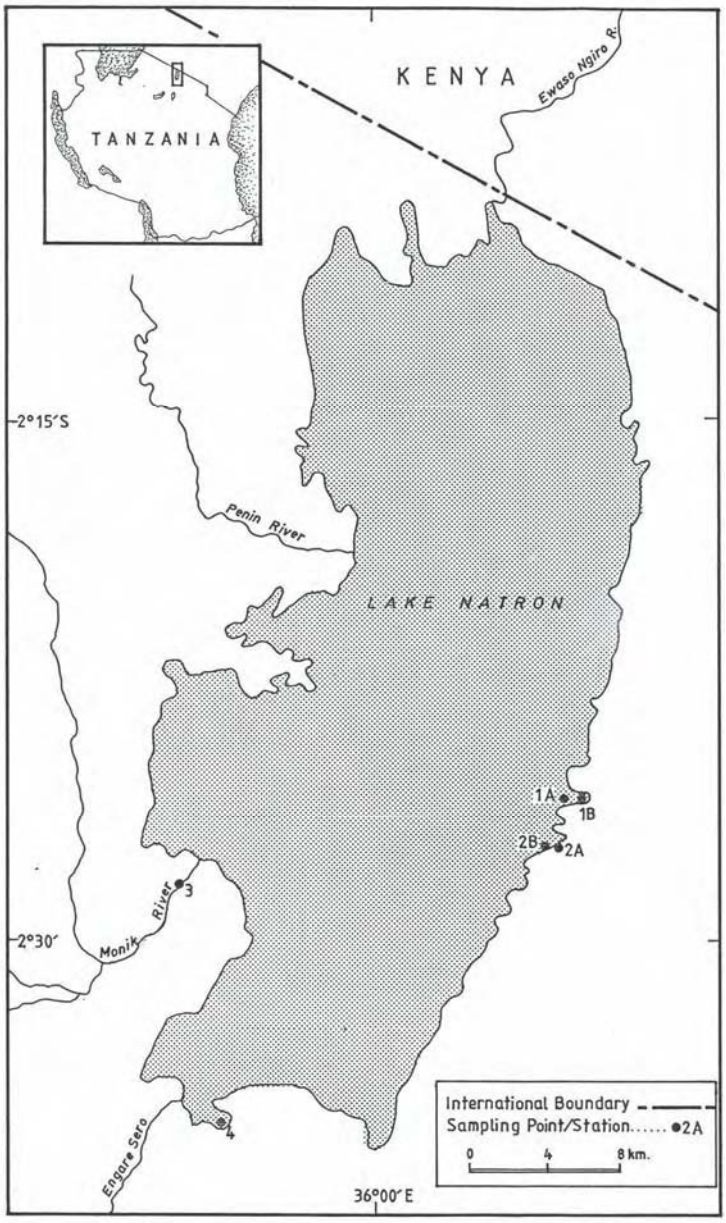
There are numerous permanent springs situated in the vicinity of the lake or in the lake itself, including hot water springs which feed salt rich water into the lake. The constantly flowing spring water is the main contributor to the formation of brine and soda crust in the lake. According to Guest and Steven (1951), there are about 28 hot alkaline springs flowing into Lake Natron. The temperature of the spring water is in the range of 30 - 50ºC.

There are several wetland patches associated with the lake: two relatively small *Typha domingensis* dominated wetland patches on the western shore and two medium sized to large partially fresh water wetlands on the eastern side. The wetlands are a source of water for wild and domestic animals.

During the fieldwork, fish and microalgae were studied from six sites located within Lake Natron. In total nine microalgae species were identified from water samples collected from the six sampling sites. Contrary to the popular belief, *Arthrospira fusiformis* was not found in the water samples collected from six sampling stations for which microalgae were examined.

The dominant microalgae were pinnate diatoms *Navicula* ssp. (especially *Navicula scolipleura* and *Navicula sphaerophora*). Other microalgae found in the water column in Lake Natron included cyanobacteria of the genera *Pseudoanabaena*, *Chroococcus*, and *Microcystis* as well as a diatom *Navicula oblonga* although these occurred at relatively low numbers. These results suggests that in addition to *Arthrospira fusiformis*, there must be other important food sources for resident Lesser Flamingo and cichlid fish flocks in Lake Natron allowing for food diversity.

**Figure 5-9: Location of the aquatic sampling sites**




It has long been asserted that the flamingos are specialised in that they feed only on *Arthrospira fusiformis*, a species of cynobacteria, or bluegreen algae that is abundant in the lake's alkaline waters. Although not encountered in the water samples collected in this study, it is worth noting that more recently, hepatotoxins and neurotoxins produced by *A. fusiformis* and *Spirulina subsalsa* were blamed for deaths of hundreds of Lesser Flamingos in numerous Soda lakes in east Africa.

**Table 5-1: Algal and fish species composition and abundance for six sampling sites in Lake Natron.**

| Site ID & Place | Algae | | Fish | |
|---|---|---|---|---|
| | **Species** | **Cells/ml** | **Species** | **No. caught** |
| 1A<br>Lake Natron at Old Stamico Camp | *Pseudoanabaena* sp.<br>*Gomphocymbella burni*<br>*Microcystis* sp. | 2<br>2<br>1 | *Oreochromis alcalicus* | 25 |
| 1B<br>Saline water spring at Old Stamico Camp | *Navicula scolipleura*<br>*Navicula sphaerophora*<br>*Navicula* sp. 1<br>*Microcystis* sp. | 1006<br>1251<br>1014<br>2 | *Oreochromis alcalicus* | 1433 |
| 2A<br>Freshwater Spring | *Navicula scolipleura*<br>*Navicula sphaerophora*<br>*Navicula oblonga*<br>*Chroococcus minutus*<br>*Cymbella* sp. | 39<br>8<br>3<br>3<br>2 | Undescribed species (samples awaiting taxonomic identification) | 33 |
| 2B<br>Lake Natron | *Navicula sphaerophora*<br>*Navicula scolipleura*<br>*Navicula* sp.1<br>*Navicula oblonga*<br>*Chroococcus minutus*<br>*Cymbella* sp. | 35<br>20<br>1<br>6<br>1<br>4 | *Oreochromis alcalicus* | 17 |
| 3<br>Monik River | *Navicula scolipleura*<br>*Navicula sphaerophora*<br>*Navicula oblonga* | 42<br>112<br>7 | *Oreochromis alcalicus* | 218 |
| 4<br>Lake Natron at Southern lagoon | *Navicula oblonga*<br>*Navicula scolipleura*<br>*Navicula sphaerophora*<br>*Cymbella* sp. | 1<br>3<br>5<br>2 | *Oreochromis alcalicus* | 254 |

With regard fish, a small species of fish (possibly a sub-species of *O. alcalicus*) was collected in addition to the endemic alkaline tilapia *Oreochromis (Alcolapia) alcalicus*. The newly caught fish differ from *O. alcalicus* mainly by having an inferior suctorial mouth as opposed to terminal mouth which is characteristic of *O. alcalicus*. The new species was sampled from one site, a freshwater spring 400m from the edge of the lake on the eastern shore (sample site number 2A). The preserved specimens of the un-named species caught during the present sampling at Lake Natron are awaiting taxonomic identification/confirmation from the cichlid experts. In the present study *O. alcalicus* specimen ranging from 2.0 to 11.1 cm in length were caught from a wide variety of habitats, ranging from predominantly freshwater habitats in the Monik River (salinity = 0.2 ‰), hot saline springs on the periphery of the lake (salinity = 5-20 ‰) to numerous lagoons on the edge of the lake itself (salinity = 20-25 ‰).

The ability to excrete urea rather than ammonia (100% ureotely) as their sole nitrogenous waste and the use of the swim-bladder as a primitive air-breathing organ make *O. alcalicus* unique among teleost fish and renders the species of special evolutionary importance. Very few tropical freshwater fish species such as lungfish (*Protopterus aethiopicus*) and catfish (*Clarias* sp.) are known to possess accessory breathing organs other than gills.

On average, more than 65% of all male and female fish caught in the samples during this study were carrying mature and/or ripe gonads. Capture of large number of spawning/spent females of the resident fish species suggests that the present conditions in pools and lagoons around Lake Natron are suitable for breeding of both *O. alcalicus* and the presently un-identified sub-species. Breeding fish were only observed in Sites 1B, 2A, 3 and 4. All these sites were located in or near the freshwater inflow (along lower river mouths, hot saline and freshwater springs).

The survey also revealed that fishing is not an important economic or social activity among local people around Lake Natron in Tanzania.

The major ecological importance of the alkaline tilapia in Lake Natron lies on food and feeding relationships where *O. alcalicus* contribute to a substantial increase in faunal diversity by extending the food chains to fish eating birds, of which the Great White Pelican is dominating.

With regard to their conservational status, *O. alcalicus* are classified as “threatened” in the IUCN Red data book. Due to a limited home range with no known history of undertaking long up-river spawning migrations into areas outside the lake, *O. alcalicus* are more susceptible to extinction from adverse environmental effects operating on a lake-wide scale. No specific management requirements have yet been set for threatened fish species, however, establishing management requirements for fish of conservational concern is the focus of ongoing work by NEMC.

This study has identified that:

- The low water/dry season refuge are the springs associated perennial saline/semi-saline pools (these are not changing) and the fresh water swamps (created around the outflows and deltas of the perennial rivers).

- The most critical habitats include fresh water swamps created around the outflows and deltas of the perennial rivers). The study observed breeding to occur in the inflow channels from the springs (breeding was not observed in fish caught from the Lake itself)

- Dispersion of the population occurs during Lake flood events as seen in 2007 where the lake surface is continuous.

- The saline habitats contain one/possibly two endemic species and no other fish species. The freshwater habitats near the river deltas and the river channels have a higher diversity but no endemism. A few purely freshwater species are found in the Ewaso Ngiro Delta where they support significant subsistence riverine fisheries.

## 5.7 Small Terrestrial Vertebrates

Given the harsh environment in the immediate surroundings of Lake Natron, little scientific study of its small vertebrate fauna appears to have been conducted. Early visitors and collectors focussed on what was termed the "Maasai area" of East Africa, but this included portions of both of what are now Kenya and Tanzania. Some of the earliest collecting was conducted by G.A Fischer, a German who visited the "Maasai area" in the late 1880s (see Rodel & Hallermann, 2006 for a brief summary). Other records of mammals are sometimes given for nearby localities in the area, such as Longido, see Swynnerton & Hayman (1951) for details. The only report available to us which includes data on small mammals is that of Kasule et al. (1993); small mammal data was not included in the Uasso Nyiro report. To our knowledge there is no publication summarising information on the vertebrate fauna of Lake Natron area.

In Tanzania, no other detailed studies have been conducted in such dry environmental conditions. Studies at Usangu Game Reserve, Mbeya Region, Tanzania for dry and wet seasons were conducted over several years but the environment there although seasonally wet and dry, is generally much moister and freshwater is present at least at some localities through out the year). The Royal Geographic Society conducted surveys at Mkomazi National Park, but this area includes at least some sites with freshwater and is within a relatively well-protected National Park in north-eastern Tanzania (Coe et al., 1999). Serengeti National Park has received the attention of biologists for years, but its fauna is much richer than that of the Natron area and is not directly comparable, nor are the ecological conditions the same (Sinclair & Norton-Griffiths, 1979; Sinclair & Arcese, 1995, Sinclair et al., 2007). Basic species lists are available for the fauna of the Serengeti (amphibians and reptiles: Channing et. al, 2004; Kreulen, no date); small mammals, Senzota (1978) Verschuren, 1965).

### *5.7.1 Field Investigations*

From 20-27 January 2007, Standard small vertebrate trapping techniques were used to assess the presence of the small vertebrate fauna. A summary of the survey are provided below.

**Table 5-2: Summary of the field survey of the proposed project area**

| Taxonomic Group | Common Name | Scientific Name | Distribution, Notes |
|---|---|---|---|
| Class Amphibia | | | |
| Family Bufonidae | Desert Toad | *Bufo xeros* | Widely distributed, from Algeria to the dry savannas of Sub-saharan Africa, known from the drier parts of Uganda, Kenya and Tanzania.<br><br>In addition to the individuals trapped, two were collected at the Moivaro tented camp area during the scoping exercise, when the males were also vocalising. |
| Family Ranidae, Ranid or "typical" frogs | Ridged Grass Frog | *Ptychadena anchietae* | A single individual was collected at a wetland near Panini during scoping. |
| Class Reptilia | | | |
| Order Sauria, Lizards | | | |

| Taxonomic Group | Common Name | Scientific Name | Distribution, Notes |
|---|---|---|---|
| Family Gekkonidae, Geckos | Nyika Gecko | *Hemidactylus squamulatus* | Known as an inhabitant of Acacia Commiphora woodland, but also found in some places in dry Zambesian woodland. |
| | Banded Velvet Gecko | *Homopholis fasciatus* | The single individual sampled is a range extension, however, its occurrence is not unexpected, since it is known from dry country from diverse localities |
| | Turner's Thick-toed Gecko | *Pachydactylus turneri* | A species of moist and dry savanna, from sea level to 1800 m altitude. In East Africa its distribution in East Africa is patchy. It is probably more widely distributed but is simply undersampled. |
| Family Lacertidae, Lacertid Lizards | Southern Long-tailed Lizard | *Latastia longicaudata* | A common and widespread species of the Somali-Maasai semi-desert area but is also found in *Acacia-Commiphora* woodland. This appears to be the first known from the Lake Natron area. |
| Family Scincidae, Skinks | Tree Skink | *Trachylepis planifrons* | A single individual was seen on the eastern shore of the lake during the scoping visit. |
| Order Serpentes, Snakes | | | |
| Family Boidae, Boas | Kenyan sand boa | *Eryx colubrinus* | Known from northern and eastern Kenya and northeastern Tanzania, with a single record from Ruaha National Park in southern Tanzania. The animals captured represent a range extension for this species, but it would be expected to occur. |
| Family Colubridae, "typical' snakes | Northern Stripe-bellied Sand Snake | *Psammophis sudanensis* | One individual was captured in a BPFL; it is a widespread species and would be expected to occur in the Project Area. |
| Class Mammalia, Mammals | | | |
| Order Insectivora | | | |
| Family Soricidae, Shrews | White-toothed or Musk Shrews | *Crocidura* sp. | |
| | | | |

| Taxonomic Group | Common Name | Scientific Name | Distribution, Notes |
|---|---|---|---|
| Order Rodentia | | | |
| Family Muridae, Muroid rodents | Pygmy Mouse | *Mus* sp. | While there appear to have been to records directly associated with the Lake Natron area, there is a record mapped in Kingdon (1974) indicating a position approximately between Lake Eyasi and Lake Natron for *Mus bellus* and we tentatively place the pygmy mice captured in that taxon until reports from a specialist on the genus *Mus* are received. |
| | Tatera Gerbils | *Tatera* sp. | *Tatera* cf *robusta*<br>The single specimen trapped does not agree with all features of this species but this probably reflects inadequate original descriptions rather than an unusual taxon. Tatera gerbils are found in a wide variety of habitats, including grassland and woodland in dry areas. |
| | Spiny Mouse | *Acomys* sp. | Possibly *Acomys wilsoni* or *Acomys nubilus;* Swynnerton & Hayman (1951) record *Acomys nubilus* Dollman, 1914 the type specimen from "Magadi, (presumably in Kenya) southern Masailand " and at the foot of Longido Mountain, Tanzania. The exact species boundaries of members of the genus *Acomys* have not yet been precisely determined (see Wilson & Reeder, 1993). |
| Order Chiroptera, Bats | | | |
| Suborder Microchiroptera, Insectivorous bats | | | |
| Family Megadermatidae "False Vampire" bats | Yellow-winged Bat | *Lavia frons* | Seen frequently in scrub in the vicinity of Moivaro tented camp and at Panini; recorded from Ol Donyo Lengai by Swynnerton & Hayman (1951). |
| Order Carnivora | | | |
| Family Hyaenidae | Spotted Hyena | *Crocuta crocuta* | Widespread in the Lake Natron area, noted as present at Longido by |

| Taxonomic Group | Common Name | Scientific Name | Distribution, Notes |
|---|---|---|---|
| | | | Swynnerton & Hayman (1951) and heard and seen during the fieldwork. |

Other species that probably occur in the area, based on their presence in dry habitats and general widespread distributions in the region are presented below.

**Table 5-3: Species of small vertabrate expected to occur in the location of the project site**

| Taxonomic Group | Common Name | Scientific Name | Distribution, Notes |
|---|---|---|---|
| Class Amphibia | | | |
| Family Bufonidae | | *Bufo parkeri* | This small toad is undercollected and is known from dry localities north of Lake Natron (Olorgesaille in Kenya) and to the south (Usangu area, Tanzania) (Channing & Howell, 2006) and so might well be found in the Natron area. |
| Family Ranidae | Sand Frog | *Tomopterna* sp. | A specimen of frog collected by Fischer in the late 1800s had for years been misidentified as a member of another genus and only recently was placed in this genus. |
| Class Reptilia | | | |
| Family Testudinidae, Tortoises | | | It is likely that at least one species of tortoise, *Geochelone pardalis*, the Leopard Tortoise, occurs in the Lake Natron area but due to the harsh, dry conditions these would have remained in hiding or aestivation during our visit. Given the lack of suitable habitat (granite fissures in kopjes), it would seem unlikely that the Tanzania/Kenya/Zambia endemic Pancake tortoise, *Malacochersus tornieri*, would occur in the Project Area. |
| Order Sauria, Lizards | | | |
| Family Cordylidae | | *Cordylus beraducci* | This species has only recently been described and is known from the drier portions of northern Tanzania and is also found in Kenya (Spawls et al., 2004). |

| Taxonomic Group | Common Name | Scientific Name | Distribution, Notes |
|---|---|---|---|
| Family Scincidae | | *Trachylepis dichromis* | This skink was only recognised as different from *Trachylepis brevicollis* in 2005 and Branch et al (in prep) indicate that it is found in the vicinity of Lake Natron. |
| Family Varanidae | Nile Monitor | *Varanus niloticus* | Nile Monitor lizards were reported by local residents to occur on the western side of the Lake. |
| Order Serpentes, Snakes | | | |
| Family Pythonidae | | *Python* sp. | Pythons would be expected to occur in areas of wetlands with freshwater. |
| Family Elapidae | | *Dendroaspis polylepis.* | Black Mambas would be expected to occur as they are widely distributed and able to survive in dry areas. |
| | | *Naja* spp. | Cobras are probably present, based on their wide distribution in similar habitats. |
| Family Viperidae | | *Bitis arietans* | Puff Adders are widely distributed and likely to occur in the Natron area. |

### *5.7.2 Other Observations and Records from the Literature*

The study by Kasule et al. (1993) trapped 33 small mammals in bushland and Maasai dwellings. Four of these were shrews (no attempt was made by the authors to identify these to genus) and twenty-nine were Multi-mammate rats in the genus Mastomys . The latter is a widespread genus associated with human agriculture and disturbance. Kasule et al. (1993) further remark upon the absence of the Roof Rat *Rattus rattus*, a common human commensal species.

The only standard reference for the Tanzanian mammalian fauna that provides detailed locality data based on specimens is Swynnerton & Hayman (1951) but the taxonomy used therein is outdated, sometimes making comparisons difficult. Furthermore, little collecting seems to have done in the immediate vicinity of Lake Natron. However, the following records were noted and are provided for comparative purposes:

The species “white-toothed” or “musk” shrew, *Crocidura fisheri Pagenstecher*, 1885 was described from Nguruman, west of Lake Natron, and has also been reported from near Engare Nanyuki. These specimens will need to be examined by a specialist before they can be identified to species level.

Kingdon (1974) is the standard reference for East African rodents, but unfortunately, he did not provide detailed localities nor details of specimens examined. However, he does record a member of the “Egyptian Gerbil” genus, *Gerbillus*, *Gerbillus pusillus*, from immediately south of Lake Natron. He also notes that this rodent is recorded as prey of *Eryx colubrinus*.

No concentrations of large mammals were evident; occasional individuals and/or small groups of zebra, gazelles, and wildebeest were seen, however. Surprisingly, no baboons were seen in the vicinity of the proposed project site. Insectivorous bats unidentified to species, possibly members

of the family Hipposideridae, were seen catching insects at night at the Moivaro tented camp during scoping. No nocturnal primates (galagos, bushbabies) were seen or heard.

### *5.7.3 Significance of Findings*

There were few species of small vertebrate detected, it was to be expected that reptiles, many of which are adapted for relatively dry conditions, were relatively more speciose than the other groups. The large number of Bufo toads present probably reflected that they had bred earlier and we were capturing subadults. None of the vertebrate groups sampled was especially speciose or abundant.

None of the species detected is listed as threatened by the IUCN criteria. Several of the groups present represent taxa that are included in the CITES (Convention on International Trade in Endangered Species of Fauna and Flora) to which Tanzania is a signatory; see Table 5-4.

**Table 5-4: Reptiles of the Lake Natron area (some of which were detected during the present study) on the CITES Appendix II**

| Taxon | Common Name | Occurrence in Project Area | CITES Appendix |
|---|---|---|---|
| Testudinidae | Tortoises | At least one species probably occurs | Appendix II |
| *Varanus* | Monitor Lizards | *Varanus niloticus* Reported to occur | Appendix II |
| Pythonidae | Pythons | *Python* sp. probably occurs | Appendix II |
| Boidae | Boidae | *Eryx colubrinus* was trapped | Appendix II |
| Cordylidae | Maasai Girdled Lizard | Almost certainly occurs, known from Longido area. | Appendix II |

Aside from possible disturbance and possible destruction of some habitat in which these species are found, another effect of the project might be to increase the accessibility of the general area to animals for the live animal export trade in Tanzania.

Based on the study sampling, the small mammal and herpetofaunal affinities of the Lake Natron area appear similar to those of the generally dry areas of Africa, as indicated by the presence of the amphibian the Desert Toad, *Bufo xeros*, also known from desert and semi-desert in west and north Africa and the snake *Eryx colubrinus*, the Sand boa, known from semi-desert and desert areas of Africa. Egyptian gerbils in the genus *Gerbillus*, typical of semi-arid habitats, are recorded from near Lake Natron (see Kingdon, 1974). We are unaware of any species of small terrestrial vertebrate endemic to the Lake Natron area. The other species of small vertebrates detected are distributed widely in woodland and other habitats.

In conclusion no small vertebrate of conservation concern was collected, nor was any species endemic to Tanzania or the Lake Natron area. During the sampling period, conditions were dry and relatively few species and low numbers of animals were detected.

## 5.8 Avifauna

Although the project area supports a wide variety of birds the study focussed on water birds and most particularly the lesser flamingo which is of greatest conservation concern. Full details are contained in Appendix F.

### *5.8.1 Introduction to Lesser Flamingo*

Lesser Flamingo are known to move several hundred kilometres between saline (rift valley) lakes in East Africa, and between salt pans in southern Africa (Childress *et al*. 2004, McCulloch *et al.* 2003, Simmons, 2000), although there is little data to show a link between the two populations although some movement has been suggested. The species appears to be adapted to respond to deterioration in local conditions by moving elsewhere, and thus depends on a network of suitable sites (BirdLife International).

**Figure 10: Flamingos at Lake Natron**

Previous studies, which include specific analysis of the Lesser Flamingo breeding sites (Brown, 1955, Brown & Root, 1971) and environmental impact assessments (Johnson, 1991, Knight, 1993) have in the past been carried out at Lake Natron. All of these studies have confirmed the critical importance of this ecosystem to Lesser Flamingo, especially its globally important breeding sites. Further conformation of the importance of this site is shown through the designation of Lake Natron as a globally important Ramsar site due again to the presence of Lesser Flamingo (see policy and legal framework in Chapter 3).

Field surveys initially focused on the entire Lake Natron basin in order to establish the important sites for resident and migratory waterbirds. Once this was completed an aerial survey of Lesser

Flamingo numbers was carried out across the entire Lake basin. The aerial survey included a detailed look at the breeding.

The ornithological survey included an assessment of the entire lake to identify the most important sites for not only Lesser Flamingo, but also other resident and migratory waterbirds Figure 5-11 illustrates the most suitable site for any construction, based on current knowledge was chosen for several reasons; ie there is no freshwater inputs, mudflats or standing vegetation so important to this and other species of waterbirds. The site is an equal distance from each of the known lesser flamingo breeding sites (c. 17km).

The Lesser Flamingo *Phoenicopterus minor* is classified "Near Threatened", indicating that it is considered likely to qualify for a threatened category in the near future. The species is listed in Column A of the African-Eurasian Migratory Waterbird Agreement (AEWA) action plan, Appendix II of the Bonn Convention (CMS) and Appendix II of the CITES convention, and thus requires special consideration.

The total population is estimated to be between 2.2 - 3.2 million (this number is currently under revision) (Wetlands International, *in press*) and occurs primarily on saline lakes, pans and coastal wetlands throughout sub-Saharan Africa and from the Arabian Peninsula to India (BirdLife International 2000). Total population declines have been suggested (Simmons 2000), but this is difficult to quantify because of the extensive movement typical of the species. The Lesser Flamingo is known to breed successfully in only three locations (Sua pan in southern Africa, Lake Natron in East Africa, and the Rann of Kachchh in India (Ali 1974), all of which are threatened and require additional protection (Simmons 2000, Jadhav and Parasharya 2004).

Lesser Flamingo are known to move several hundred kilometres between saline (rift valley) lakes in East Africa, and between salt pans in southern Africa (Childress *et al.* 2004, McCulloch *et al.* 2003, Simmons, 2000), although there is little data to show a link between the two populations, some movement has been suggested. The species appears to be adapted to respond to deterioration[1] in local conditions by moving elsewhere, and thus depends on a network of suitable sites (BirdLife International 2000, McCulloch *et al*. 2003, Childress *et al*. in press), many of which, like Natron, are completely unprotected (Childress et al. in press).

Environmental threats include soda-ash mining, salt extraction, damming of water inflows for agriculture irrigation, land claim, water pollution and human disturbance at breeding sites (BirdLife International 2000).

[1] This could be flooding, drought, disruption in food sources or changing predator interactions.

### *5.8.2 Lake Natron as a Key Site for Lesser Flamingo*

Lake Natron is the only breeding site for Lesser Flamingo in East Africa and is globally the most significant breeding site for this species (Brown, 1955. Brown and Root, 1971. Baker and Baker,2002). The majority of breeding occurs during October – November[2] although breeding to a lesser degree of success can occur throughout the year. There are a number of clearly significant reasons why Lake Natron is preferred by this species. There are five main conditions that the flamingo require to successfully breed at lake Natron:

1) Isolation of nesting sites from mammalian and avian predators. There is no other site within the range of the East African Lesser Flamingo which currently provides these parameters of isolation from mammalian predators. Documented evidence has suggested that a single episode of disturbance can cause the whole breeding colony to abandon the nest site.

2) Presence of freshwater springs throughout the year. The juvenile birds, once in a crèche move towards fresh water in large groups. If you look at the distribution of Lesser Flamingo's at Natron, large concentrations gather at the river deltas and springs to wash their feathers.
3) Presence of microscopic salt water algae for feeding throughout the year.

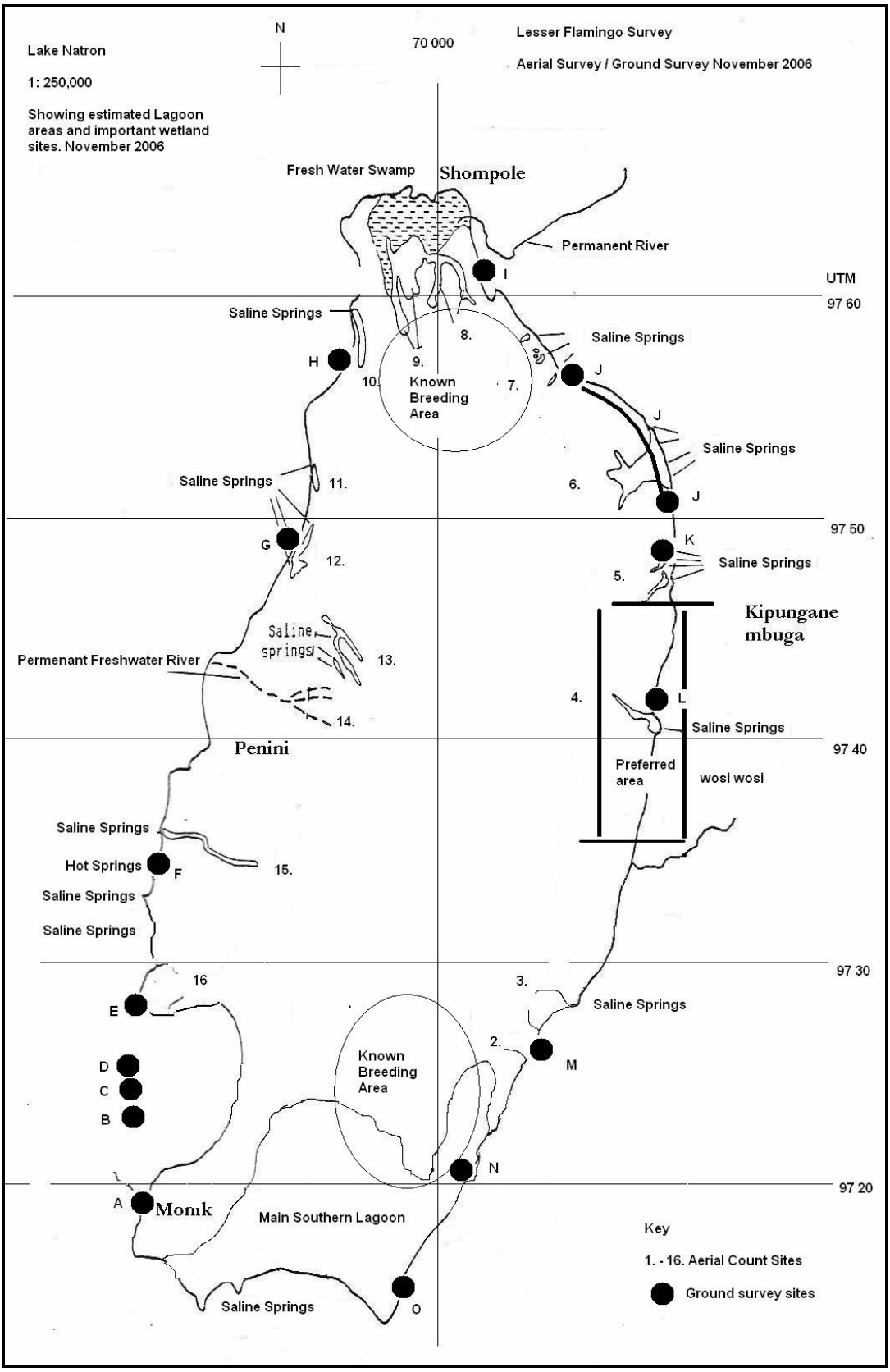
4) Presence of suitable substrate for nest construction. This is extremely important, the 'preferred' breeding sites are in areas were this mud is available, in dry years the colonies can be more spread out and follow the cracks in the trona where suitable mud can be accessed (these are known as string formation nests).

5) Suitable areas for the young when in a crèche to move, feed and obtain freshwater as outlined above.

Other than breeding, Lake Natron is a key feeding site for this species throughout the Year with numbers often exceeding 200,000 individuals (c. 8% global population). As mentioned this species requires a network of sites in order to respond to changing environmental conditions.

[2] Source; Tanzanian Bird Atlas

**Figure 5-11: Map Showing site of lowest potential impact. (base map from Watson & Nimmo, 1991)**



### *5.8.3 Breeding Strategy and the Importance of Lake Natron*

In order to stimulate nuptial display and thus breeding, Lesser Flamingo form flocks ranging in several 1000's which carry out an elaborate display. Mating then may or may not occur, but if it does it usually occurs on the outer edges of the display flocks. These display grounds tend to be in specific locations and not specifically in breeding areas, for example Lake Nakuru is known to be an important display ground but no breeding has occurred there for 45 years (Brown & Root, 1971). At Lake Natron, egg laying tends to occur at the end of the dry season between August and November and possibly into December (if rains are late and extend the dry season). Usually one egg is laid (in rare cases 2).

A critical point in the breeding cycle is outlined by Pennycuick & Bartholomew (1973); 'it is possible that the primary limitation on breeding might be the time needed by the female flamingo to save up enough energy to produce the egg, rather than the food concentration needed for incubation'. The authors go on to point out that food type (microscopic algae) needs to be in a concentration of c.0.25 kg / $m^3$ adjacent to suitable breeding areas. The important point to note here is that Lake Natron is not the only breeding site for one reason but for a combination of factors, both biotic and abiotic, many of which are not fully understood.

Breeding attempts by this species in late 2006, early 2007 have failed at Natron due to heavy rains and excessive flooding. In southern Africa breeding has failed this year at Sua Pan due to intense heat and drought causing the adults to abandon their young (G.McCulloch, *pers comm*.).

**Figure 5-12: Nest sites on Gelai Mudflats, 1st November 2007**

### 5.8.4 Water birds other than Flamingo

Water bird populations require a network of suitable sites, rather than a single spatial or temporal resource. All of the migrant species that variously utilise Natron respond to changing conditions by moving, often daily. These changes in prevailing conditions are natural and sometimes dramatic, such as the rains of late 2006 which caused water levels to be extremely high; this will have reduced the areas of open mudflats which the waders tend to use most.

Important species are shown below, these count numbers are from 2005 waterbird count (Baker, in press) and show species that exceed Ramsar 1% levels and thus qualify the site for Ramsar.
Lake Natron is the most import global site for Chestnut-banded Sandplover, shown clearly in this table; it prefers open mudflats close to the shoreline. These data show that on the 5th January 4,357 birds were counted at Natron whilst the project count on the 6th November 2006 counted 877, the vast majority of which were north of Wosi Wosi (site J).

**Table 5-5: Ramsar 1% species population levels and existing bird counts (these figures were substantiated for some of the species during this study)**

| Species | RAMSAR 1% levels | Count Results 14-15 Jan 2005 |
|---|---|---|
| Cape Teal | 64 | 122 |
| Chestnut-banded Sandplover | 45 | 4,357 |
| Marsh Sandpiper | 750 | 1,451 |
| Little Stint | 10,000 | 19,276 |
| Gull-billed Tern | 380 | 64 |

### 5.8.5 Importance of Lake Natron for Birds

The main importance of Lake Natron is as the most essential breeding site for lesser flamingo, a threatened species under the IUCN categories.

Considering what is known about Lesser Flamingo and the critical importance of this ecosystem to the breeding and population dynamics of this species, along with thousands of other waterbirds, any form of development which may change the ecology of this ecosystem entails risk.

When er land use change is considered, it must be on a regional basis, the network of lakes in the rift valley that are used by Lesser Flamingo, and many other species are all under threat. One of the unique elements of Natron is actually the lack of threats when compared with other rift valley lakes and the remoteness and harsh nature of Natron has always been a benefit from a pure conservation point of view. The springs and rivers that feed Natron provide the environment for aquatic life that these birds feed on. Water birds would be effected if there were changes to the aquatic ecosystem which could alter the amounts or types of invertebrates and crustaceans available as a food source

Water birds would additionally be affected if there were changes to or impacts on the springs and permanent / seasonal water inputs which create the ecological conditions for invertebrate and vertebrate organisms which provide the food source.

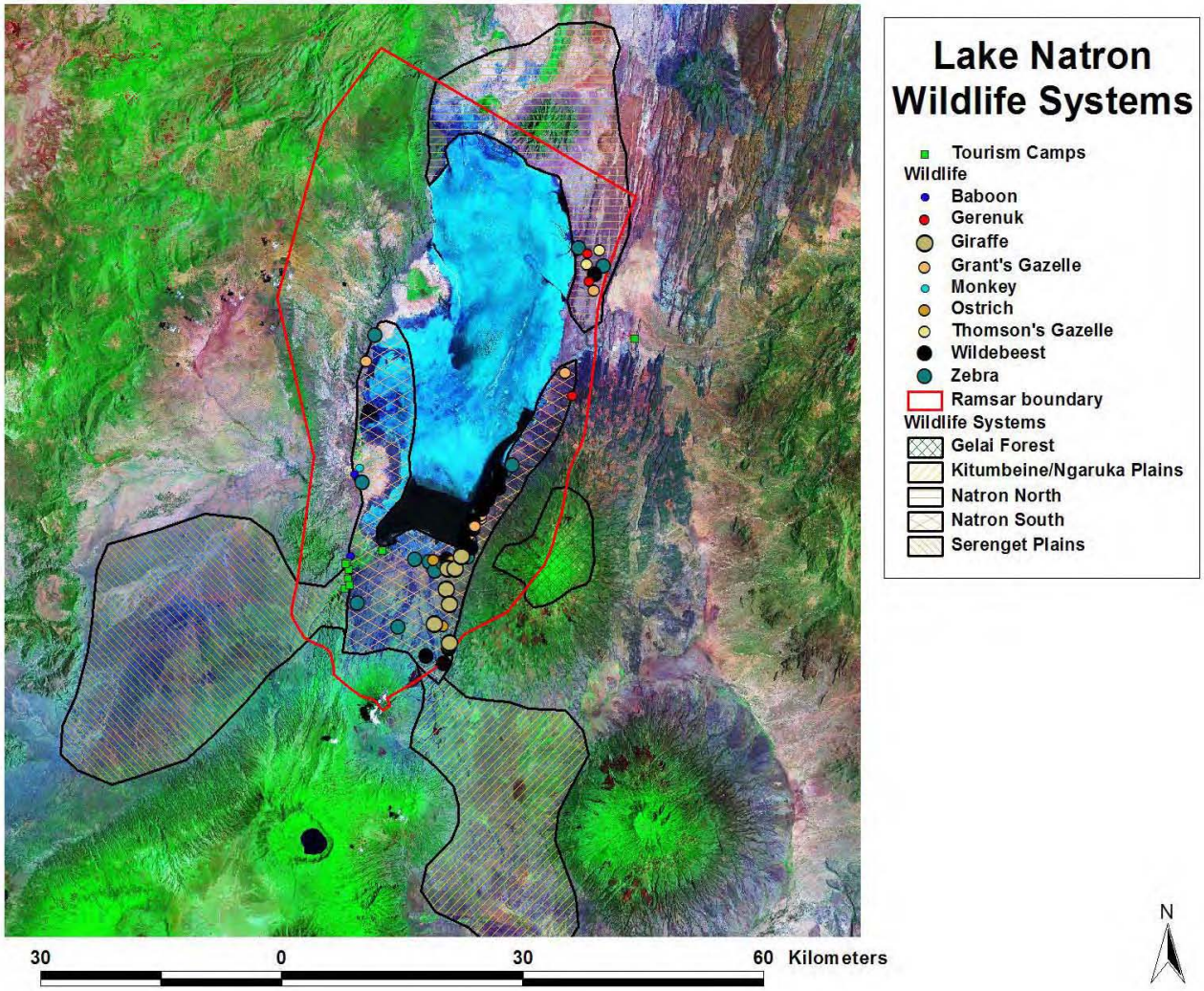
Lake Natron is also the most import global site for Chestnut-banded Sandplover (a threatened species?)

## 5.9 Ungulate Wildlife Systems

The Lake has permanent and migratory wildlife populations. The permanent species are either those adapted to arid systems reptiles, rodents rodentivoures (foxes and jackal), insectivoures and generalists (mongoose, Gerinuk, ), or dependent on available fresh water. There are permanent populations of primates along the river systems and near settlement. There are also permanent larger ungulate populations in the well watered Galei forests.

Apart from the Wosi Wosi area, these permanent populations appear to be under threat from intensive land use practices (TAWIRI & FZS, 2002). In the west side of the lake there is displacement of wildlife due to expansion of arable agriculture, irrigation and settlement. To the south east (Magadi) there is competition for dry season grazing and systematic attempts to exclude wildlife from the dry season range. On Gelai there is considerable settlement, arable agriculture and pastoral activities.

**Figure 5-13: Wildlife systems and observations August 2006**

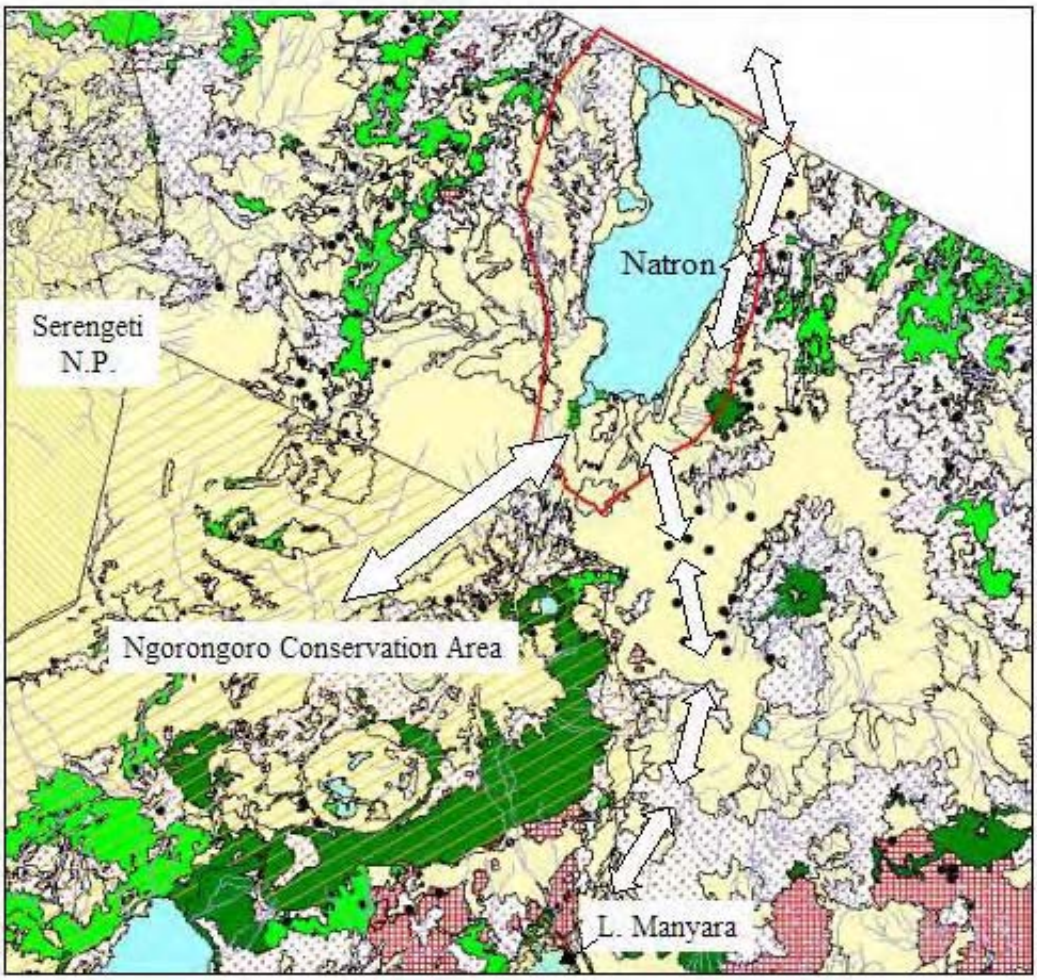


During the dry season there are relatively large populations of migratory and nomadic ungulates using the fresh water and semi sodic springs and associated wetlands for dry season grazing. During the wet season ungulates move onto the open grasslands to the south east and south west.

Literature suggests two migratory corridors between the Lake and other wildlife systems:

- A link between the Ngorongoro Conservation Area and Natron along the open grass plains
- A link between Lake Manyara National Park (Mto wa Mbu GCA) and the Lake Natron GCA along the approximate alignment of the existing Mto wa Mbu to Engare Sero road.

**Figure 5-14: Wildlife movement corridors suggested in the literature**

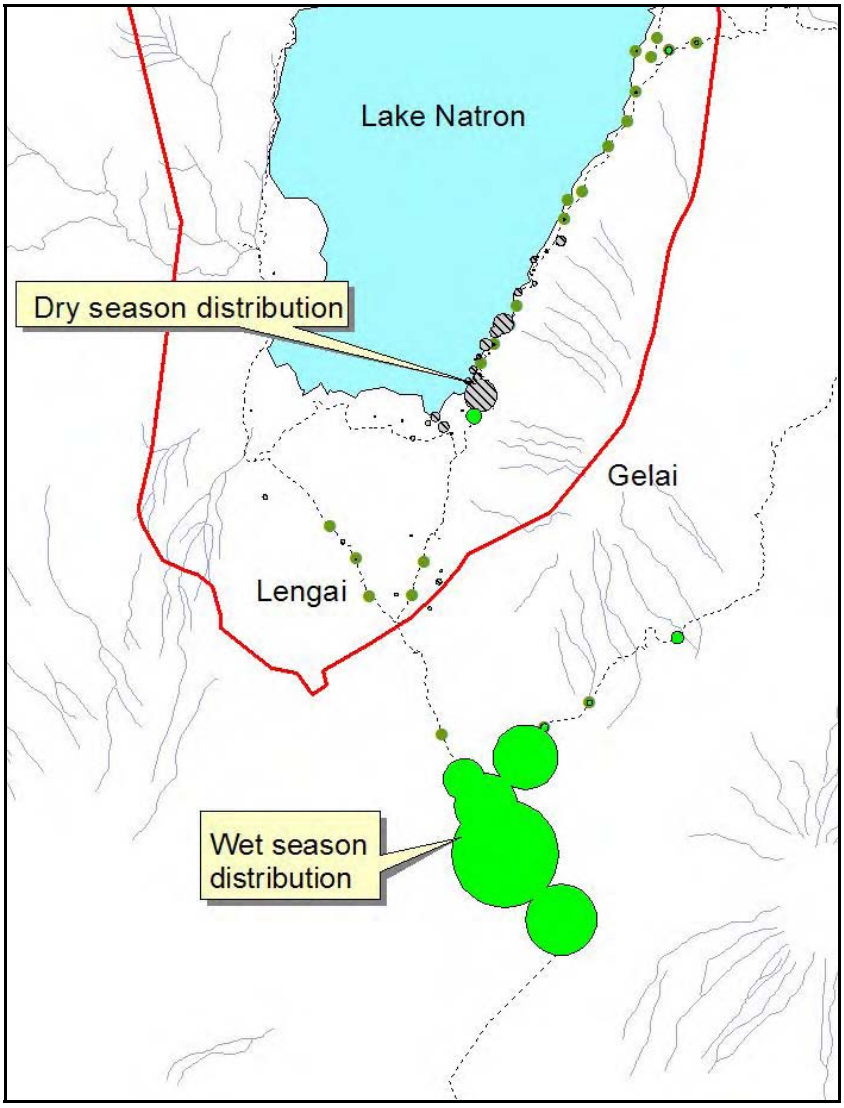



The wet and dry season observations carried out during this study indicate that there are two sub populations of wildlife which are:

- Wildlife population in the Wosi Wosi area which have a link between the northern slopes of Gelai;
- and the fresh water of the Ewaso Ngiro swamp comprising the dry season ungulate population using the grazing resources in the south east (Magdi) area of the lake and appear to move onto the open grasslands between and south of the Gelai – Kitenbene area.

The ungulate species comprise Grants Gazelle, Thomson's Gazelle, Zebra, Wildebeest, Ostrich, Gerenuk (not found on the plains) and Giraffe.

**Figure 5-15: Large wildlife ungulate movements at Lake Natron during wet and dry season (based on field observations 2006 dry-2007wet)**




An aerial and ground survey undertaken in the dry season of 2001 to assess population levels of Gerenuk, Lesser Kudu and Fringe Eared Oryx. The survey covered the Lake Natron (GCA) Hunting Block North which is situated between the Lake (the western boundary) and the main road between Arusha and Kenya (Eastern Boundary) (TAWIRI & FZS, 2002). The survey found healthy populations of Gerenuk and Lesser Kudu but sited only 40 Fringe Eared Oryx.

The majority of Gerenuk and Oryx were located either adjacent to the Lake's eastern shore or occurred along the eastern foothills of Gelai. The lesser Kudu population was located slightly further east along the eroded escarpment towards Longido. The survey report expressed concern about range degradation, high levels of fire (up to 40% of Oryx habitat was burned) and the spread of Boma into the hunting block.

The authors of the survey also identified the need for further surveys to include a wider area particularly the Lake Natron South Hunting Block, The additional surveys (which have not been conducted) are needed to increase the limited understanding of seasonal ungulate population

movement patterns. They also suggested the increase in community conservation education and anti poaching surveillance.

The results of the 2001 survey indicate that the Lake Natron Hunting Block North, particularly the Lake shore and the lower slopes between Gelai and the Longido escarpment are important for Gerenuk, Lesser Kudu and to a lesser extent Fringe Eared Oryx. It also gave an indication as to the extend of change occurring in the hunting block due to increased human settlement.[3]

**Poaching**

In 1997 poaching was recorded as a serious and increasing concern in Monduli District (Meindertsma and Kessier) although a slight decline in poaching was reported for the hunting blocks (GCA), due to anti-poaching activities carried out by the hunting companies.

Poaching, as a threat to wildlife populations, could increase significantly as a result of human immigration due to the limited capacity of Department of Wildlife in the Natron area.

## 5.10 Vegetation

### *5.10.1 Plant and Township area*

**Acacia Commiphora scrub**

This vegetation covers the area north of Wosi Wosi hamlet, around the lake where the plant is to be constructed and most of the access south of the plant site, changing only at the outskirt of Magadi village.

The composition is mainly deciduous dwarf woody shrub with scattered medium height trees supported by relatively un-weathered basaltic larva and exposed rocky outcrops. On the rocky outcrops there are a number of succulents and tall trees.

The dwarf and succulent species commonly associated to this *Acacia – Commiphora* scrub include *Adenium obesum Commiphora camestris, Kleinia longiflora, Euphorbia uhligiana, Sansevieria ehrenbergiana, Jatropha ellenbeckia*, and *Euphorbia matabelensis.*

Non succulent species are *Acacia tortlis, Sterculia quenquiloba, Delonix elata, Acacia melifera* and *Cordia sinensis*.

The herbaceous and shrub layer is composed of mainly *Duosperma, Barleria eranthemoides, Hypoestes verticillaris, Tephrosia pumilla* and *Justicia flava*. Common grass species around this area are *Cenchrus setigerum* and *Aristida barbicollis.*

At the lakeshore the vegetation is mainly edaphic grassland (see description below).

**Acacia tortilis woodland**

This vegetation type borders the edaphic grasslands and is common along the road from Engare Sero to Moinik and also from Magadani to Wosi Wosi area particularly in areas of fresh spring water. It is characterized a single stratum dominated with single tree species of *Acacia tortilis* with patches of grassland.

[3]TAWIRI & FZS 2002 Wildlife census of Oryx, Gerenuk and Lesser Kudu in the Lake natron Game Contolled Area North – dry season, 2001

The understorey layer is dominated with small scrubs; such as I*ndigofera spinosa, Duosperma qudrangulare, Barleria submollis* and *Aerva javanica* and some grass species like *Digitaria macroblephara, Dactyloctenium australe* and *Sporobolus iocladus*.

**Calotropis procera scrubland**

Along the road to Wosi Wosi a patch of pure stand of *Calotropis procera* scrubland dominate the settlement at Magadi village. This unique overgrowth is representative of the effects of overgrazing and poor regeneration potential of natural species.

**The Lake Vegetation**

The lake is devoid of macrophytic vegetation, but is very productive in terms of algae, with blue-green algae (*Cyanophyta*) such as *Spirulina spp*. dominating the saline waters (Finlayson and Moser 1991). The large saline mud flats surrounding the waters are generally considered to be saline deserts. These salt-encrusted flats are covered in a layer of blue-green algae during the rainy season.

**Swamp and Soda flats**

*Sporobolus spicatus* is about the only grass on the seasonally submerged soda flats. On the edges of the flats particularly on the western Lakeshore close to Moinik village permanent *Typha domongensis* swamps are common. All around the Lakeshore swamps of *Cyperus laevigatus* dominate the mud flats.

In addition to the dominant swamp species a few halophytes are also found growing on the saline soils fringing the lake. These include *Dactyloctenium* spp., *Juncus maritimus, Salvadora persica, Sporobolus robustus, Suaeda monoica* and *Triplocephalum holstii*.

### *5.10.2 Plant Ecology*

The lake is devoid of macrophytic vegetation except at the fresh water Typha swamps at the edge of the Lake in the area between the Moinik and Peninj rivers. The mineral composition and non turbid nature of the waters from the sodic springs provide ideal conditions for the production of blue-green algae (*Cyanophyta*).

The fresh water Typha beds and waters are important for waterbird diversity and as a source of fresh drinking water for the Flamigo.

Around the Lake, but predominantly on the southern shores there are large areas of short halophytic grasslands dominate by *Sporobolus spicatus* and *S. robustus*.

In the areas of the less sodic springs, dence stands of *Cyperus laevigatus* and *S. spicatus* occur which are used, together with the *Sporobolus* grasslands, by domestic stock and wildlife as the late dry season grazing area.

As a result of the low rainfall and the sodic nature of the volcanic soils surrounding the Lake, the terrestrial vegetation of the plains is open grassland suitable for wet season ungulate grazing.

Forests and woodlands are important to the ecology of Natron but these are all situated in the upper escarpments and all, apart from some of Gelai Forest Reserve, fall outside of the Ramsar site. The forests of Gelai, the western rift escarpment and the Mau Hills of Kenya are all under threat from timber abstraction, arable agriculture and settlement. There is little doubt that ongoing

changes will have significant long-term impacts on fresh water quality, quantity and flow regimes.

## 5.11 Land Cover

The land cover of the basin is dominated by the Lakes wetland and surrounding grasslands and bush. Woodlands and forests are only found along perennial drainages and at higher altitudes (Gelei Forest Reserve and Loliondo Forest Reserve). Land cover is steadily changing in the more wooded areas as it is converted to agricultural land. Figure 5-16 indicates the land cover of the Basin.

Land cover in the Ramsar site is made up of the wetlands (36%) surrounded by grasslands on the volcanic soils (50%) and bush (13%). There are few areas of woodland and forest with most of the forest located in the Gelei Forest Reserve. Wood resources are therefore limited as is agricultural land. Scattered cultivation occurs in less than 4.2% of the area.

**Table 5-6: Land cover within the Ramsar Site** (Source: Natural Resource Level Land Use and Natural Resource Mapping Project; HTS 1996)

| Unit | Area (ha) | Percent |
|---|---|---|
| Bush (dense) | 34.1 | 1.5 |
| Bush (open) | 162.0 | 7.0 |
| Bush (scatted clutivation) | 5.4 | 0.2 |
| Bush thicket (emergent trees) | 106.0 | 4.6 |
| Forest (natural) | 11.1 | 0.5 |
| Grassland/bushland | 231.7 | 10.1 |
| Grassland (open) | 532.6 | 23.1 |
| Grassland (open, seasonally inundated) | 266.7 | 11.6 |
| Grassland (scatted cultivation) | 94.9 | 4.1 |
| Grassland (wooded) | 22.9 | 1.0 |
| Inland water body | 755.9 | 32.9 |
| Swamp/marsh | 77.0 | 3.3 |
| Woodland (open) | 0.7 | 0.0 |
| Total Area (ha) | 2,301.0 | |

looking at land cover in the Natron Basin, it is clear that most of the wooded resources and areas of high rainfall all lie outside of the Ramsar site i.e. the river basins most important to the Lake hydrology all lie either in Kenya or outside of the Ramsar site.

**Table 5-7: Land cover within the Natron catchment basin** (Source: Natural Resource Level Land Use and Natural Resource Mapping Project; HTS 1996)

| Unit | Area (ha) | Percent |
|---|---|---|
| Bush (emergent trees) | 101.8 | 1.5 |
| Bush (dense) | 231.1 | 3.4 |
| Bush (open) | 756.0 | 11.0 |
| Bush (scatted clutivation) | 27.9 | 0.4 |
| Bush thicket (emergent trees) | 106.0 | 1.5 |
| Cultivated (mixed cropping) | 52.3 | 0.8 |
| Forest (natural) | 17.5 | 0.3 |
| Grassland/bushland | 882.0 | 12.8 |
| Grassland/Bushland (cultivation) | 20.3 | 0.3 |
| Grassland (open) | 2511.0 | 36.4 |
| Grassland (open, seasonally inundated) | 303.9 | 4.4 |
| Grassland (scatted cultivation) | 242.3 | 3.5 |
| Grassland (wooded) | 403.7 | 5.9 |
| Inland water body | 755.9 | 11.0 |
| Swamp/marsh | 79.5 | 1.2 |
| Urban | 0.5 | 0.0 |
| Woodland (closed) | 65.5 | 0.9 |
| Woodland (open) | 339.5 | 4.9 |
| Total area (ha) | 6,896.6 | |

**Figure 5-16: Land Cover Map of the Natron Basin (Source: Natural Resource Level Land Use and Natural Resource Mapping Project; HTS 1996)**

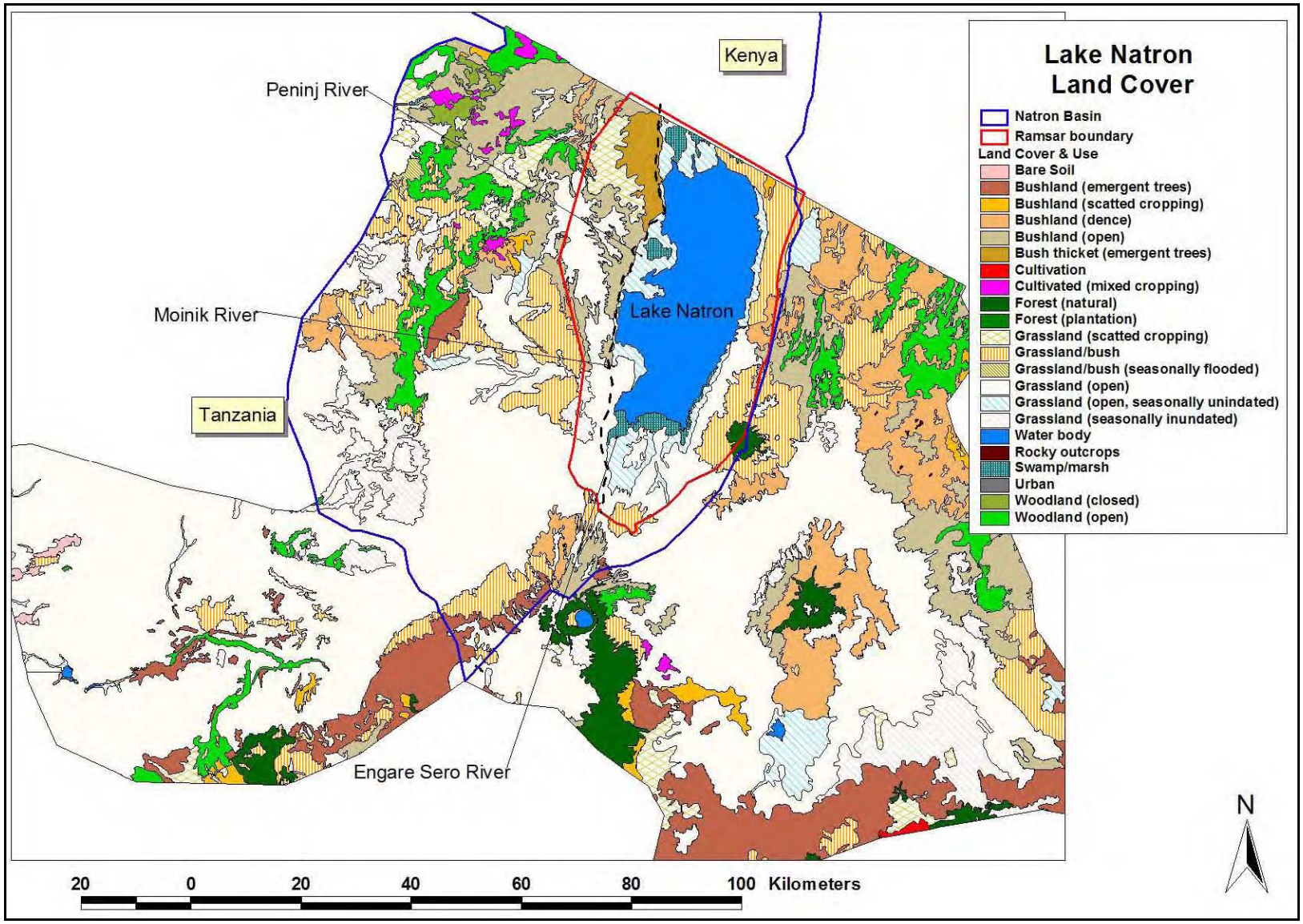


**Figure 5-17: Photograph from the centre of the site facing east towards the eastern boundary (green flush of grass is the result of burning) (24th January 2007)**

**Figure 5-18: Habitats and existing settlement near the proposed Soda Ash abstraction plant site**

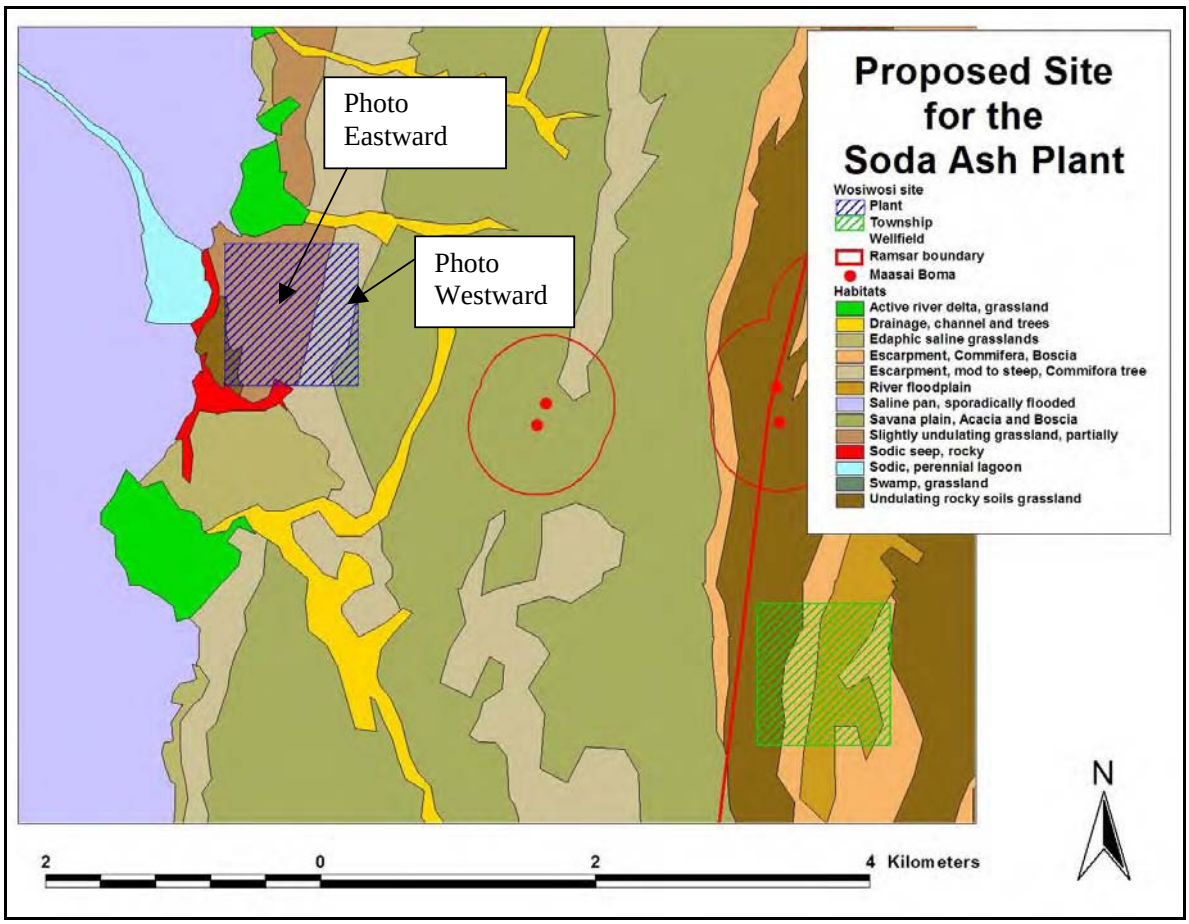


**Figure 5-19: Photograph of the site from the eastern boundary facing west towards Pinyinyi (24th January 2007)**

# 6 IDENTIFICATION OF IMPACTS

## 6.1 Introduction

This section focuses on the impacts that could potentially occur due to the implementation of proposed project.

The EIA baseline work has found that, there is indeed change occurring, both near the Lake and in the catchments of the rivers feeding Lake Natron. This change will accelerate exponentially as soon as the tar road from Mto wa Mbu to Loliondo is constructed (this is a TANROADS project which is in its final design phase and is not related to the proposed Soda Ash abstraction.). It has, therefore, been a difficult but essential task to separate out the impacts from the proposed project from those as a result of ongoing change and the new all-weather road etc.

There have been many concerns expressed due to the location of the proposed project in a wetland of international concern, the Lake Natron Ramsar Site. The importance of the Lake to certain bird populations and the transboundary importance of the lesser flamingo population which, although breeding at Lake Natron, move about and Feed in most of the Rift Valley Lakes has been identified as an important trans frontier concern and thus potentially effects countries in addition to Tanzania.

Birds, particularly internationally threatened species that are large and well known, will have large scale international support if the wider public feel there is any threat to them from the project. This makes decision making move from being based on environmental and economic criteria to that of the political arena.

## 6.2 Approach to Assessment of Impacts

This ESIA has followed the approach outlined by NEMC and has identified impacts and concerns from the extensive process of consultations (Appendix C) and from the specialist reports provided by members of the ESIA team.

The impacts issues identified are listed here and the impacts have been subject to an assessment based on five criteria which are grouped and scored as follows:

**Table 6-1: Impact assessment criteria**

| Group | Code | Criterion | Scale | Description |
|---|---|---|---|---|
| A. Criteria that are of importance to the condition, that individually can change the score obtained | A1.N | Importance of Condition | 1 | Important to national/ International interests |
| | A1.D | | 1 | Important to district interests |
| | A1.S | | 1 | Important to sub-district interests |
| | A1.L | | 1 | Important only to the local condition |
| | | | 0 | No importance |
| | A2 | Magnitude of change/ effect | +3 | Major positive benefit |
| | | | +2 | Significant improvement in status quo |
| | | | +1 | Improvement in status quo |
| | | | 0 | No change/status quo |
| | | | - 1 | Negative change to status quo |
| | | | - 2 | Significant disbenefit or neg. change |
| | | | - 3 | Major disbenefit or change |
| B. Criteria that are of value | B1 | Permanence | 0 | No change/ Not applicable |

| Group | Code | Criterion | Scale | Description |
|---|---|---|---|---|
| To the situation, but should not individually be capable of changing the score obtained | | | 1 | Temporary or of short duration |
| | | | 2 | Permanent |
| | B2 | Reversibility | 0 | Reversible |
| | | | 1 | Irreversible |
| | B3 | Cumulative | 0 | Non-cumulative/ single |
| | | | 1 | Weakly cumulative/synergistic |
| | | | 2 | Strongly cumulative/ synergistic |

In order to do the calculations, first the A1 criteria – importance of the condition to the area of impact – are added together. This gives equal importance (i.e. a score of 1 point each to the national/international, district, sub-district and local levels. By adding these points we can get a weighting, which reflects the importance. It is possible to score one point only at the national/international level, but be of no importance at the local level.

The Environmental Score (ES) for all the questions are then summed for the each site for the particular aspects. The scores for the component aspects will show the sensitivity of the site to different issues.

The next step is to provide a rank for the impact. The ranking shows the overall significance of the changes occurring as shown below in Table 6-2.

**Table 6-2: Environmental significance and scores**

| Environmental Score | Description of Range Band |
|---|---|
| +>+40 | Major positive change/impacts |
| +31 to + 40 | Significant positive change/ impacts |
| +21 to +30 | Moderately positive change/ impacts |
| +11 to +20 | Moderate to slight change / impacts |
| +1 to +10 | Slightly positive change / impacts |
| 0 | No change/ Status quo/ Not applicable |
| -1 to -10 | Slightly negative change / impacts |
| - 11 to -20 | Moderate to slight change / impacts |
| -21 to -30 | Moderately negative change/ impacts |
| -31 to - 40 | Significant negative change/ impacts |
| >-40 | Major negative change/impacts |

Within each of the major categories of impact, the range bands can then be grouped, and the numbers of times in which each range band is recorded. This is presented in the Summary table. This gives an indication of the scale of overall impact and orientation (positive or negative) of the candidate site in question. It also highlights the most significant types of impact.

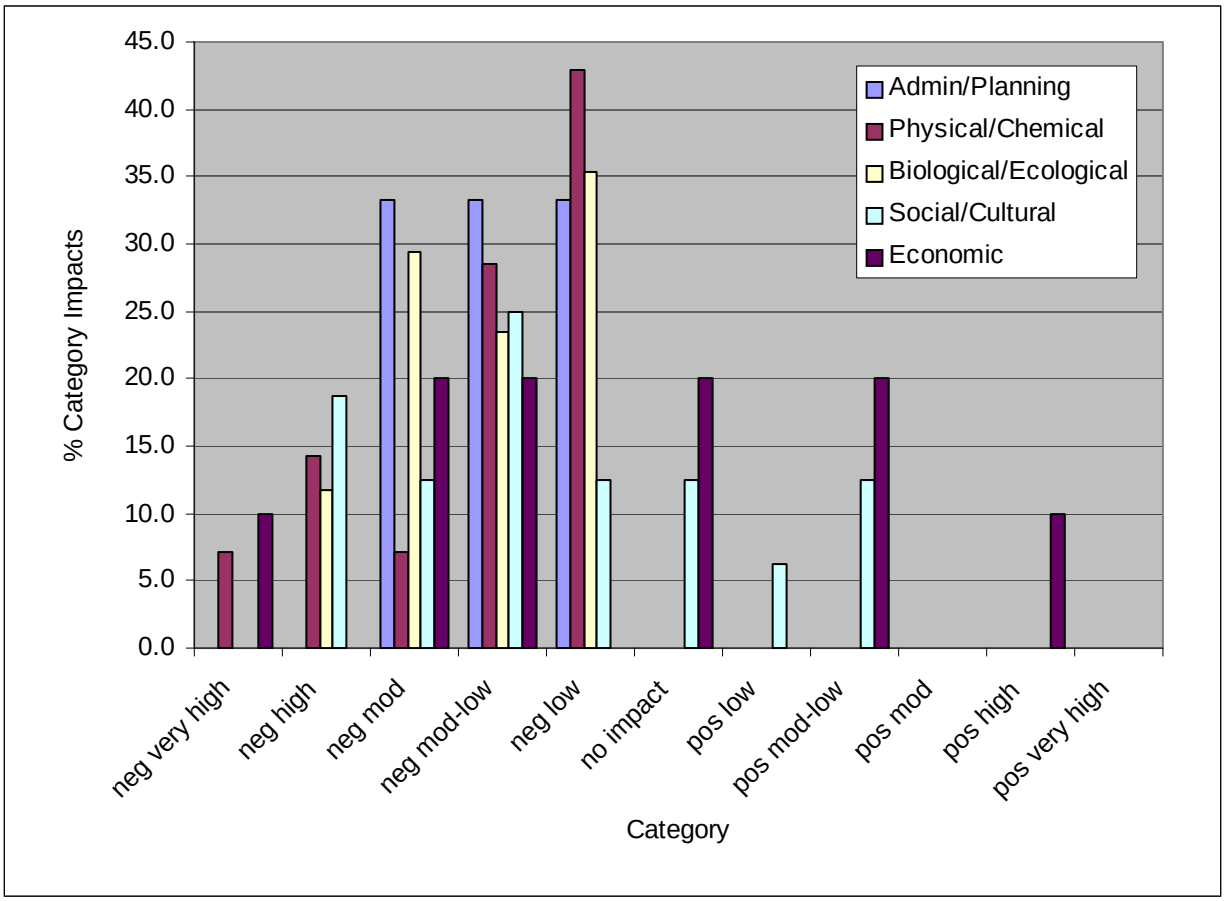
## 6.3 Summary of Findings

The summary indicates that overall, if not mitigated, the impacts of the project are largely negative. Of most concern are the impacts to the natural biotic environment and on the planning and management of the Ramsar site. The social impacts, particularly those linked to social disturbance, conflict over resources and the impact of uncontrolled/unplanned settlement into the Ramsar site are also of serious concern.

The positive impact relate to short term employment opportunities and the long term economic input in the districts from Longido to Tanga. The impact on tourism is largely negative (loss of

wilderness value) but the tourism impacts are also linked to the new tar road which are not included in this analysis.

**Figure 6-1: Summary of the impacts identified for the proposed soda ash development**




## 6.4 Transboundary Issues

### *6.4.1 Changes Occurring in the Ewaso Ngiro River Basin*

The largest source of fresh water inflows into the Lake basin comes from Kenya. The Kenyan catchment varies from high rainfall (in the upper reaches) to low rainfall and arid as one drops into the Rift. Throughout the Kenyan portion of the basin there is pressure on land resources with clearing of land for arable agriculture, high levels of livestock production and settlement. There has also been a significant multi purpose project development proposed for the Ewaso Ngiro. Such projects or steady land use change will/are changing water quality and quantity from this river.

### *6.4.2 Transboundary Concerns Relating to the Flamingo Population*

As indicated in the introduction, birds, particularly internationally threatened species that are large and well known, will have large scale international support if the wider public feel there is any threat to them from the project.

The status of the Lake Natron basin as a wetland of international importance (Ramsar site) and the importance of the basin to paeliartic migrants, and other water birds (such as African

Spoonbill *Platalea alba*; Cape Teal *Anas capensis*; Chestnut-banded Sandplover *Charadrius pallidus*) and the lesser flamingo is of importance to the decision making process. Although unsubstantiated, locally and internationally there is a feeling that the Ewaso Ngiro Multipurpose Project was stopped due to Tanzanian concerns for Lake Natron and, that the proposed development may undermine the position taken by Tanzania on this issue.

The bird resources at Lake Natron are a shared resource which requires a network of lakes across East Africa to maintain a healthy population. There is thus a feeling that decisions made about their main breeding ground are of wider interest.

## 6.5 National Lake Basin and Catchment Issues

Lake Natron falls into two districts (Ngorongoro and Longido and the present access route traverses Monduli). The lake is also administered as a Controlled Game Area (Department of Wildlife) and is now ratified as a Ramsar site and thus under the Ngorongoro and Monduli District Councils in collaboration with the Wildlife Division District Executive Director, Ngorongoro. The management and planning for the Lake basin is thus linked to district, national and international structures. This leads to a complex institutional arrangement.

Changes in land use are occurring with NGO support for the establishment and growth of irrigated agricultural activities in the delta's of the perennial Lake rivers. There is also rapid growth of dryland and irrigation farming higher up in the western escarpment of Ngorongoro District.

Development planning that will have significant cumulative impacts include the construction of a tar road linking Mto wa Mbu to Loliondo via the Lake and the proposal for development of hydropower on the Peninj River.

The tourism industry is growing rapidly as a result of an improved security situation and the establishment of new tourist facilities.

These changes that are occurring in the basin are resulting in changes in settlement patterns, increase in overall human population, increase pressure on arable soils, water resources, firewood and grazing.

## 6.6 Direct and Indirect Impacts Potentially Resulting from the Proposed Development

These impacts are dealt with in the following groupings:

- Administrative and Planning Impacts
- Changes to the Physical/Chemical Environment
- Changes to the Biological/Ecological Environment
- Social and Cultural Impacts
- Economic Impacts

### *6.6.1 Administrative and Planning Impacts*

These impacts are secondary impacts affecting the basin and are largely a result of the proposed development being placed in an area where the administrative structures are changing and in the absence of a management plan for the Ramsar site.

| | |
|---|---|
| Impact: | The proposed soda ash development **may threaten the Ramsar status of the Lake** if the project attracts large numbers of people into the area and changes settlement patterns. These impacts will occur in the absence of accurate information being available to the public etc. |
| Impact No. | A/P 1 Change in physical planning |
| Ranking: | Negative moderate to slight |
| Characteristics: | This impact will have international and national repercussions and would occur due to the cumulative effects from other projects |

| | |
|---|---|
| Impact: | Development will undermine the Ramsar planning process if the project attracts large numbers of people into the area and changes settlement patterns. These impacts will occur in the absence of accurate information being available to the public. |
| Impact No. | A/P 1 Change in physical planning |
| Ranking: | Negative moderate to slight |
| Characteristics: | The development will occur prior to the Ramsar plan preparation and will therefore have to be included in future planning. |

| | |
|---|---|
| Impact: | The development may undermine changes occurring in GCA planning and development of WMAs |
| Impact No. | A/P 1 Change in physical planning |
| Ranking: | Negative slight |
| Characteristics: | The area is presently managed as a GCA and the Department of Wildlife is beginning to develop WMAs. The proposed industrial development may undermine the vale of the area for game management |

| | |
|---|---|
| Impact: | Environmental authority and district personnel unable to ensure mitigations are implemented resulting in predicted impacts occurring |
| Impact No. | A/P 2 Change in administrative responsibility |
| Ranking: | Negative moderate |
| Characteristics: | Local administrative structures too weak (capacity, skills and legal mandate) to manage the development effectively |

| | |
|---|---|
| Impact: | Loss of the Lake Natron Ramsar status |
| Impact No. | A/P 3 Change in non related developments |
| Ranking: | Negative moderate |
| Characteristics: | Possible cumulative impact of Ewaso Ngiro project and soda ash abstraction on ecology and Ramsar designation status |

| | |
|---|---|
| Impact: | Clash with existing lease agreement and illegal occupation of the site |
| Impact No. | A/P 4 Establishment of infrastructure |
| Ranking: | Negative moderate |
| Characteristics: | The proposed development falls into a GCA leased out to the hunting industry by Department of Wildlife |

### 6.6.2 Changes to the Physical/Chemical Environment

The project will be processing brine to produce Soda Ash for export from the Lake basin. There will be a number of changes to the physical environment from land take to use of resources such as fresh water and the abstraction of Soda Ash. In the process of operating the plant and housing the workforce, pollutants will be produced and waste will need to be managed.

| | |
|---|---|
| Impact: | Depletion of fresh groundwater for plant and township operation |
| Impact No. | P/C 1 Changes in ground water quality/quantity |
| Ranking: | Negative slight |
| Characteristics: | Changes in ground water quality/quantity due to abstraction rates of up to130 cubic metres per hour |

| | |
|---|---|
| Impact: | Groundwater pollution and loss of aquifer |
| Impact No. | P/C 1 Changes in ground water quality/quantity |
| Ranking: | Negative slight |
| Characteristics: | Seepage of effluent into groundwater |

| | |
|---|---|
| Impact: | Leachate from solid water reaching GW or seeping into the Lake |
| Impact No. | P/C 1 Changes in ground water quality/quantity |
| Ranking: | Negative moderate to slight |
| Characteristics: | Solid waste management |

| | |
|---|---|
| Impact: | Loss of grazing land |
| Impact No. | P/C 2 Changes in crop and grazing areas (productive land) |
| Ranking: | Negative moderate to slight |
| Characteristics: | Land take for the establishment of plant, housing and access corridors |

| | |
|---|---|
| Impact: | Loss of critical dry season grazing along SE shores of Lake Natron |
| Impact No. | P/C 2 Changes in crop and grazing areas (productive land |
| Ranking: | Negative moderate |
| Characteristics: | Access route linking the project site to the Mto wa Mbu to Loliondo road along the eastern shores of the Lake |

| | |
|---|---|
| Impact: | Emissions and discharges that will negatively impact on the Lake |
| Impact No. | P/C 3 Changes in pollution discharges |
| Ranking: | Negative moderate to slight |
| Characteristics: | Operation of plant such as the boiler operations, power generators |

| | |
|---|---|
| Impact: | Lake chemical composition significantly changed due to Soda Ash abstraction |
| Impact No. | P/C 4 Changes to Lake water quality |
| Ranking: | High |
| Characteristics: | The resource report estimates a resource life span of the upper brine layers is about 50 years at the proposed rate of abstraction of 500,000 tons per annum. The composition of the Lake brines will change |

| | |
|---|---|
| Impact: | Emissions of carbon and SO2 from boiler flue stack and fly ash deposited in lake thus negatively changing water quality for present life forms |
| Impact No. | P/C 4 Changes to Lake water quality |
| Ranking: | Negative slight |
| Characteristics: | Operation of boilers and disposal of fly ash by-products |

| | |
|---|---|
| Impact: | High noise levels will reduced wilderness value of the Lake environment and |

| | |
|---|---|
| | disturb biota |
| Impact No. | P/C 5 Change in sound levels |
| Ranking: | Moderate |
| Characteristics: | Operation of the plant, steam and power plants, transport vehicles and possibly rail, will create noise |

| | |
|---|---|
| Impact: | SO2 smell and smoke reduces natural quality of Lake |
| Impact No. | P/C 6 Change in air quality |
| Ranking: | Negative Slight |
| Characteristics: | Emissions from the use of coal in steam boiler furnaces (1-200 tons of coal to be incinerated hourly) |

| | |
|---|---|
| Impact: | Reduce night time wilderness value of the Lake |
| Impact No. | P/C 7 Change in light levels |
| Ranking: | Negative very high |
| Characteristics: | High levels of light pollution from town, plant and security systems due to the 24 hour plant operation which will require high quality lighting |

| | |
|---|---|
| Impact: | Reduced fresh water inflows from the Wosi Wosi River due to abstraction |
| Impact No. | P/C 8 Changes to surface water flows |
| Ranking: | Negative slight |
| Characteristics: | Abstraction of surface water from the Wosi Wosi River |

| | |
|---|---|
| Impact: | Change to Lake structure and composition and change to surface water movement due to obstacles |
| Impact No. | P/C 8 Changes to surface water flows |
| Ranking: | Moderate to slight |
| Characteristics: | Creation of roads and tracks onto the Lake bed and the laying of pipes and cables on the surface for power and pumping of brine |

### *6.6.3 Changes to the Biological/Ecological Environment*

Many of the concerns raised both locally and internationally relate to the potential impacts of the project on the living environment and changes to ecosystem processes. Here issues such as threat to the endemic fish specie, disturbance of Lesser Flamingo and other bird populations and the disruption of wild animal movements in the access corridor are raised.

| | |
|---|---|
| Impact: | Threat to the viability of endemic fish populations |
| Impact No. | B/E 1 Changes to fish populations |
| Ranking: | Negative slight |
| Characteristics: | Change in water composition due to removal of soda ash or changes of fresh water inflows (such as reduced fresh water flows on the Wosi Wosi drainage). This is ranked low as the key habitat for the endemic fish population (the soda springs) is not affected by the project. Reduction of fresh water flows will be minimal. |

| | |
|---|---|
| Impact: | Potential threat to endemic species of fish. Threat to lesser flamingo populations |
| Impact No. | B/E 2 Changes in biodiversity |
| Ranking: | Negative moderate |
| Characteristics: | There are one, possibly two endemic fish species using springs and perennial lagoons. Any change to the key flamingo breeding criteria (discussed in the avifauna section) will be of concern. There is possibility of long term change |