# Using Road Works to Enhance Community Water Supplies in Mozambique

## African Community Access Programme (AFCAP/MOZ/004/A)

### Phase 1 Final Report – Feasibility Study


Department of Civil Engineering

Eduardo Mondlane University

Av.de Moçambique Km. 1.5


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## List of abbreviations

| | |
|---|---|
| ANE | Administração Naçional das Estrada (National Agency for Roads) |
| DNA | Direcção nacional de Águas (National Directorate of Water) |
| DNHA | Direcção Nacional de Hidráulica Agrícola |
| EN | Estrada Naçional (National Highway) |
| MISAU | Ministério da Saúde ( Ministry of Health) |
| Mts | Metical (Mozambique national currency) |

## Executive summary

Access to water supply is poor in rural Mozambique particularly in the dry season. Efforts are being made by the Government of Mozambique to increase access to water supply in the rural areas. At the same time, the government is also striving to improve road infrastructure to facilitate better connection between rural urban areas and hence increase the economic development. These road networks being constructed or improved require construction materials such as sand and stones and as a result, excavations are made along the roads to extract these materials. These excavations known as borrow pits tend to store water during the rains and are referred to as 'road ponds'. Road ponds can also be formed by building road crossing structures on water courses that retain storm water. Communities that are in close proximity to these road ponds use them as a source of water supply for domestic purposes, watering animals, irrigation and for recreation.

The finding of this report are based on extensive literature search available worldwide, field observations, primary and secondary data analysis, field visits in Mozambique and Burkina Faso for comparative analysis. In Mozambique two provinces were selected for field visit based on their known water scarcity situation. The provinces of Gaza in South and Tete in central Mozambique are well known for the prevailing aridity of the climatic covering extensive areas. Moreover, these provinces are less privileged in terms of availability of surface runoff and groundwater. Albeit that two major rivers run across these two provinces, Limpopo in Gaza and Zambezi in Tete, most of the area located away from the river experiences extreme low rainfalls. Groundwater in Gaza is either at greater depth or brackish when found while in Tete the geological settings with predominately pre-cambric formations limit the potential of groundwater. Therefore, the selection of these two provinces assumed that these conditions would likely result in communities resorting to non-ordinary uses of water, usually found in temporary impoundments such as road ponds.

Evidence from the field visits made to Tete and Gaza provinces has shown that the road ponds that are close to communities are being utilised as water sources. However, there are potential hazards to users of the road ponds, as the majority are shared with animals and some do not have safe access. The fact that people are using water from the road ponds is not debatable, but there is need to improve these sources to increase their water storing capacity and duration, reduce contamination and improve access.

This report summarises the findings from the first phase of the research entitled 'Using Road Works to Enhance Community Water Supply'. This first phase investigated the feasibility of improving 'road ponds' and 'crossing structures' to conserve water for domestic (other than drinking) and other uses. The report outlines findings from the field visits to Tete and Gaza provinces, and the learning visit to Burkina Faso. The report also includes a review of literature on the integration of water conservation into road works. The report ends with a summary of the

proposals for phase 2 of the research project, which is the design and construction of demonstration structures and improvement of borrow-pits, and evaluation of their impact on the communities surrounding the structures.

# 1. Introduction

## 1.1 Background

Many rural communities in Mozambique have poor access to water, particularly in the dry season. The task of walking long distances to collect water is often left to women and children.

Experience in Mozambique has shown that road works can be used to enhance community water supplies. For example, crossing structures built on waterways can be designed to retain water during the rains. The stored water can be used by local communities in the dry season, thus reducing the period when long trips must be made to collect water. The stored water also helps to re-charge ground water reserves.

Water is also stored in borrow-pits established during the construction of roads. This water is often used by local communities, but access to the water by the community is seldom considered by the contractors responsible for opening borrow-pits and rehabilitating them at the end of the construction period.

The small bodies of water retained by crossing structures and in borrow-pits are known as Road Ponds.

## 1.2 Purpose of the research

The purpose of the project is to undertake research on using road works to enhance community water supplies on a larger scale in Mozambique. The research will be carried out in three phases:

- *Phase 1:* Preliminary study and evaluation of existing road crossing structures and borrow pits that retain water and are used by the communities.

- Phase 2: The identification of sites for the construction of new structures for research and demonstration purposes, construction of demonstration structures and borrow-pit improvements, and evaluation of the impact of the works

- *Phase 3:* Preparation of a Community Road Ponds manual for Mozambique.

## 1.3 Scope of work

It was agreed that *phase 2* will proceed only if there is a positive outcome from the preliminary study from Phase 1. *Phase 3* will proceed only if sufficient positive impacts are demonstrated by the pilot projects constructed under Phase 2.

The success of the project will depend on establishing effective collaboration with relevant government agencies at both national, provincial and district level, including the National Directorate of Water and the Ministry of Agriculture. Collaboration will also be required with development partners, including UN agencies and NGOs, and with local communities. The activities proposed for phase 1 are as follows:

*Phase 1 – scope of work:*

- Establish a Project Steering Committee of key stakeholders in the project
- Visit at least three sites in Mozambique where road ponds have already been created by road crossing structures. Undertake an assessment of these structures, including their ability to retain water, impact on ground water, behaviour during floods, maintenance requirements, and impact on the local community
- Visit at least three sites where local communities use water retained in borrow pits. Undertake and assessment of the value of this resource to the community and whether it could be optimised through improved design of the borrow-pit.
- Agree with ANE the class of road and other road-specific criteria determining where road ponds could be created
- Agree the function of the road ponds with the DNA, the Ministry of Agriculture, and the communities in the chosen locations, including whether the water can be used for human consumption
- Assess the feasibility of constructing road ponds and borrow-pit improvements on a larger scale in Mozambique. Estimate the optimal size of road pond structures taking into account the cost of construction and the value of the benefits to the local community
- Provide recommendations for phase 2 of the project.

This report outlines activities that were conducted in Phase 1 including reconnaissance study made to two provinces, Gaza and Tete. The detailed field reports are attached in appendices 1 and 2.

# 2. Review of literature

## 2.1 Overview of rural water supply in Mozambique

Mozambique lies on the East Coast of southern Africa with an area of 799380 $km^2$ and 2800km coastline on the Mozambique Channel. The country is bounded by Zimbabwe, Malawi and South Africa on the west, by Tanzania on the north, and South Africa and Swaziland.

Mozambique has a tropical and subtropical type of climate, with a dry season that lasts from April to October. July (winter) temperatures average 21.1° C at Pemba in the north and 18.3° C at Maputo in the south. January (summer) temperatures average about 26.7° C along the coast and lower in upland areas. Average annual rainfall decreases from 1422 mm in the north to 762 mm in the south. There are some extremely dry arid to semi arid areas with average rainfall around 350 mm per annum mostly in the interior of the southern parts of the country in Gaza province around Chicualacuala and Chigubo districts, and in Inhambane province in Funhalouro and Mabote Districts.

In average terms Mozambique has a considerable amount of surface water. The mean annual runoff (MAR) is estimated to be 216,000 $Mm^3$ year of which about 100,000 $Mm^3$ is generated by rainfall within Mozambique. There are 13 major and 104 minor river basins in Mozambique. The Zambezi River Basin is the main source of runoff, which contributes 50% of the MAR. Lake Niassa, shared with Malawi and Tanzania, also contributes significantly to the surface water resources. The per capita availability of surface water is of the order of 15 $m^3$/d taking into account the runoff generated within the country and increases to 33 $m^3$/d if cross-border flows are included. Considering the expected increase in surface water consumption it is anticipated that the availability will drop somewhat (<1,700 $m^3$/hab/yr) from its present surplus level by the year 2025 (SADC-EU, 1990). Although Mozambique is endowed with large surface water resources, the majority is concentrated in the Zambezi river basin, which has almost 50% of the countries resources. Mozambique also lies in an area of highly seasonal runoff with rainfall concentrating between October and March of the following year.

Groundwater is a good alternative for water supplies as it is impacted less by rainfall seasonality. The oldest geologic units in Mozambique are rocks belonging to the Precambrian Basement Complex including metamorphic rocks, basic igneous intrusions and granitic intrusions. Greenschists, gneisses and granites are the predominant rock types. The complex occupies most of the northern and western part of Mozambique (57%) and occurs in the form of plateaus and mountains.

Basalt, rhyolite and sedimentary formations belonging to the Karoo Supergroup (5%) occur only in the eastern margin. The lower units are dominated by mudstones and contain some coal beds while the upper units are mostly sandy and coarse grained. The uppermost volcanic sequence consists of a number of superimposed basaltic and rhyolitic flows.

Post Karoo sedimentary formations cover almost the entire region south of the Save River, the coastal parts of Sofala and Nampula provinces and the lower Zambezi Valley (38%). The sediments were deposited in two Meso-Cenozoic basins; the northern or Rovuma Basin and southern or Mozambique Basin, associated with the East African Rift Valley System. The sedimentary sequences are characterised by predominantly arkosic sandstone in the western part of the basin and mainly marine transitional sequences in the coastal part. The sequences are intensively faulted with very limited folding. Almost 70% of these sedimentary basins have a cover of unconsolidated material commonly with a thickness of 5 to 10 m.

The overall hydrogeology of Mozambique was investigated as part of the hydrogeological mapping project (1987) that produced the only Hydrogeological Map of Mozambique at 1:1 000 000 scale. In the map, about 60 % of the area is basement complex and volcanic terrain and 40% sedimentary. Considering that 40% of the more productive aquifers in the sedimentary basins contain brackish water, it was concluded that only approximately 17% of the country has groundwater resources with yield prospects of > 3 $m^3$/h of potable water.

The three main hydrogeological units correspond to the following geological units: a) aquifers related to the crystalline basement complex, b) aquifers occurring in Karoo formations and c) aquifers related to post Karoo formations.

Groundwater is generally of good quality. Poor water quality (high salinity) is common in some areas like the interior of Gaza and Inhambane which are more arid areas, with Tertiary formations, the most prominent aquifer, bearing saline water. The combination of low rainfall and high salinity in water poses a great challenge in water resources development for human and economic uses in these areas.

Rural water supply in Mozambique is largely through shallow boreholes installed with hand pumps or traditional open wells without protection.

There are large discrepancies in water supply coverage data provided by the National Water Directorate (DNA) and the National Statistics Institute (INE). There are differing population figures ("rural" and "urban") used by the INE and DNA as well as different perceptions about what should be considered coverage by minimal services or adequate access. For instance, while the INE estimated coverage for rural water supply as 23.2% (without the small reticulated systems) in 2003, the DNA points to 40% in the same year (with small piped systems estimated at 4.2% coverage).

The Government of Mozambique developed a 10 year Rural Water and Sanitation Strategy Plan (PESA-ASR) (2006-2015) with the objective to increase coverage and meet the MDG’s. The PESA-ASR has three different scenarios, the most ambitious scenario plans to build 18,190 dispersed water points between 2006-2015. To reach this target the programme envisages an accelerated annual rate that will gradually increase from 1,765 in 2009 to 2,045 sources per year. Despite the big efforts by the government to invest in rural water supply programmes, the coverage is still very low.

Rural communities that lack infrastructure for water supply resort to non-safe sources to meet their water needs. In some cases young children, especially girls, walk long distances to collect water from neighbouring communities. The lack of water, has an impact on human health and child education with long-term effects on community development. The situation is worse in the dry or arid districts and exacerbated in dry months between May and October when virtually no rainfall occurs.

## 2.2 Water supply from road works

Water scarcity, particularly in the dry season, is common in most parts of the developing countries, as is also the case in Mozambique. Water scarcity affects the production of food and other agricultural development, which in turn affects the general livelihood especially of the rural population. Rural communities use water from any available source including road ponds and water reservoirs formed as a result of road works. Roads and railroads and their embankments are major landscape elements that have a strong effect on water storage and retention.

There is little documented evidence of using road works to improve access to community water supply. However, in many parts of Africa where road works have created borrow pits and other water reservoirs, nearby communities are known to use these bodies of water. In some arid and semi-arid regions around southern Africa, rainwater harvesting (RWH) through earth works and waterways crossing structures related to road construction have been implemented and some good results were obtained. In Africa, similar interventions have been carried out in Tanzania where rainwater was harvested from roads mainly for agricultural purposes, (Hatibu et al 2000). In Latin America such as Brazil and Argentina where rainwater run-off from paved and unpaved roads is stored for later use, (oas.org undated). This review analyses the few documented interventions and outlines lessons that can be learnt and their applicability to Mozambique for the planning and management or such interventions and the health and socio-economic impacts.

## 2.3 Making the most of road infrastructure for water conservation

The case studies in this section describe how roads can contribute to water retention as was described by Nissen-Petersen (2006). In Kenya and in many African countries, borrow pits are excavated during road construction. The laterite soil found at the bottom of these pits is in demand for surfacing roads. These borrow pits can also be used as water storage ponds. Past experience from Kenya has seen channels dug from the roads to the pit at a 3% incline to avoid scour. Critical sections of the pit are plastered by a mix of clay and lime to prevent too much seepage. Spillways paved with stones have also been created to prevent collapse of the pit due to water pressure. The correct height can be calculated by gradually increasing the spillway.

Another type of storage pond is the charco dam, which requires more manual labour than the borrow pits, but with reduced seepage and evaporation. The most commonly used design for the charco dam is in the shape of a ‘calabash’ cut into half, as it provides maximum storage for minimum amount of work and also has evenly distributed internal and external pressures. Charco dams, also known as small earth dams, are very common in the semi-arid parts of Tanzania where they are usually built by individual farmers.

## 2.4 Rain water harvesting for managing natural resources

As mentioned earlier, few publications exist that document experiences of improving water supply through road works. However, a Technical Hand Book published by SIDA’s Regional Land Management Unit edited by Hatibu and Mahoo (2000) and with contributions from various authors give important relevant information, case studies and guidelines for integrating road works with rainwater harvesting (RWH).

### *2.4.1 Integrating rain water harvesting with road infrastructures*

The review begins by looking at various techniques and factors that determine the potential for RWH[1]. It points out that improving borrow pits and road crossing structures to store more water for immediate and later use can be classified as RWH. Conducting a good estimation of the expected runoff in a given area is important for facilitating planning of RWH schemes such as road ponds. According to the authors, the availability of runoff is determined by the following:

- Land surface: Assuming all factors remain the same, the characteristics of land surface can indicate the extent of runoff that can be expected. It is noted that some of the factors

[1] Hatibu, N.; Kajiru, G.; Sekondo, E (2000). Technical integration of RWH into development plans: think globally, plan locally.

that can affect runoff generation are *slope, length, vegetation cover and surface roughness of the catchment.*

- Slope: Steep slopes in any catchment are necessary for obtaining high runoff efficiency, however, slopes more than 5% are prone to a high rate of erosion. Erosion control measures will therefore become necessary in any catchment (e.g. borrow-pits) with more than 5% slope.
- Length: Catchment length has an important effect on water harvesting potential including peak discharge, rise time, and total runoff time. As the length of a catchment increases, its runoff rates and peak runoff decreases because retention losses increase with length of the catchment. A very large catchment will result in reduced surface runoff yield per unit area.
- Vegetation: This is important for runoff and sub-surface flow from a given catchment. Vegetation consumes a large amount of water through evapotranspiration, hence reducing the total amount of runoff yielded by a catchment. Its effects include:
  - Interception leading to evaporation from the canopy
  - Increased surface ponding and slowing down of water which assists infiltration thereby reducing runoff yield
  - Increased hydraulic conductivity as a result of root channels, which also leads to increased infiltration.
- Surface roughness: Rough surfaces facilitate infiltration and reduce the runoff yield from a given area. As a result, areas with large portions of continuous surface will have a very high runoff yield coefficient. In order to reduce costs, the guidelines recommend the exploitation of naturally occurring continuous hard surfaces. One of the cheaper methods of providing RWH schemes where the available catchment area does not have the desired characteristics is compaction of the earth, especially in relatively flat terrain. Other types of surface treatment that can be used include vegetation removal, surface cover and chemical treatments.
- Risk of soil erosion: Catchments that have been treated either by removal of vegetation and stones are prone to soil erosion. The guidelines advise the utilization of naturally occurring runoff, but if it becomes necessary to clear an area to increase runoff; one approach will be to divide the catchment into small

sub-catchments using stone bunds. The water from the respective sub-catchment can then be conveyed to the catchment outlet using graded channels.

- Soil type: The type of soil is an important determinant factor of how much runoff can be expected. The main factors are infiltration rate, water holding capacity and hydraulic conductivity of the soil. The most important is infiltration, which can be affected by a combination of;
  - *soil texture,*
  - *presence of large openings in the soil caused by tunneling organisms and plant roots increases infiltration.*
  - *antecedent soil moisture reduces the rate of infiltration because the soil lacks capacity to store additional water.*
  - *Soils with high values of water holding capacity and low hydraulic conductivity will take in more water and thus have reduced runoff.*

**Table 1. The effect of soil texture on infiltration rates (mm/hr)**[2]

| **Soil texture** | **Ground cover** | |
|---|---|---|
| | *Bare* | *Forest* |
| Sandy | 20-25 | 40-50 |
| Loam | 10-15 | 20-30 |
| Clay | 0-5 | 5-10 |

Source: Hatibu, et al (2000).

- Catena sequences: This refers to a systematic arrangement of soil types along the slope of a landscape. It provides a logical framework that can be used to assess the behaviour on a given catchment.

- Rain fall characteristics: Infiltration rate and runoff is affected by rainstorm amount, intensity and distribution. Where available, meteorological records can be used to establish a detailed description of rainfall characteristics.

The information extracted from the literature review relating to the techniques and factors that affect the potential for RWH will provide the framework for the phase 2 of the work to

[2] Hatibu, N.; Kajiru, G.; Sekondo, E (2000). Technical integration of RWH into development plans: think globally, plan locally.

improve water supply through improvements of borrow pits and road crossing structures in Mozambique. These factors will be studied in detail in order to ensure that appropriate and sustainable designs are made for the intervention.

Although the majority of the literature focuses on RWH, it is applicable to the work in Mozambique considering that road ponds are a form of RWH. Moreover, the literature pointed out the potential to integrate road and railway infrastructure with RWH systems and vice versa.

- Roads and railways: These can act as cutoff bunds, which concentrate runoff and direct it into culverts or bridges. Similar to the situation in Mozambique, the authors acknowledged the lack of integrated management of runoff after it has left the road, resulting in gully erosion. They gave examples of gully erosion that has formed down-stream of the culverts on some highways in Tanzania. The authors pointed out inadequate awareness amongst planners as the main reason for failure to use this resource. They suggested that integrating RWH with roadworks will reduce erosion caused by water drained from the road, as well as the cost of supplying water for domestic, livestock and crop production.

- Borrow pits: These are excavations made to extract materials such as sand and stone for road construction. The majority of these excavations are left open, which goes against environmental and road construction regulations. These borrow pits can be used as storage reservoirs for rainwater. Although they are usually not planned for RWH purposes, people residing along the highways use the water for drinking, for livestock and for horticultural purposes. The authors identified examples of borrow pits that store rainwater and are utilized in Morogoro – Domoma, Dar es Salaam – Morogoro and Chalinze – Segera highways. The situation is no different in Mozambique where similar infrastructures have been found to exist along highways. The authors recommended that integrating RW harvesting into road works would be a cost effective way of supplying much needed water. It has the advantage of harmonising culverts and borrow-pits to become effective water harvesting features along the highways.

### *2.4.2 Use of borrow pits on the Morogoro-Dodoma highway in Tanzania*

Borrow pits along highways form an important source of water supply for communities living along these roads. In the above mentioned case in Tanzania, the majority of the settlers were originally pastoralists who are thought to have become permanent settlers as a result of the water availability in the borrow pits. The authors identified a total of eight pits over the 70km spread of the settlements. Some of the important observations made about these systems include:

- The borrow pits were not originally designed for rain water storage;
- Of the 27 pits observed, only 3 have been modified or improved by the users, indicating that they are opportunistic users that do fully understand the nature of the borrow pits;
- Only one of the borrow pits was linked to a graded road drainage channel, indicating that the road surfaces are not being used adequately as catchments.
- The case study indicates that borrow pits can be used successfully as sources of water. The criteria for choosing the location of borrow pits during road construction should therefore include the possibility of using them in future as storage ponds for RWH.

### *2.4.3 Potential problems associated with road pond improvements*

- Cost of improving existing borrow pits and other road structures to increase their water storage and retention capacity;

- Siltation leading to loss of storage capacity;

- Evaporation, which can reach up to 10mm/day in semi-arid areas. One approach that has been used to reduce evaporation is to reduce the surface area volume by using deep storage reservoirs. Another approach is to shade the water surface from wind and direct sun.

- Seepage as a result of soil type and the amount of compaction in the embankment is another common problem faced in storage systems. It can be reduced by compacting the reservoir floor or pudding by cattle while the soil is moist. Adding clay soil or manure before pudding will also reduce seepage.

- Health hazards such as waterborne diseases or disease vectors and pollution can be associated with road ponds. Creation of vector habitat such as snails that harbor the schistosoma parasite that causes bilharzia and mosquitoes that spread malaria are likely to occur with the construction of rainwater surface reservoirs such as borrow pits. The combined use of road ponds by humans and animals can lead to water contamination by zoonotic diseases, dip chemicals and even nitrates which can cause health problems for humans.

## 2.5 Data collection and appraisal for RWH potential

In order to appraise the potential for RWH from various catchments including road structures and borrow pits, it is necessary to collect technical and social data.

Technical data include:

- Topographical mapping of the target areas
- Understanding of soils
- Climatic data often collected by the Institute of Meteorology. A detailed knowledge of the rainfall pattern in the target area is important from the beginning of the planning. The recommended time interval for data collection is 2-3 years using stations 2 kms part. Where this is not possible, the most important information that can be collected includes *daily rainfall amount; rainfall intensity; average, minimum and maximum decadal, monthly and annual rainfall amounts*
- Data on hydrology, water resources and their corresponding demands is the next most important planning data after climate.

Socio economic data of RWH[3]

Some of the socio-economic factors that should be considered when planning for RWH include the policy and legal framework that governs land tenure, water rights and public infrastructure.

- Land tenure: This is a very important consideration when planning for improvements of road ponds particularly borrow-pits. Land tenure is the system of land ownership or acquisition and is governed by land laws, land policies or customary land ownership systems. Borrow pits can be located on *general land; reserved land, village land or individual land.* Understanding land tenure at the planning stage will avoid potential future disputes regarding access to the water sources.
- Water resources including understanding of water rights for different uses.
- Identification of local institutions existing in the target area in other to understand their potential influence and impact on the planned improvements. The four main institutions that can be identified include: *local government; central government; community-based organizations and NGOs.*
- Equity is another important social consideration during the planning stage. The improvements of road ponds should not result in inequality, particularly relating to the ownership of resources. Other important aspects of equity that should be considered include;

[3] Lazaro, E.; Senkondo, E.; and Kajiru , G. (2000)

- gender relations;
- tree-crop and livestock relationships
- cost components
- direct and indirect benefits.

## 2.6 Stages of project planning [4]

Planning for RWH including its integration into road structures can be divided into six stages as shown in figure 1.

- *Stage 1*: Project initiation where the nature of the problem is defined, stakeholders are identified to analyse the problem, and potential solutions and finally preliminary goals and purpose are stated.

- *Stage 2: Reconnaissance* study should be implemented by a multi-disciplinary team. The analysis of the information collected should be used to decide and ascertain if it is feasible to continue with further project development.

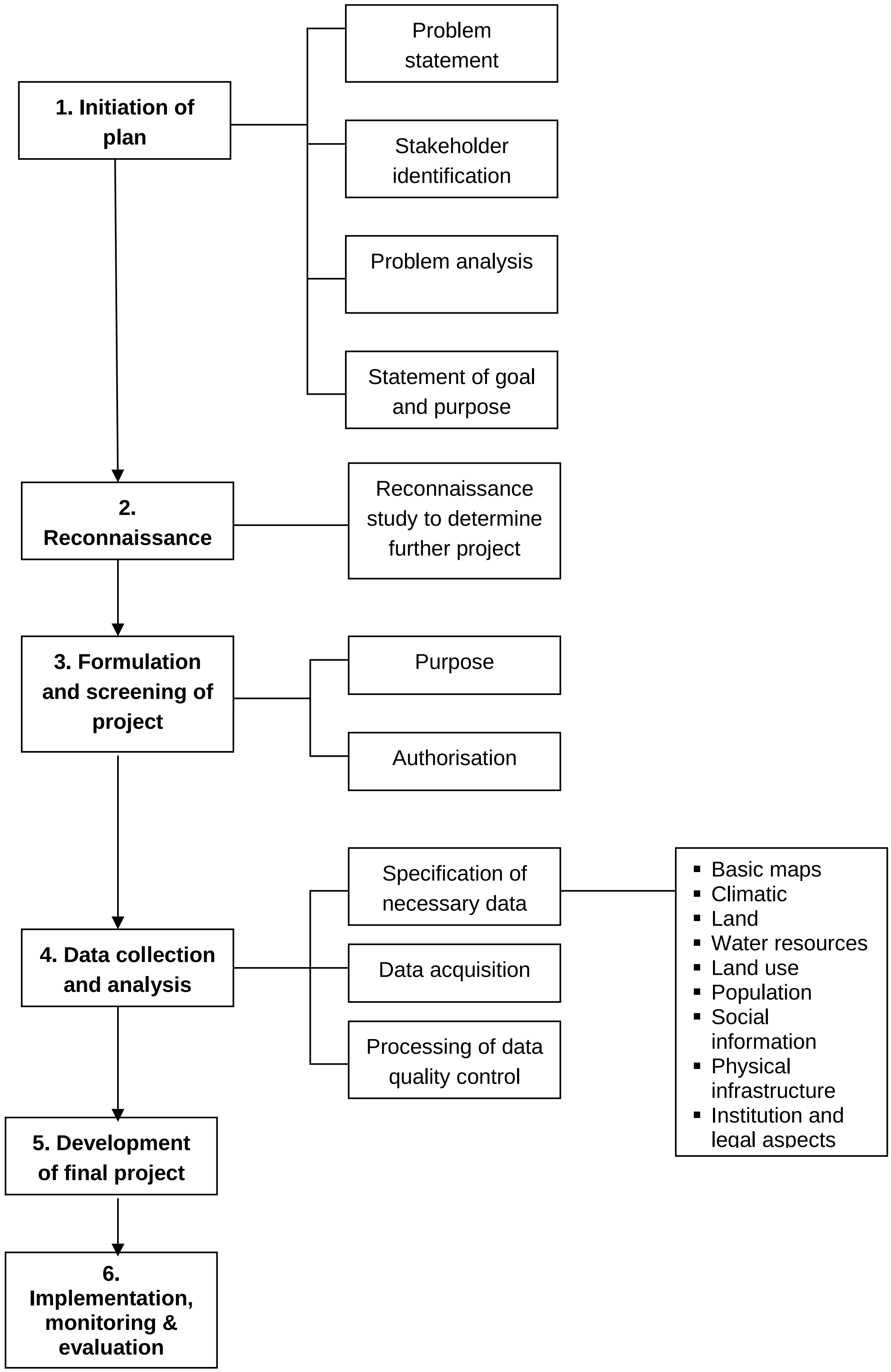
- *Stage 3: Formulation and screening of alternatives* to identify project intervention options to facilitate further development of the project. Necessary authorization should also be acquired at this stage.

- *Stage 4: Data collection and analysis* involves the collection of technical and social data to facilitate the development of the final project plan and intervention designs.

- *Stage 5:* Project implementation, monitoring and evaluation.

[4] Gowing, J.; Senkondo, E.; Lazaro, E. and Rwehumbiza, F. (2000)

**Figure 1. Stage of planning for road ponds improvement projects (*adapted from Gowing, et al 2000)***



## 2.7 Summary of the literature review

The review of literature provided some background information on water resources in Mozambique. More importantly it looked at experiences of integrating RWH with road infrastructures and provided a framework for planning for such interventions. The review outlines some important factors to take into consideration when planning for project intervention. It also outlined the stages for project planning, the data requirements and problems associated with such interventions. As mentioned earlier, the literature will provide the framework for developing phase 2 of the roads ponds projects in Mozambique. Although the reconnaissance study was completed prior to the literature review, the project still follows the recommended stages outlined in the review. Moreover, the preliminary data collected at this stage will be built on, in line with the recommended data requirements for phase 2.

## 3. Methodology used for Phase 1

The phase 1 of the road ponds project covered stages 1 – 2 of the project planning steps outlined in figure 1. After the project was conceptualised, discussions both formal and informal were held with ANE who have the responsibility for road works in Mozambique and are therefore the main stakeholders for the research project. As a result of the discussions with ANE, agreements were reached on the Provinces and sites to visit for the reconnaissance study.

The first visit was made to the Province of Tete and was really used to verify the presence and use of road ponds such as borrow pits and road crossings. It formed the basis for developing a more detailed reconnaissance study to Gaza province, hence the more detailed report for Gaza.

During the field visit, the researchers observed three major types of water reservoir; borrow pits, road crossing structures where water is retained (e.g. culverts) and small dams (in Tete Province only). In Gaza province, the team observed three borrow pits and two road crossing structures. In Tete, the team observed two dams (a small concrete dam and an earth dam), a large road crossing structure (bridge), two borrow pits and a smaller road crossing structure (box culvert). The characteristics of the respective reservoirs were defined and are presented in the field reports in appendix 1 and 2. Discussions were also held with current users, local leaders, government officers and community-based organisation operating in the areas. The different uses of water from the roads and seasonal variations were also discussed.

On completion of the first field visit made to Tete, the preliminary findings were discussed with ANE and it was on this basis that Gaza was identified for the second field visit.

As part of the phase 1, discussions were held with other stakeholders including the National Directorate for Water; Ministry of Health; The Department of Agriculture and the Ministry of Environment. The objective was to raise awareness and get their perceptions of the planned interventions. Extracts from these discussions are presented in section 5 of this report. Phase 1 will be completed with a workshop of the major stakeholders to discuss the detailed findings of phase 1 and prepare a draft proposal for phase 2.

# 4. Results and findings

Road construction and improvement of access roads is one of the priorities of the Government of Mozambique, as part of the development program, ensuring the flow of goods and people, and facilitating communication internally and with the outside world. In this context, major works have been carried out not only on main roads but also on secondary and tertiary roads to ensure communication with the districts, villages and communities.

The construction of roads is always associated with earthworks, which can be landfill excavation along the strip where the road passes, depending on topographical conditions and characteristics of existing materials. Besides the need for earth moving during construction of roads, material is needed for the maintenance, which makes this process almost permanent. As a result, depressions known as borrow pits are formed where the soils are extracted and they become ideal places for storing water. Apart from the borrow pits, road crossing structures provide an opportunity for storing water as a result of watercourses and the direct precipitation on the ponds that are created there (see Figure 2).


**Figure 2. Examples of water reservoirs resulting from road construction**

## 4.1 Findings from the field visits to Tete and Gaza provinces

The initial studies were carried out in the provinces of Tete and Gaza (Figure 3), where there are areas with acute water scarcity, which hinders human, economic and social development and calls for the need to find alternatives for the capture and conservation of water. Both in Tete and Gaza, there are areas where the water shortage can go beyond 800 mm per year. In these regions, the population encounters many difficulties, and may travel between 15 to 20 km (walking) in search of water. People are normally only able to transport around 20 litres of water per trip.

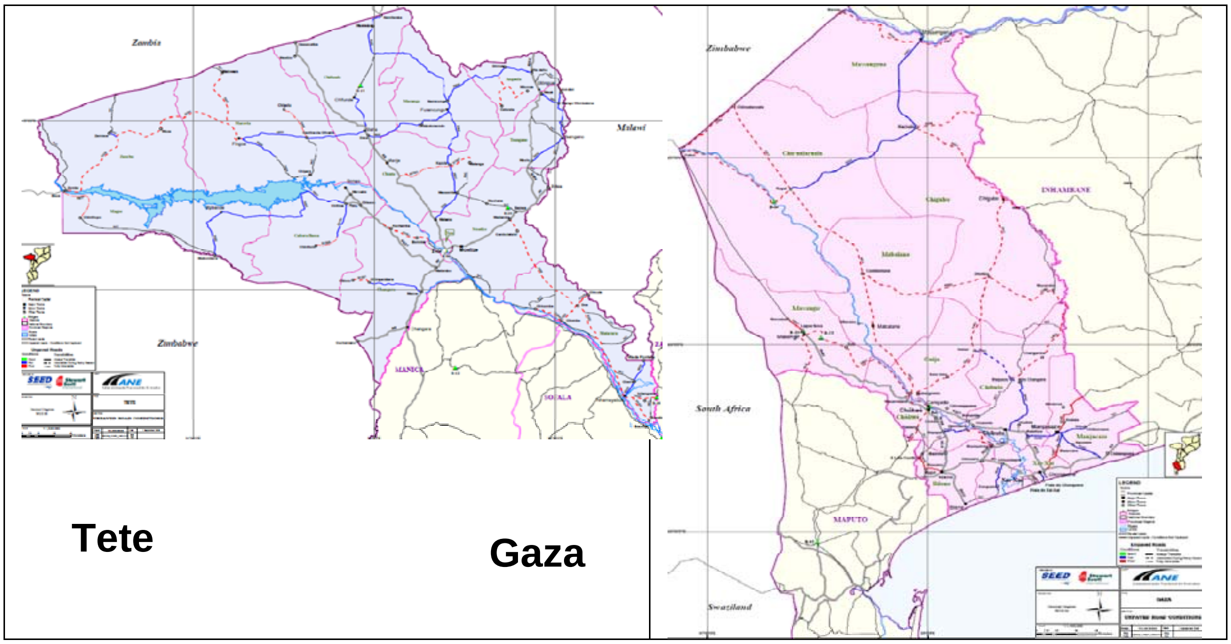



**Figure 3. Road maps of Tete and Gaza provinces.**

In Tete, the N7 road (including diversion to Mafupayanzo) and N221 (Chibuto / Chicualacuala) in Gaza were visited. In both provinces, water reservoirs resulting from road construction and construction of crossing structures (culverts, drifts) were identified. They either had a depression that collects rainwater or small ephemeral streams. As far as it was possible to observe, these ponds associated with roads works are a major source of water supply for the population living in the surrounding areas. The main uses as shown in figure 4, 5 & 6 include:

- Watering of livestock
- Human consumption - in Gaza, the District of Chicualacuala, people living near these ponds consume the water directly, without any treatment.
- Bathing and Laundry
- Construction / production of fired bricks

- Irrigation
- Fishing
- Recreation for children


Figure 4. Laundry and cattle watering at ponds resulting from road works

Figure 5. A man drinking water directly from a road pond

Figure 6. Women collecting water for domestic consumption in PA Niza, Gaza

Figure 7. Fishing in a pond created as a result of road works.

Preliminary results indicate that the reservoirs of water associated with construction of roads are an important source of water supply in arid and semi-arid areas. However, there is need to improve their design; construction; management and maintenance to create easier access, reduce water losses through seepage and evaporation, and improve water quality. This will ensure that water stored in the reservoirs do not constitute a danger to public health and the environment, as it is the major concern of the main stakeholders interviewed (ANE, DNA, MISAU, DNHA). To this end it is proposed that projects for rural roads and access roads in arid and semi-arid regions include the storage of water in places where conditions (topography, soils) allows for this to happen, as was observed in the rural roads of Burkina Faso.

## 4.2 Findings from the learning visit to Burkina Faso

A learning visit was made by members of the research team to Burkina-Faso in November 2009. Burkina Faso is a relatively arid country, where evaporation losses are up to 2m a year, and precipitation is less than 400 mm, with a prevalence of intense rainfall of short duration, focused on a 3-month period of the hydrological year. In this context, the Government, as part of its priorities, maximizes water storage. The government strategy defines that all roads should include in their design, capturing and storage of water, where conditions for such (topography, soils, etc) allows, in order to benefit the communities living in these areas. The structures range from borrow-pits to drifts and culverts that create small ponds or flood plains for agriculture.

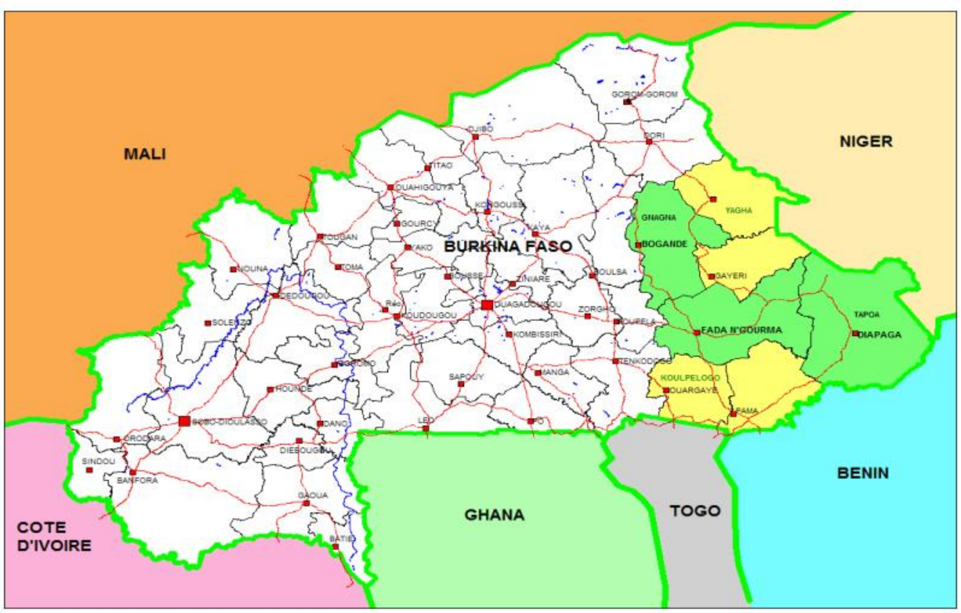



Figure 8. Map of Burkina Faso showing areas visited circled

#### 4.2.1 Drawings and designs

Currently, the Government has the support of some international organizations and donors, which, in their funding, included research and piloting of models of construction, management and upkeep of roads, including the so-called 'road ponds'. During the stay of the research team of the EMU and ANE, it was possible to visit one of these projects, funded by Swiss Development Corporation (SDC) in the province of Fairy.

The method used in this project is called HIMO, which means labour intensive. This is a participatory method where the local community is involved in the design, and definition of the alignment of the road, and local artisans are trained both for collecting material and for road construction. There are standard technical specifications for road sections crossing water courses, which can be modified depending on local conditions (see Figures 9 – 14).

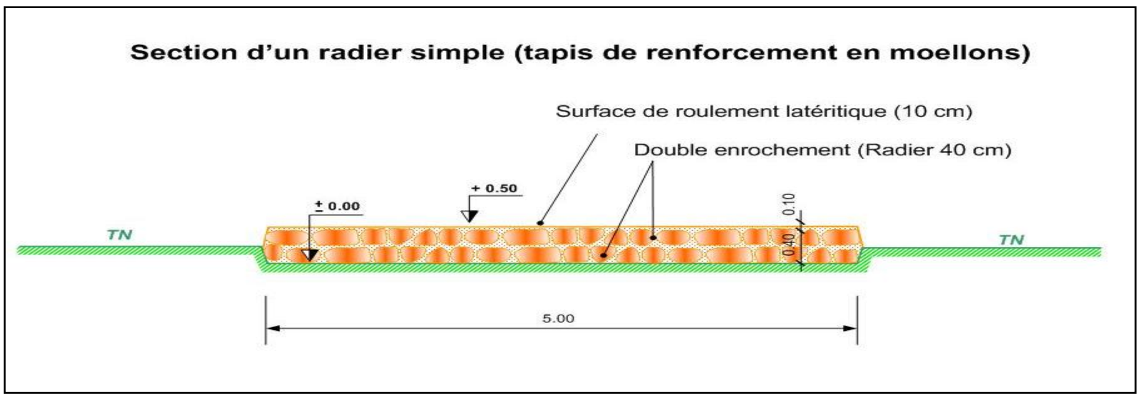



**Figure 9. Section of improved road using rubble**

This type of improvement is suitable for short sections experiencing temporary flooding or with wet conditions over long periods.

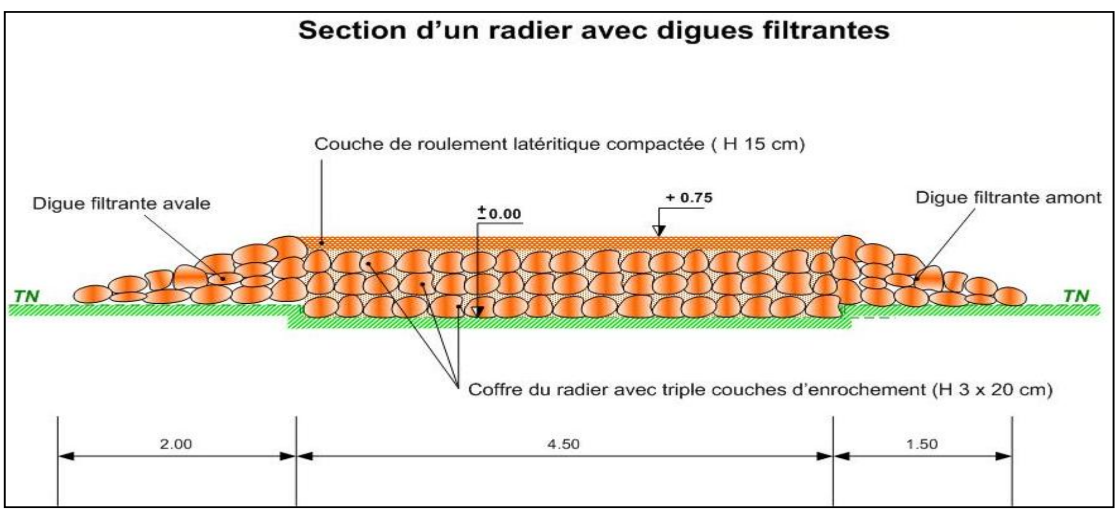



**Figure 10.Section of improved elevated road with compacted lateritic soils**

This improvement is suitable for areas experiencing high water levels over long periods. The road section made of compacted lateritic soils and is laid over a triple layer of rubble that is supported laterally by filtering dykes/levees.

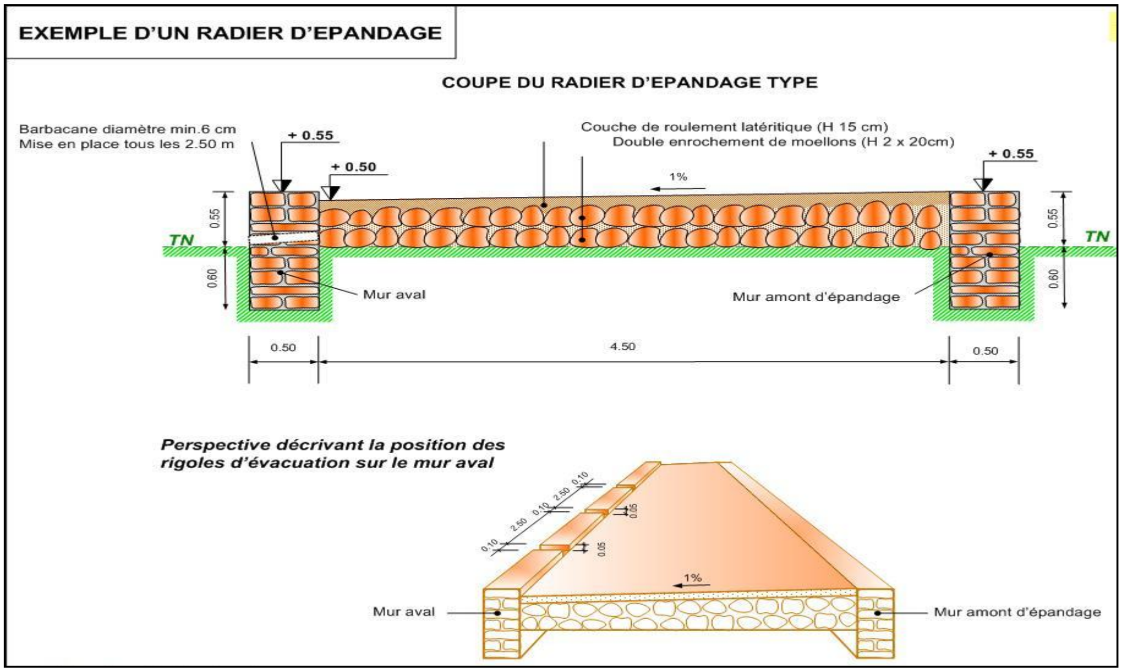



**Figure 11.Section of improved road of compacted lateritic soils with overflow**

This improvement is suitable for long sections experiencing moderate to low water levels. The design allows for overflow over the road surface.

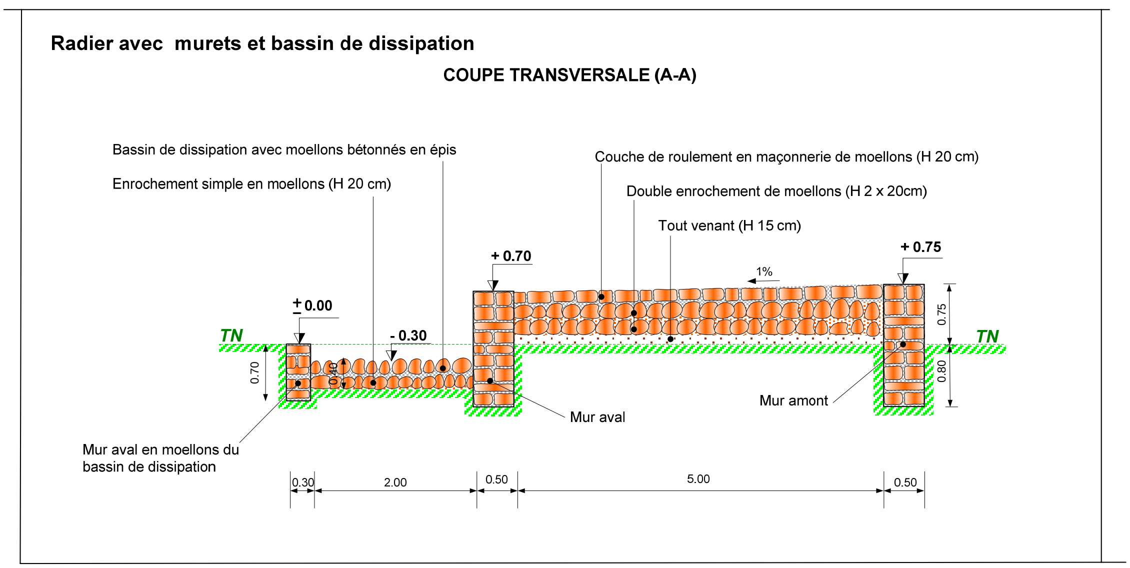



**Figure 12. Section of improved road with rubble and lateral supporting walls**

This type of improvement is suitable for short sections experiencing rapid overflow by flooding. The design includes an energy dissipation basin on the downstream side.

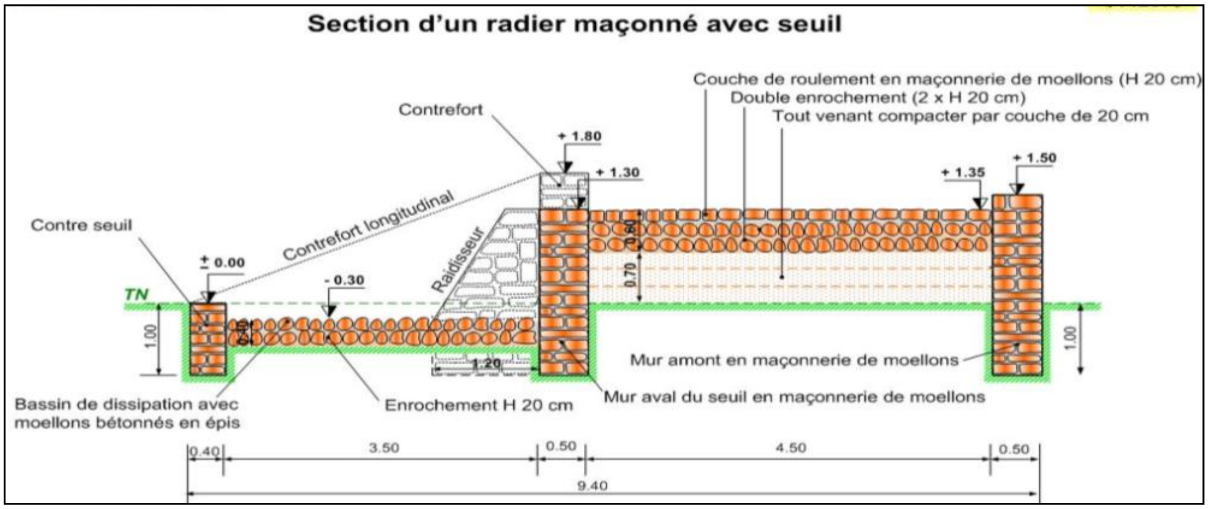



**Figure 13. Section of improved road slightly elevated.**

This improvement is suitable for areas experiencing high elevated water levels. The design is more complex and includes structural strengthening measures to improve stability. The structure also allows for overflow and includes an energy dissipation basin on the downstream side.

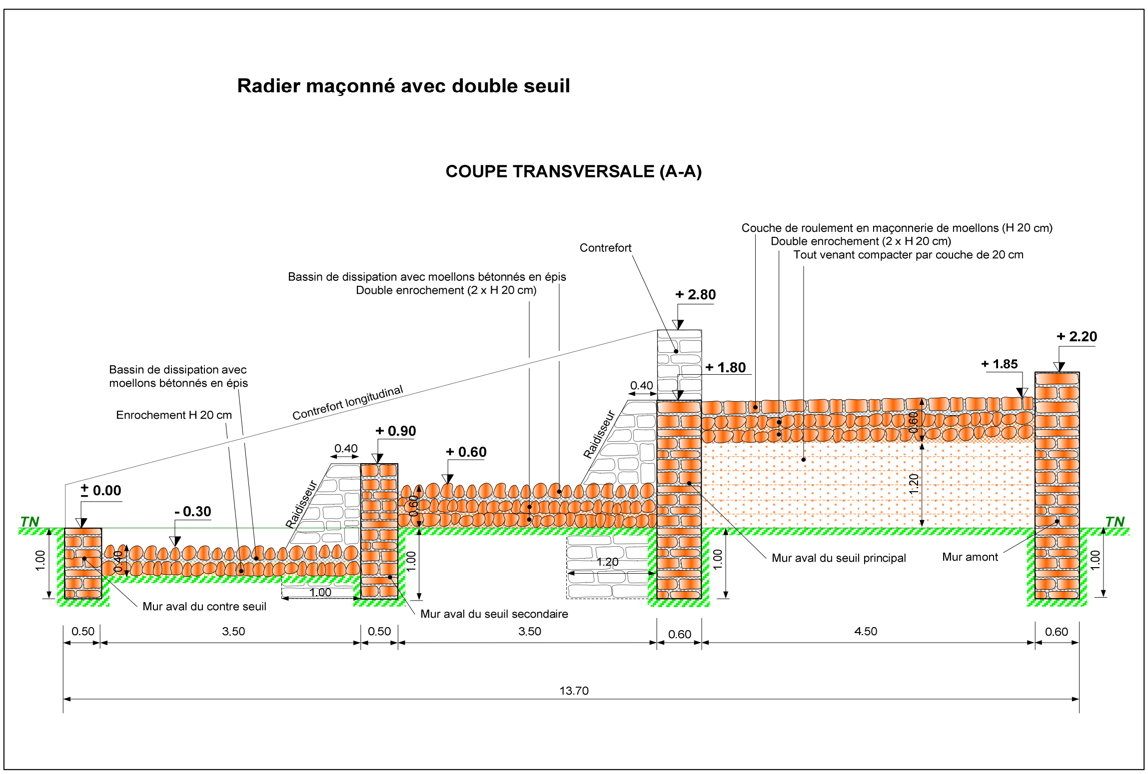



**Figure 14. Section of improved road slightly elevated.**

This improvement is similar to figure 13 but more suitable to severe and rapid overflowing conditions and high water velocities. The design is more complex and includes structural strengthening measures to improve stability. The structure also allows for a severe and rapid overflow and includes a double energy dissipation basin on the downstream side.

#### *4.2.2 Information on costs*

In Burkina Faso, the cost of individual works, water storage and improving sections of the road crossings vary between $6,000 to $45,000 depending on their complexity. The cost of road construction ranges from $13,000 to $17,000 per kilometre of road. Despite not having undertaken studies that assess the impact of the construction of the water reservoirs, one can observe development in the area due to both the construction of the access road and water availability.

In parts of Mozambique, where evaporation losses rise to 2m a year, and precipitation is less than 400 mm, the Government has as one of its priorities to maximize water storage. In this context, rural roads should include the capture and storage of water in their design.. Lateritic soils are available in many parts of the country in enough quantities with good strength and plasticity suitable for this kind of work.

# 5. Feasibility for road ponds improvements in Mozambique

The field visit made to two provinces, Tete and Gaza as part of the phase 1 of the research project concluded that 'road ponds' are important sources of water supplies for communities living in rural areas of Mozambique. Water from these sources is used for various purposes including domestic uses, fishing, agriculture and recreation. The communities visited recognized the importance of these sources and in some cases they organize themselves to protect the water from contamination. This happens mostly in areas where alternative water sources are scarce or are at great distance from the villages where people live. One thing to keep in mind about these areas is that as long as there are no safer water sources nearby, people will continue to use the road ponds supply, even with known risk of consuming contaminated water. These sources are not safe for use in their current state, and the majority of the sites visited had animal faeces in the surrounding area that eventually enter the ponds. In addition, there was clear competition between the various users and uses, from animals to humans and from food preparation to bathing and washing clothes.

Since these reservoirs are important sources of water supply to the population, they could provide added value and contribute to the social and economic development of the beneficiaries if they were improved.

According to ANE, rough estimates[5] from the few existing cases of improved sections of road with water storage indicates that these types of structures (small dams) cost around $40,000. No information was found on studies carried out to quantify the economic benefits of these structures, but a qualitative evaluation was made by the project team during the visits to Tete and Gaza. It is clear that improving these sections to store water has a lot of benefits for the population living in the surrounding areas, as described previously in this report. As a result of the findings in the field and discussion a number of issues have been flagged in relation to the feasibility of road ponds. Most of these issues have been subsequently been discussed and reconfirmed in a stakeholders workshop held in Maputo. Here the most important aspects considered crucial, for successful implementation of 'road ponds' and 'road crossing structures', and that should be taken care of, to ensure that;

- Those sites selected are within easy access to the surrounding communities and will be utilised optimally.
- The majority of the existing road ponds formed as a result of borrows pits created during road construction. In order to optimise the use of these borrow pits, there is need for the Government of Mozambique to include in their strategy of road construction, the

[5] Generally this costs are not separated from the total cost of the road, which makes it difficult for ANE to estimate the real cost of these type of infrastructure

excavation of borrow-pits in such a way that they could be used for water conservation on completion of the road works.

- Excavation of borrow pits for road construction should be done in way that they are able to conserve water, and at the same time providing easy and safe access for people to use the water. This will ensure that mishaps such as the reported drowning of a child in Chibuto district are prevented.
- There is little information on the costs of this type of infrastructure in Mozambique separate from the total cost of the road, so detailed studies must be carried out to evaluate the cost versus benefits for each selected site depending on the local conditions.
- Efforts should be made to involve and train the local community that will potentially use the improved road ponds and/or crossing structures on proper management of the water reservoirs. This will ensure that they maximise the use of the water and minimise contamination as much as possible.

Using road works to enhance community water supply in Mozambique is not without its challenges. As in many countries, the government department that is responsible for roads is different from the department that is responsible for water supply. In normal circumstances, these two departments do not have a lot in common and are not used to working together. The first challenge will be to convince the road engineers of the need to integrate water conservation in road works by making appropriate adjustments to the design of crossing structures and modifying the methods of excavation for construction materials. The second challenge will be to convince the water department that there is great potential in improving these sources, which they and the health sector will likely consider unsafe (although they are already being used). One major challenge will be to get all these key stakeholders to work together where required, even though, when interviewed, they all recognized the benefits of the road ponds and the need for improvement. They all agree that there is a need to work together in finding mechanisms for better management and use of these sources. Discussions were held with staff of DNA, MISAU, MICOA and ANE and they all acknowledged that the communities in the vicinity of road ponds use these sources, however, they are still a bit hesitant about accepting road ponds as viable water sources for health and safety reasons. In areas where water-borne diseases such as bilharzia and malaria are prevalent, health promotion and education must be a major component of the road pond improvement project. Mitigation measures to reduce the spread of diseases such as malaria is to introduce fish that feed on mosquito larvae into the reservoir. The use of hand dug wells that collect water filtered through the sand medium was proposed as a mechanism to improve water quality for domestic consumption.

The government of Mozambique is working to increase road networks to facilitate economic and general development particularly for the rural population. Evidence from the field visits to Tete and Gaza provinces has shown that road works can create opportunities for water conservation either in borrow pits or at road crossing structures. Other countries in Africa have maximised the opportunity created by road works to conserve water such as in revealed during the learning visits to Burkina Faso. There are also documented experiences of conserving water during road works by improving borrow pits and modifying crossing structures to store water for longer. The preliminary study in Mozambique concludes that road works can contribute not only to economic development but can also help to improve access to water supply for domestic (other than drinking) and agricultural purposes. Evidence has shown that communities in the vicinity of road ponds will continue using them as water sources with or without improvement, hence the need to integrate road pond improvement in road work plans.

# 6. Estimating the benefits versus cost of integrating water conservation in road works

Road works are continuously being undertaken in many parts of Mozambique. It is a well known fact that improving road networks helps to bring economic development and improve the general well being of the population. Including water conservation in already planned road works will bring added value and maximise the benefits of road networks. In the preliminary study conducted in Tete and Gaza Provinces respectively, it was found that people already use water from road ponds for personal hygiene, consumption, agriculture, recreation and income generation activities. However, it is clear that road ponds are not being used to their optimal capacity because they have not been improved. Improvements of road ponds can be done either as part of construction project or by the communities itself. In fact community interest or demand for improved road ponds could be a good indication for longterm sustainability of the infrastructure in terms of operation and maintenance. Improvements considered here could include such thing like, modified design of road structures to store water for longer in ponds, fencing to prevent animals for drinking directly in sources to be used for domestic water consumption or even reducing the slope to the pond to enable enables reach the water without risk of injury. It is difficult to estimate the additional cost of these modifications, as it has not been tried in Mozambique on a large enough scale. Similar modifications carried out in Burkina Faso cost \$6,000 to \$45.000 depending on the complexity. This is in addition to the cost of actual road construction, which ranges from \$13,000 to \$17,000 per kilometre.

Although there are no official studies on the benefit versus costs of improving road ponds, similar studies relating to improving access to potable water shows immense benefits such as health, economic, convenience, etc. A study in the arid regions of Kenya where small dams were constructed to improve seasonal access to water supply not necessarily for consumption showed significant improvements in the quantity and quality of household livestock, agricultural produce, family income and general wellbeing of the population.

The main cost of improving road crossing structures is incurred at the time of road construction. The additional cost is small when compared to the budgeted total cost of the road works. The benefits of improving road works can be calculated over the life of the structures for at least 10 years or more as long as the required maintenance is carried out. The economic benefit will include the value of labour and time saved fetching water and watering livestock. Other benefits are the improvements in the condition of livestock, income from the sale of irrigated farm produce and value of food grown for the household including increased opportunities for fishing. There are also health benefits, as a result of increased food production and more reliable access to water, which allows for improvements in personal hygiene.

The use of road ponds as an option for water supply is probably more viable in regions with scarce water resources. An example is the arid and drought prone areas of Gaza where the arid conditions are exacerbated by the presence of saline groundwater. In such environments traditional technologies such as boreholes and rainwater harvesting have limited application. Compared to the drilling of a borehole fitted with handpump, the use of road ponds is clearly a less attractive option. A borehole fitted with handpump costs roughly \$8000, and can optimally serve up to 300 people. Equally, rainwater harvesting technology based on roofs or improved surfaces is cheaper ranging from roughly \$2000 to \$4000 and able to serve up to 50 people. However, when these solutions are not possible in particular areas due to climatic and water resources conditions, road ponds can be a good option for minimizing water shortages, or providing complementary sources.

In order to calculate the actual costs versus benefits of improving road crossing structures a few computations are necessary. The cost of improving road crossing structures to conserve water is a function of the size of structure to be built. In this case the size of the structure will be a function of the volume of water that is required to meet the demands, calculated as follows:

- Water demand for domestic use:

  The general assumption is that these sources are not for drinking, but field evidence shows that they are used for consumption particularly where there are no alternative sources. Assuming that these sources are not used for drinking, they can still be used for other domestic purposes such as food preparation and domestic cleaning. The water use of a typical African family in semi-arid area is taken to be 15 litres/person/day, which is equivalent to 75 litres for a household of five. This quantity is commonly used for drinking and cooking.

Table 2. Example a household water requirement in semi-arid areas

| No. of persons | Daily consumption per person | No. of days without rain | Total annual water requirement |
|---|---|---|---|
| 5 | 15 | 150 | 11,250 litres |

- Water requirement for livestock: This will vary depending on type of animal, number of animals per household, season, temperature and moisture content of animal forage. The table below shows water requirements for various types of livestock on various seasons.

Table 3. Example of water requirements for livestock

| Type & no. of livestock | Daily water consumption per animal | No. of days without rain | Total annual water requirement |
|---|---|---|---|
| Milk cows x 2 | 50 | 150 | 15,000 litres |
| Zebu cows x10 | 27 | 150 | 40,500 litres |
| Goat x 10 | 3 | 150 | 4,500 litres |
| Sheep x 10 | 4 | 150 | 6,000 litres |
| Total requirements for watering livestock | | | 66,000 litres |

- Water for irrigation: Estimating the amount of water required for irrigation is often difficult, as it depends on the type of irrigation method used, climate, soil type and the period the crops are grown. A drip irrigation project conducted by the Kenya Agricultural Research Institute estimated water requirements for growing tomato/kale using drip irrigation on ¼ acre as follows:

Table 4. Example of water requirements for irrigation in arid areas

| Type of irrigation | Type of crop | Daily water requirement for 90 days on ¼ acre (approx. 1000m$^2$) | Total annual water requirement |
|---|---|---|---|
| Drip irrigation | Tomatoes/kale | 1,000x90 | 90,000 litres |

- Total water requirements for a family of five: The table below shows the total water requirements for a family of five. This total multiplied by the number of households in a target community will indicate the water requirements and also the potential benefit of improving access through road crossing structures.

Table 5. Example of total annual water requirement for a household of five people

| | |
|---|---|
| Domestic water for household for 150 days | 11,250 litres |
| Watering 32 animals for 150 days | 66,000 litres |
| Drip irrigation of ¼ acre for one growing season | 90,000 litres |
| **Total water requirement** | **167,250 litres (167.25 $m^3$)** |

Phase 2 will provide an opportunity to estimate and document the actual costs versus benefits of improving road crossing structures to conserve water for agricultural and domestic uses. A key component of this phase is the baseline survey and thereafter the monitoring that will enable collection of data for sound assessment of the benefits versus the cost of improving road crossing structures.

# 7. Proposal for phase 2

Phase II of this project is designed based on the results of the feasibility study carried out on integrating road works with water conservation and storage to enhance water supply in rural communities in Mozambique. The Feasibility Study covering the provinces of Tete and Gaza produced sufficient evidence that demonstrates the potential of road works related water storage infrastructure to improve the provision of water supplies for the poor. The visits to several sites in Tete and Gaza also raised concerns related to the potential health and environmental risks associated with this infrastructure that needs careful analysis. The Phase II project objective is to design interventions for road crossing structures and borrow pits to improve their water conservation potential. The designs will be tested and monitored at two sites in Mozambique.

The phase II of this project will look at both engineering and social aspects of integrating water storage into road works.

The following activities are foreseen for phase II:

- Identify two provinces for the construction of research and demonstration sites.
- Identify at least two sites in each of the two provinces where road crossing structures could be modified or built to improve water storage, and two sites where borrow pit improvements could be carried out. (The number of demonstration sites will depend on the budget provided for the works by ANE). The final selection of sites will also depend on community interest and demand for it once they are fully informed about the initiative and it's potential.
- Prepare a conceptual design for each of the proposed road pond structures indicating its location, alignment, height of the water retaining structure, approximate volume of water to be retained, and recommended type of structure and soil characteristics.
- Prepare a conceptual design for demonstration borrow-pit improvements
- Establish participatory, representative community road pond committees for the respective sites. These groups will represent community views concerning the design and operation of the ponds. Efforts should be made to have representative involvement in these project groups and extra effort may be needed to involve traditionally excluded members of the community, such as women and female heads of households. The capacity of the community road pond committees to manage and maintain the

community road ponds will be developed as part of the project. This will include training for the operation and maintenance of the infrastructure and controlling water quality.

- Monitor the behaviour of the ponds over two full rainy seasons, including their durability, their operation and management and their impact on the local environment, the local economy, social and community development, and the health and safety of the community and road users.

A detailed activity plan and budget is attached in appendix 4.

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# Appendix 1.
# People Consulted

| | | |
|---|---|---|
| Ana Cândido | - | MISAU |
| Bernardino Novela | - | DNA |
| Julaya Mussa | - | MISAU |
| Rui Branco | - | ANE |
| Luís Fernandes | - | ANE |
| Aurélio Nhabetse | - | DNHA |

# Appendix 2.

# STAKEHOLDERS WORKSHOP LIST OF ATTENDANCE

## UNIVERSIDADE EDUARDO MONDLANE

## FACULDADE DE ENGENHARIA

## CENTRO DE ESTUDOS DE ENGENHARIA - UNIDADE DE PRODUÇÃO

**PROJECT** AFCAP - ROAD PONDS

STAKEHOLDER'S CONSULTATION WORKSHOP

**Date** February 25th, 2011

**LIST OF PARTICIPANTS**

| No | Institution | Name | Contact details | |
|---|---|---|---|---|
| | | | Tel | e-mail |
| 1 | ISUTC | Jocelyne Machevo | 824866740 | jocelyne.machevo@hotmail.com |
| 2 | SCDS | Gaye Thompson | 823287320 | gaye@tvcabo.co.mz |
| 3 | UEM | Saturnino Chembeze | 823212010 | schembeze@hotmail.com |
| 4 | UEM | Odete Muxímpua | 823054579 | muximpua@gamil.com |
| 5 | Fundo de Estradas | David Geilinger | 828198090 | david@fe.gov.mz |
| 6 | LEM | Carla Cumbane | 823839282 | carlacumbane@yahoo.com.br |
| 7 | ANE | Nkululeko Leta | 828207659 | nkululeko.leta@gmail.com |
| 8 | ISUTC | António Rocha | 828415300 | rocha.ajda@gmail.com |
| 9 | MISAU | Celson Langa | 825288465 | celsolanga@yayahoo.com.br |
| 10 | LEM | José Hunguana | 822551650 | josehunguana@gmail.com |
| 11 | ANE | Rui Branco | 826731523 | rbranco@ane.gov.mz |
| 12 | ANE | Francisco Manheche | 827855932 | fmacheche@ane.gov.mz |

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**Date** February 25th, 2011

**LIST OF PARTICIPANTS**

| No | Institution | Name | Contact details | |
|---|---|---|---|---|
| | | | Tel | e-mail |
| 13 | LEM | Elias F. Chamba | 823891430 | efechamba@hotmail.com |
| 14 | ANE | Rafik Mamad | 827236830 | rmamad@ane.gov.mz |
| 15 | MINAG | Eugenio Nhone | 823960540 | eugenio.nhone@gmail.com |
| 16 | INAQUA/Minestéio das Pescas | Arlindo Marcos | 827392060 | arlindomabasso@gmail.com |
| 17 | INAQUA/Minestéio das Pescas | Margarida Bechardas | 824113960 | mbechardas@inqua.gov.mz |
| 18 | AFCAP | Rob Geddes | 827898468 | rgeddes@africaonline.co.zw |
| 19 | MINAG | Albano Leite | 825095340 | Albanoleite@yahoo.com |
| 20 | | | | |

# Road ponds stakeholders meeting

**Venue and date:** Faculty of Engineering, EMU, February 25, 2011

**Participants:** (see attached list)

**Objectives:** Present and discuss with stakeholders key findings of the feasibility study carried out by the Faculty of Engineering, as part of the AFCAP initiative in Mozambique. Analyze and propose the best strategies for a feasible use of road ponds considering the constraints placed by each of the sectors concerned.

**Meeting Agenda:** See attached agenda.

## 1. INTRODUCTION

At the beginning of the workshop each participant had the opportunity to introduce himself and briefly explain his role at the institution they represented. Introductory remarks were made by Rob Geddes representing AFCAP. Dinis Juízo presented the feasibility report findings to guide the discussions. The presentation was discussed in plenary session. Group discussions followed with participants focusing on the following aspects in each group:

- Group I – Discussion on technological questions. How to implement water retention structure in the form of "Road Ponds". What is needed in terms of regulations, design specifications etc.
- Group II – Allowed uses, water demand assessment, infrastructure management mechanisms and the involved actors, advantages and disadvantages of the use of such type of storages.
- Group III – Analysis, social and environmental studies associated with "Road Ponds".

The group discussed the issues indicated above and reported back at a plenary section. This document presents the results of the debates within groups and complementary contributions during plenary section.

## 2. MAIN ISSUES RAISED RELATED TO THE FINDINGS

### *Regarding the use of stored water*

- Given the potential water quality problems associated with impoundment of waters in open borrow pits, drilling wells next to it, one should consider the potential of using the sand medium to naturally treat the water. This can be achieved by digging wells next to the impoundment, a solution manageable at the local level with potential to improve water quality.

- The use of water wells next to borrow pit should be investigated within the existing policy framework. In principle in Mozambique the government seems to favor more the use of Afridev hand pumps rather than rope pumps. The potential policy implications of the use of hand dug wells equipped with rope pumps should be investigated.

- A survey to indicate the areas with potential for the use of road ponds is necessary. This would facilitate planning of possible interventions. The selection of potential areas for this option should be based on the lack of formal sources for water supply.

- Road ponds have good potential for being used in fish farming, with great impact in terms of protein uptake at community level. However, in this case the challenge is more related to the fact that the water is not permanent and cyclical fish farming will be required. The pond will eventually need to be re-populated every rain season.

- Road Ponds should not be regarded as the main water source, but as an alternative to secure and improve availability of water for different needs. The use of Road Ponds should be considered within a framework of a national program on small dams that are more sustainable and reliable than the road ponds.

***From the structural and technological point of view***

- The technical analysis in the following phases should look into the feasibility of introducing changes in existing water crossing structures, e.g. bridges, with the intention to allow water retention upstream.

- Borrow pits require, by definition, rehabilitation after use. What are the implications of keeping them open, in terms of the contract? Investigate the necessary modifications in contracts in order to make it possible for a contractor to finish the use of borrow pits with some interventions to make it usable by local communities in the event they is water accumulation.

- Consideration should be given to reducing water losses to ensure greater availability, e.g. evaporation and infiltration losses. There have been attempts by MINAG[1] to develop some small dams in arid regions, which however were not feasible due to excessive water loss through evaporation. A technical assessment to determine the minimum size for a borrow to be considered for impoundment of water is necessary.

[1] Ministry of Agriculture

- Specific studies on the usefulness of these reserves should be carried out, considering that water is available in these ponds during the rainy season when, from the agricultural viewpoint, there is little need for irrigation. How can the water be kept for the dry season?

- Other mechanisms continue using the water stored underground should be considered, when no surface water is available in the pond. An example is digging wells for groundwater exploitation.

***On the possibility of conflicting uses***

- During the field visit it was noticed that different uses of water were competing for the use of water without regulation. Concerns have been raised of health impacts of simultaneous use of water for bathing, drinking, fishing, and animal watering. The discussion at the seminar showed that some uses, although, at first might seems not recommendable, they are in fact desirable. For example fish farming is likely to benefit from the presence of cattle and its excrements, because this allows fertilization of the ponds and a favorable environment to the development of fish.

### 3. GROUP DISCUSSIONS

1. *What are the technological options that can be adopted to better use these water storage ponds and acceptable costs?*

    a. Given the large of structures that can potentially create Road Ponds, it is not possible at the moment to have a figure on the costs; this will depend on the details of the possible interventions and the local characteristics.

    b. Once potential sites is identified for the development of such infrastructure it will be necessary to prepare specific projects. The type of intervention will depends on various factors such as population needs, geomorphological settings, paedological characteristics of the region.

    c. The range of options for intervention in these areas include small embankment dams depending on the availability of soils in the vicinity, drifts and borrow pits improvement. The interventions on borrow pits will range from compaction of the foundation to reduce infiltration, improved access slopes to reduce the risk of injury of animals entering the pond for watering.

    d. As indicative figure, the costs should not exceed 100 to $ 200 000.

2. *What are the recommendations regarding community organization and mechanisms for demand management, stakeholders participation, advantages*

*and disadvantages of using road ponds and the need of environmental management?*

a. Any intervention should be made with strong community participation, considering their needs, organizational and management capacity. Specific studies concerning this should be undertaken during the design.

b. During the construction phase, the community must be involved, should be sensitized and trained for the management and maintenance of these sources.

c. The management structure to be established must be the least bureaucratic as possible and community-based, with the support from local governments, when needed.

d. Mechanisms should be developed for joint planning, dialogue and dissemination of information to the communities.

e. Various uses shall not cohabit, except livestock and fish farming, and agriculture if possible.

f. Whenever possible, and if necessary, different ponds should be developed for different uses. Segregate the domestic water use from all other forms of uses.

3. *Risks, advantages and disadvantages of improved road ponds*
   a. Advantages
      i. Storage and improvement in conditions for water use that can contribute to increase food security and improve livelihoods conditions based on fish farming, agriculture and livestock keeping.

      ii. Improved access to water for domestic activities can increase the householders' time availability to develop other activities.

      iii. Improving the welfare of the beneficiary communities.

      iv. Reduction of erosion associated with borrow pits.

   b. Risks
      i. Potential contamination of water and thus proliferation of water born diseases
      ii. Potential discontinuation of used by communities, risk of proliferation of pathogens and proliferation of mosquitoes.
      iii. None permitted uses, such as human consumption that can endanger the communities' public health.
   c. Disadvantages

i. No disadvantage which was not related to the risks presented above was identified.

# Appendix 3.
# Tete field visit report

# Using Road Works to Enhance Community Water Supplies in Mozambique

## African Community Access Programme (AFCAP/MOZ/004/A)

## Initial field assessment – Tete Province

Field visit report 1 by:
Department of Civil and Building Engineering
Eduardo Mondlane University
Av.de Moçambique km. 1.5

August 2009

Contents amendment record

This report has been issued and amended as follows:

| Revision | Description | Date | Signed |
|---|---|---|---|
| 1 | First draft | May 2009 | DJ |
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| 3 | Third draft | 17/09/09 | Chimbeze |
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| 5 | Fifth draft | 30/09/09 | AG |

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## List of figures



## List of abbreviations

ANE Administração Naçional das Estrada (National Agency for Roads)

EN Estrada Naçional (National Highway)

Mts Metical (Mozambique national currency)

# 1. Introduction

## 1.1 Study background

The fight against poverty requires innovations in the way investments are made in third world countries where a multitude of challenges and scarce resources limit the impact of global socio-economic sectoral interventions. AFCAP is a continental program in Africa that aims to identify innovative ways to maximize the benefit of roads improvement programs to the rural population. Using practical and applied research, the program creates new technologies and promotes the transfer of existing technologies for use in places where they can improve the issue of accessibility in low traffic roads. A key element of the approach is the need to maximize the benefits of investment made. Hence the program focuses on identifying and developing low cost technologies for the improvement of roads and to add to the benefits of investment in roads to local people.

A question of longstanding concerns in sectoral integration is the fact that in many areas poor access to water is a barrier to development and general well being of the population. It is general knowledge that road works are associated with significant earth movement, which often creates borrow-pits. These pits are sometimes larger than what is required to construct water retention structures such as a small dam. There are also many instances where roads cross water ways resulting in the construction of structures, which can be designed to retain water that could potentially be beneficial to the rural population. These bodies of water retained by crossing structures and borrow-pits are known 'Road Ponds'.

AFCAP program in Mozambique looks at the issue of low cost technologies for the improvement of roads with low traffic and the possibility of integrating water storage facilities during road construction at borrow-pits and crossing structures. The first draft of a series of research studies under the program in Mozambique known as "Road Ponds" is being implemented by the Department of Civil Engineering of Eduardo Mondlane University in partnership with the ANE (National Agency for Road). The research project will be carried out in three phases namely:

- *Phase 1: Feasibility study* to gain an overview of the existing "road ponds" including use and the potential for improvements and possible interventions. It also facilitates the analysis of the factors that favour the adoption of the initiative, threats, opportunities and risks. This report is part of phase 1 of the research project.

- *Phase 2: Design and construction of pilot projects* including technical monitoring for a period of two years.
- *Phase 3: Production of manuals* to guide the design, construction and utilisation of "road pond", and dissemination of project findings.

### 1.2 Purpose of the field visit

This report outlines field activities undertaken in Tete province. It was the first of two field 2 visits to be carried out in order to get an overview of the existing "road ponds" and to gather information related to their water retention patterns, uses and activities at these sites; and communities' perceptions. Structures observed include borrow-pits, box culverts that retain water, and other existing structures related to road construction, which retain rain water.

With this visit, we also wanted to verify the technical conditions in which these reservoirs are created, identify the main uses, the infrastructure management procedures and the actors involved, and advantages and disadvantages of using these reservoirs in order to devise a methodology for a more detailed research. This study is part of a feasibility study for construction of road ponds as an integral part of roads' projects in order to maximise the benefits of the investments in roads.

During this visit, various "road ponds were identified and they include two small dams constructed in collaboration with ANE[1], four borrow-pits, of which three were "inactive" and with accumulated water and the fourth still active and being used for road construction. Road crossing structures such as culverts that retained water were also observed. The details of the structures observed are shown at the end of this report (appendices 1).

[1] ANE was responsible for soil analyses and supervision of the road construction on the crest of the dam, but was not directly involved in the project

## 2. Methodology

Tete was selected in coordination with ANE in Maputo and later the Tete provincial delegation proposed the sites on the primary road EN7, linking Tete city to border town, Zobue.

At each site, informal interviews were held with Technical staff from the provincial delegation of ANE; local authorities; leaders and members of farmers associations; contractors and supervisors of the road works in progress; and some users at the road ponds visited. Although the discussions were informal, interview guides were prepared prior to the field visit to guide the field research team and ensure that all key areas were covered.

## 3. Characteristics of the areas visited

The District of Moatize, located in the Central-eastern province of Tete boarders Tsangano District to the North; on the west, by Chiuta and Changara Districts; south by the Districts of Mutare and Guro (Manica); and Malawi to the East. Moatize District identified in the map in figure 1 has a population of 178.096[2] with the headquarters in Moatize. The population are mainly subsistence farmers (80%) and very few working as miners at the coal mining industry. Water-related diseases prevalent in the District include bilharzias, intestinal parasites and malaria. Data from the last MICS survey shows the main source of water supply in Tete to be non- protected wells(35.7%), followed by rivers and lakes (27.8%). Overall access to improved water supply stands at approximately 34.2% and improved sanitation at 3.4%. [3].

The District has two climates, "dry steppe with dry winter - BSW" in the South, and ‘rainy tropical savannah – AW’ in the North associated with rainy and dry seasons respectively. The average annual rainfall in the nearest station (town of Tete) is about 644mm while the annual average potential evapotranspiration is 1.626mm. The

[2] http://www.ine.gov.mz/censo2007/rp/pop07prov/tete

[3] INE, MICS, 2008

majority of rainfall occurs in the period between December and February, varying considerably in quantity and distribution from year to year. Geomorphologicaly, The district is partly located in the wide Gnaiss-Granite Complex of the Mozambique Belt where the intrusive rocks of the Post-Karroo crop out as "inselbergs". The soil is clay, and characterized by good nutrients and water retention capacity, cracks when dry, and plastic and sticky when wet. With reference to the physiographic terms, a system of plateaus form part interfluves and inserted deep valleys and narrow.

Four areas where visited in Tete District and six water reservoirs were observed. The roads visited were located in Mafupayanzo Adminstrative Post, about 7km of EN7; Sobué Administrative Post (EN7); Capirisange and Muaria Administrative Posts (EN7); and EN7 main road in Moatize District. The details of the areas visited included the associated characteristics of the reservoirs are outlined in annexes 1.

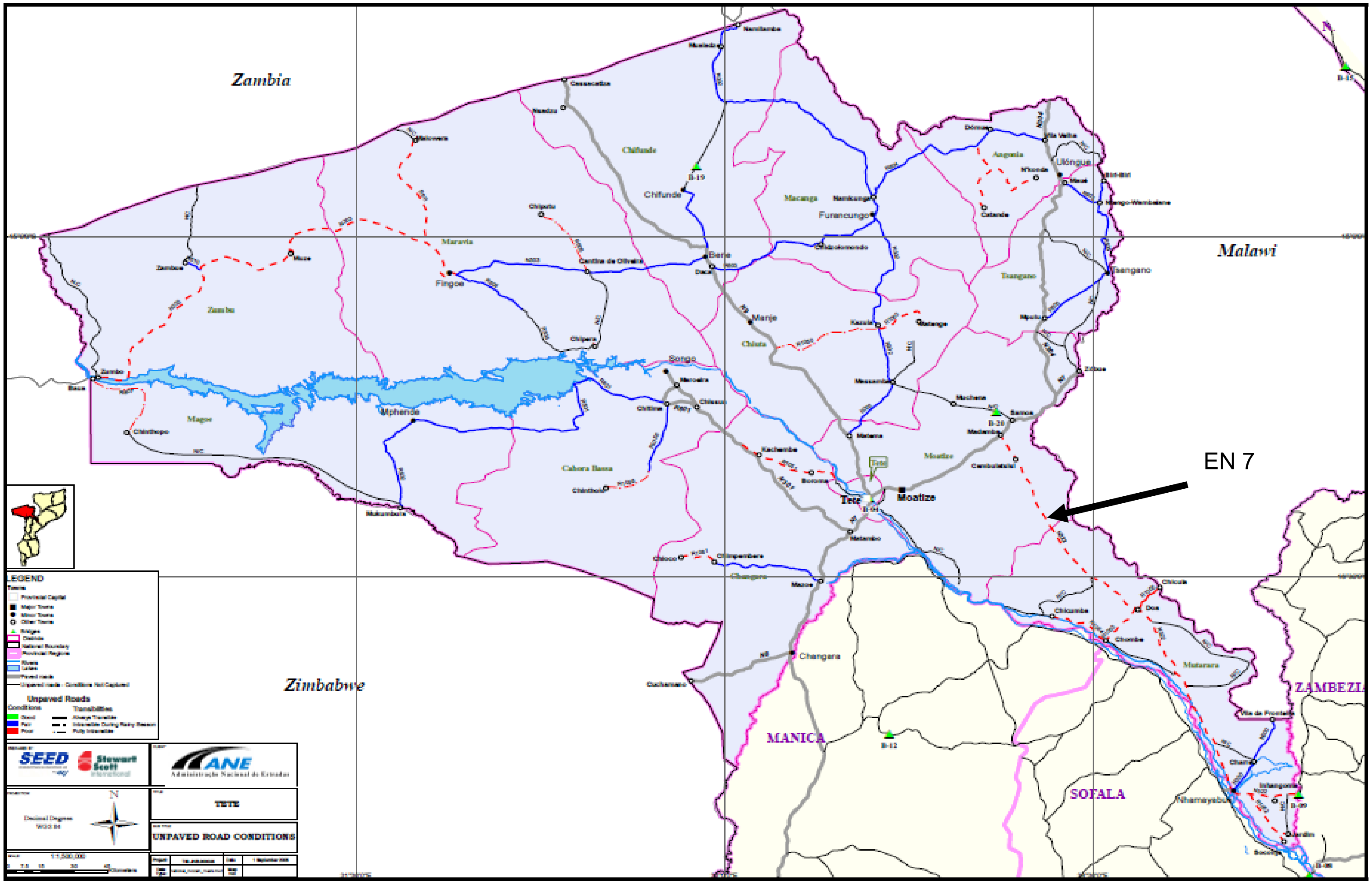


**Figure 1. Map showing location of the district visited**

# 4. Observations and key findings

## 4.1 General

Road construction works are always associated with earth movement, which can be both landfill and excavation along the route where the road passes, depending on the topographical conditions and the characteristics of materials. Besides the need for earth movement during construction of roads, soils are necessary for the maintenance of the road, which makes this process almost permanent. As a result, they create depressions where the soils are taken, and become favourable places for water storage in the event of rainfall.

The ANE in Tete has been working continuously on improving access roads to towns and districts, which include the construction of new roads and rehabilitation of existing roads. During this process, they open new borrow-pits or reuse existing pits.

At the EN7 road connecting the city of Tete to Zobue, there is on average one borrow-pit every 5km, and the minimum distance between two borrow-pits is 2km. These borrow-pits are in some cases located less than 50m from the road. Some of these borrow-pits, were flooded during the time of visit, and but this occurs only in certain periods of the year as shown in Figure 2.

**Figure 2. View of a borrow-pit with retained water**

### 4.2 Characteristic of the reservoirs identified

Six sites with road ponds including two small dams identified by ANE were visited in Tete Province, as outlined in section 3 above with details in annexe 1. All the six sites had water, which were being used by the residents of the surrounding communities. This indicates indirect added benefits of the investments made in roads in Tete Province. However there are several issues that need to be clarified regarding opportunities and risks associated with using these road ponds as water sources particularly for consumption. The main features observed are:

- Water quality

  At the time of the visit, the water in the ponds was turbid with colours that ranged from brown to white foam cover. Brown was due to the presence of animals that stir up the bottom of the depression and cause the suspension of sediment, and people taking bath; and white was the result of the soap from washing clothes.

  In most of the visited ponds there were aquatic plants, which may be a sign of eutrophication due to excessive presence of nutrients in the water. Around the ponds there were signs of cattle faeces which will naturally enter the reservoir during the rains.
  No water quality analyses were made.

- Access

  Access is mainly through the slopes of the reservoirs, some of which are steep and can potentially become dangerous. Although no improvements have been made on the access points, constant use by humans and animals have created passage ways for both humans and animals.

### 4.3 Availability of water and reservoir capacity

The depressions visited had dimensions ranging from 5000 $m^2$ to 10 000$m^2$ flooding area, and an average depth of 1.2 m to 1.5m during the visit. According to residents of the surrounding areas of the road ponds, and confirmed by observations on site, the maximum area of flooding varies from 20 000$m^2$ to 100 000$m^2$ and the maximum depth of 3 to 3.5m, which has the capacity to store up to a maximum of about 350,000 $m^3$.

According to the users, most of the visited ponds contain water from October to July, indicating that they store water for at least three months after the rainy season and are dry for two months of the year. In the few months when the ponds are dry, residents use alternative sources such as rivers and streams. The community members interviewed consider the road ponds as complementary and additional sources of water supply particularly for washing clothes, bathing and watering plants. When it comes to water for domestic use they prefer other sources deemed safer. These data are qualitative and should be checked.

### 4.4 Uses and management of road ponds and dams

- <u>The main uses identified are:</u>
    - Livestock watering
    - Bathing and laundry
    - Construction / production of bricks
    - Irrigation
    - Fishing
    - Recreation particularly for children

According to members of the communities in the vicinity of the ponds visited, the water from the ponds is not used for drinking because they consider it to be of poor quality. Moreover, the water in the ponds is stagnant and is frequented by animals thereby progressively deteriorating. Other sources which they consider better than the ponds, such as the river, well and boreholes installed with hand pumps are used for drinking and in some cases for bathing. This not withstanding, members of the community still consider the road ponds useful, as they provide complementary sources of water supply.

Fishing is mainly done in the two dams and not in any of the road ponds.

- Gender bases in relation to water use

According to the last MICS, in Tete, in 93% of the households, women collect water. During the visit, women formed the majority that were seen using the sources for washing clothes and bathing, whilst children were seen watering livestock and also bathing. . The only site where men were seen actively using water for irrigation was in Mafupayanzo where a farmers association is responsible for managing the dam. Close to the dam, women were collecting water for human consumption from a well dug on the river bed.

When interviewing groups of users, in Muaria and Capirisangi, men said they don't use the water from the ponds because its dirty and they prefer to walk long distances to the river for bathing, while their wives use that water because its near their house and they have other activities at home.

- Management mechanism

For all the visited sites, only the two dams had a management scheme, comprised of the farmers' association, the administrative post and the district agriculture services. In Mafupayanzo, there was an organized association, with a team responsible for managing the irrigation scheme supported by the district agriculture service while in Zobué, the same structure does not seem to work. There, the division of responsibilities is not clear and no one seems to feel responsible for managing the infra-structure.

None of the road pond had a defined management mechanisms.

### 4.5 Conclusion and potential for improvements

In Tete three types of water reservoir associated with road works were found, they include dams, borrow pits and culvets (annex 1). Two small dams have been built as part of agricultural development projects with technical support, and benefit from a management structure based on the farming community. However, the ability to manage and maintain the infrastructure must be studied in more detail to learn lessons for other areas. There may be need to train local artisans to maintain the dam and irrigation system. This requires the need for specialized technical support.

Borrow pits on the other hand that resulted from excavation of soils for construction of road are not built specifically for the storage of water. However, as we observed, they store water and are used by people living in surrounding areas for their own supplies and are in conditions that may endanger their life due to poor access, and the water quality is not suitable for human consumption. Some measures to improve the borrow pits are follows:

- Improving the geometry of the borrow pit so as to facilitate access and increase storage capacity.
- Compress the base and sides so as to reduce the permeability and reduce water losses by infiltration.
- Construction of wells for water extraction to allow for filtration and improve water quality.
- Develop mechanisms to protect sources in order to have controlled access, and avoid conflicts between different uses
- Also, develop community-based management structures in partnership with various government departments.

The culverts are road crossing, which allow the passage of water without jeopardizing the access roads. They are usually built on water lines that create the conditions that allow for accumulation of water. This can be improved to retain more water. The measures that can be used include:

- Construction of structures with gates that act as a small dam.
- Excavation to increase capacity, and compression of the base to reduce the permeability and water loss by infiltration.
- Develop a community-based management system with expert technical support.

Selection of a location for detailed study, improvement and monitoring will depend on several criteria including:

- Number of beneficiaries;
- Ability to retain water;
- Conditions of access;

- Hydrology of the region (precipitation, evaporation);
- Type of soil.

Thus, at this preliminary phase, in Tete province, site no. 5 in Muária may be suitable for improvement but pending more detailed study to verify the above listed criteria.

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# Appendix 1.

# Characteristics of the reservoirs visited

| **Reference** | **Description** | | | | |
|---|---|---|---|---|---|
| | Site 1 and 2 | Site 3 | Site 4 | Site 5 | Site 6 |
| ***District/Posto /Village*** | ***Moatize/Mafupayanzo /*** | ***Zobué Administrative Post*** | ***Capirisange Administrative post*** | ***Muaria Administrative Posts*** | ***Muaria Administrative Posts*** |
| Name of road | Deviation that leads to the district of 7.2 km Mafupayanzo of EN7 | Deviation of EN7 | EN 7 | EN 7 | EN 7 |
| Administrative headquarters | District of Moatize, Administrative post Mafupayanzo. | District of Moatize, Administrative post Zóbue | District of Moatize, Administrative post Capirisangi | District of Moatize, Administrative post Muaria | District of Moatize, Administrative post Muaria |
| Characteristic of the road and structure | Dirt, concrete bridge | unpaved | Paved | paved | paved |
| Paving material | Compacted earth | compacted earth | asphalt concrete | asphalt concrete | asphalt concrete |
| Distance to the nearest post | 100m of Mafupayanzo (Dam) | 500 from Zóbue | within the main village | | |
| | | | | | |
| ***Details for the body of the reservoir*** | | | | | |
| Type of water source (reservoir) | 1. (Bridge - Crossing structure) (7km from EN7) | small earth dam | ex- borrow pit - pond | ex- borrow pit - pond | box culverts |
| | 2. Small concrete dam (7,2km of EN7) | | | | |
| Dimensions(m); Length x Width x Height: | 30X30X6 | 120x100x7 | 50x10x3 | 100x50x5 | 3x4 |
| Geographical location | Latitude: 15.89$^{o}$ south | 60º S | 15.80º S | 15,83º S | 16,03º S |

| Reference | Description | | | | |
|---|---|---|---|---|---|
| | Site 1 and 2 | Site 3 | Site 4 | Site 5 | Site 6 |
| | Longitude: 34.02º This | 34.43º E | 34,21º E | 34,16º E | 33,94º E |
| | Altitude: 319m | 864 m | 364 m | 363 m | 375 m |
| Tilt | ≈ 0% | ≈ 0% | ≈ 0% | ≈ 0% | ≈ 0% |
| Levelling visual | Well capped | well capped | well capped | well capped | |
| Other uses | Live stock watering, and human use other than for watering. | Live stock watering, and human use other than for watering. | domestic use other than for drinking. | domestic use other than for drinking. | domestic use other than for drinking. |
| General state | Good (few cracks) Recently built (both) | good (few cracks) | Good | good | bad: erosion on the foundation |
| Water level | 3 m | 0.5 m | | | |
| Excavated | No | | Yes | yes | yes |
| Material of body | Concrete | earth | earth, clay | earth, clay | concrete and earth |
| Dimensions of the structure | Bridge - 4m in wide, 16m long and 3m of long with 4 leg distances of 4m | 3 m in wide | 4m in wide | 4m in wide | 4 m height of enbankmentx6 |
| Width of base | 4m | 7 to 10 | .---- | .---- | 4 m |
| Dam (vestment) | Concrete | | | | |
| Elevation associated with the passage of hydraulic | 0.5-1m | none | None | none | 30 to 50 cm |
| Features of the discharge (type and dimensions) | Central unloader with support | lateral open-channel outlet | no discharge | no discharge | box culvert |
| Disturbance | Without disturbance | small cracks on the crest-road. | No | no | erosions on the joint between the structure and the bridge |
| Any modifications made to increase storage capacity? (Describe) | no | no | No | no | yes, (people excavated to make small wells downstream of |

| **Reference** | **Description** | | | | |
|---|---|---|---|---|---|
| | Site 1 and 2 | Site 3 | Site 4 | Site 5 | Site 6 |
| | | | | | the box culvert). |
| Type of drainage into the pond | water from stream | water from stream | rain water and surface run-off. | rain water and surface run-off. | rain water, surface run-off and water from the stream. |
| Coating of Slope | Riprap | Medium-sized vegetation | large sized vegetation | large sized vegetation | small sized vegetation |
| Ravine | No | yes | Yes | yes | yes |
| Material of the bed | …… | | Clay | clay | clay |
| Localized disturbances (empty shifts, erosions, fissures, depressions, slip or subsidence) | No | erosion on the downstream slope (the main road slope and plots on the left side). | erosion on the slopes | erosion on the slopes | erosion on the joint and slopes |
| Holes dug by animals | No | No | Yes | yes | no |
| Excessive vegetation | No | No | Yes | yes | no |
| Entrainment of fines by the action of rainwater | No | On the slopes and the road embankment | from the slopes | from the slopes | no |
| Upwelling and wetlands | No | No | No | no | no |
| Means of access by beneficiaries | By slopes | By slopes | By slopes | By slopes | By slopes |
| No of months it retains water | the whole year | the whole year | 9 | 9 | 9 |
| Main purpose of the water source | Irrigation | Irrigation | livestock watering | livestock watering | irrigation |
| Approximate no. of users during visit | 1 | 20 | 4 | 10 | 1 |
| Time of visit | 7:00 AM | 8:00 AM | 9:30 AM | 10:00 AM | 11:00 AM |

| **Reference** | **Description** | | | | |
|---|---|---|---|---|---|
| | Site 1 and 2 | Site 3 | Site 4 | Site 5 | Site 6 |
| Types of uses (observed and from users) | irrigation and livestock watering | washing clothes and livestock watering | livestock watering and washing clothes, construction, washing dishes | livestock watering and washing clothes and dishes | irrigation |
| Management and conservation activities | controlled by the local farmers association | controlled by the local agriculture services | None | None | None |
| Perception of value to users | very important for their small farms | very useful for washing clothes but dangerous. A kid died last year | important because reduces it reduces the distance to the river, especially for watering their animals. | important because reduces it reduces the distance to the river, especially for watering their animals. | Important when there is no water in the stream |
| Water quality | clean, with some dry leaves | dirty, white foam from soap. | turbid water, aquatic plants and erosion on the slopes. | turbid water, aquatic plants. | turbid water |
| Water treatment methods | None | None | None | None | None |
| Potential for improvement | There is no need for improvements and the reservoirs already seems to have a management system in place. | Not much physical improvement is required but rather the emphasis should be to improve its management systems. Management systems involving the community, the farmers association, the district agriculture and infrastructures unit, as they are responsible for the maintenance should be explored. | Possibility of increasing storage capacity, reduce permeability by compacting the ground and slopes. Access to the reservoir can be improved to make it safer. Management systems involving the district government and the local authorities at the community level should be explored. | The same as site 3. Possibility to use these reservoirs for animals and the one on the site 4 for human use. | Possible excavation and improvements on the geometry to allow access for animals, and reducing permeability of the ground and slopes. Possibility to divert water for irrigation through excavation channels. Need to rehabilitate the foundation of |

| Reference | Description | | | | |
|---|---|---|---|---|---|
| | Site 1 and 2 | Site 3 | Site 4 | Site 5 | Site 6 |
| | | | | | the bridge. |

# Appendix 2.
# List of people consulted in Tete

| Name | Position |
|---|---|
| Dadi Mendes | Technical staff, ANE |
| Sigarete | Technical staff, ANE |
| Batias Laissone | Chief of Administrative Post of Zobué |
| Yona Stefani | Chief of farmer association of Mafuphayanzo |
| António Namuala | Member of farmers association in Zobué |
| António Paulo Levenaio | Member of farmers association in Zobué |
| 20 men and women from Zobué | It was not possible to register their name and occupation |
| 10 men, women and children from Muaria | It was not possible to register their name and occupation |

# Appendix 4.
# Gaza field visit report

# Using Road Works to Enhance Community Water Supplies in Mozambique

## African Community Access Programme (AFCAP/MOZ/004/A)

### Initial field assessment – Gaza Province


Field visit report by:

Department of Civil and Building Engineering

Eduardo Mondlane University

Av.de Moçambique Km. 1.5


September 2009

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| 4 | Fourth Draft | 22/09/09 | AG |
| 5 | Fifth draft | 30/09/09 | AG |

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## List of abbreviations

ANE Administração Naçional das Estrada (National Agency for Roads)

EN Estrada Naçional (National Highway)

Mts Metical (Mozambique national currency)

# 1. Introduction

This report is part of the first phase of the research project to investigate the potential use of road works for the development of water storage, as a follow-up to the visit Tete province. The results of the first visit report are presented in a separate report.

The purpose of this visit was to consolidate the results of the first visit, and to gather information on areas with different socio-cultural and geographic background from Tete. In Gaza Province, the problem of the lack of water is more intense resulting to food shortage due to drought and poor crop yields. During the field study, the team visited some water reservoirs associated with roads work (excavation or backfilling), which include borrow pits and box culverts.

This visit was also meant to gather more detailed technical information on the reservoirs; identify the main uses; management setup for the infrastructure and the actors involved; advantages and disadvantages of using these ponds.

This visit to Gaza province identified several water reservoirs associated with borrow pits and box culverts. A total of thirteen sites were visited, of which nine (9) were borrow pits, and five (5) of these have been decommissioned and no longer excavated for road works while the remaining four (4) were still active. Of the 5 inactive burrow pits, three (3) had water and two (2) were dry. Four (4) box culverts were observed in detail out of which three had associated ponds and one was dry. The box culverts are located between the Limpopo Railway line and box culverts (crossing structures) that were built in parallel along this route.

No dam was visited in Gaza Province, but the District Administrator mentioned that there were two dry dams in Mabalane. The soil type in most parts of Gaza Province is loose sandy soil with high permeability, which may explain the reason for the dry dams, as sandy soils have very limited water storage capacity.

## 2. Methodology

Following the presentation of the Tete visit report to ANE, it was proposed during the discussions to include cases studies from other provinces with more severe water shortage in the feasibility study. It was assumed that areas with severe water shortages are more likely to lack alternative water supply sources and hence the potential benefit of having road ponds would be higher. Gaza province is known to be arid and therefore experiences greater water shortage. The fieldwork included:

- Informal interviews with the technical staff of the ANE delegation in Gaza and they proposed Chibuto –Mapai road, EN 221.
- The team identified water reservoirs and made visual analysis of their conditions, specifically,
    - the general state of the environment and sanitation,
    - the quantity and quality of water stored,
    - the maximum dimensions of borrow pits,
    - the type of soil
- The team conducted semi-structured interviews with the district (the District Administration of Mabalane and health services) and in the nearby settlements.
- The team also conducted 4 focus group discussions that consisted of women only, children only, and two mixed groups respectively.
- Informal interviews were conducted with people using water from the ponds at the time of visit.

## 3. Characteristics of the areas visited

The Chibuto-Mapai route crosses five districts of  Gaza Province. In the southerly - northwest direction are the districts of Chibuto, Guijá, and Chokwé; the districts of Mabalane and Chicualacuala follow the left bank of the Limpopo river, from Macarretane in Chokwe in the direction of Mapai.

The description and differentiation of soils in the region is given on the basis of typical natural vegetation cover. The EN 221 is extended by recent fluvial deposits of the Limpopo River, a region with mostly *Xanatsi*, *Ntlhava* and *Simbire* tree cover, depending on the type of predominant vegetation. *Xanatsi* is predominantly a clay soil vegetation cover located in lower areas and slopes. *Ntlhava* is found in higher areas of sandy soils with low water storage capacity, and *Simbire* are found in the intermediate areas of very deep soils with low water storage capacity.

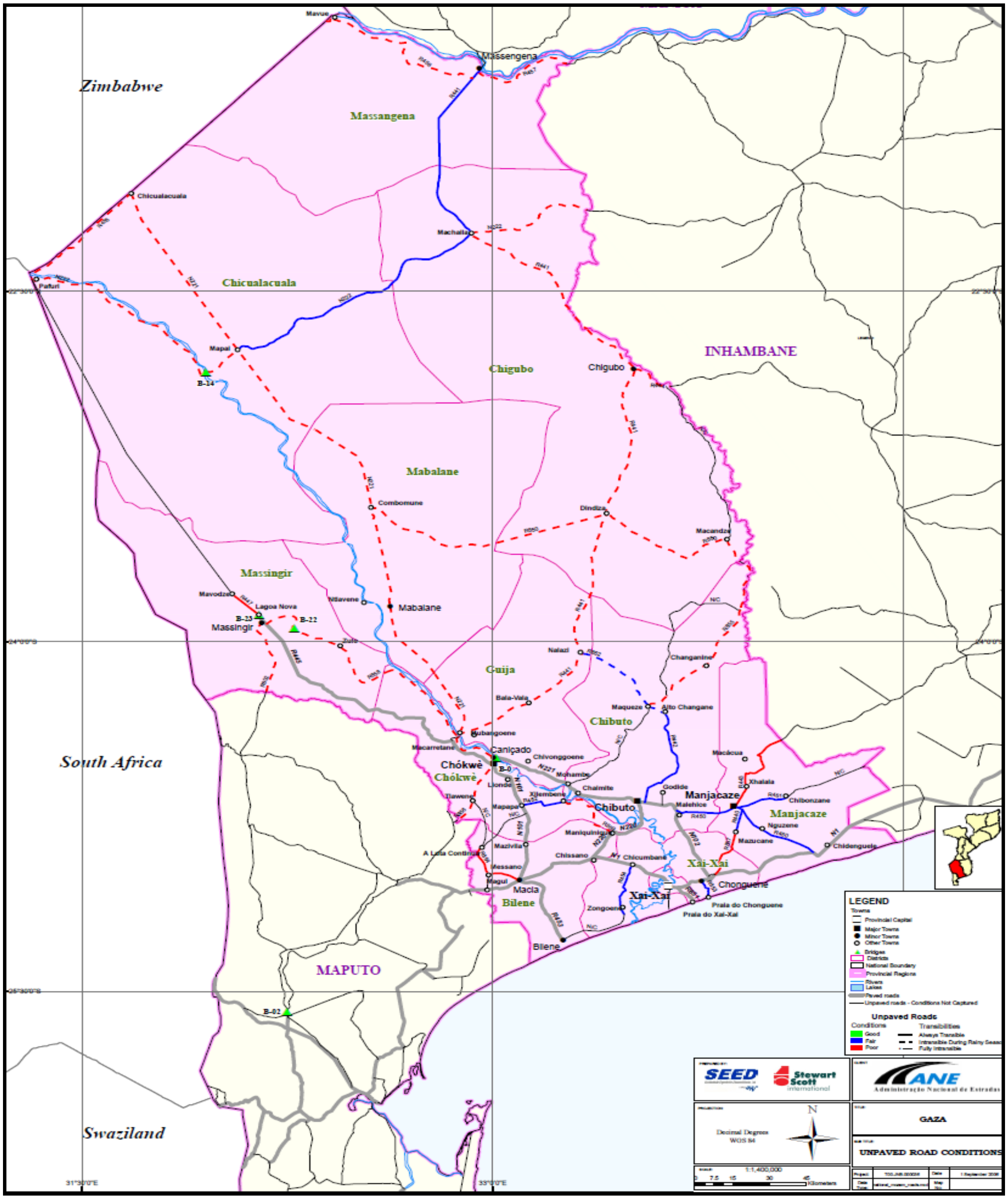


**Figure 1.** **Road map of Gaza District**

The climate is semi-arid to arid characterized by low precipitation (less than 500mm) and high potential evapotranspiration, in the order of 1500 mm, thus causing water deficit of about 800 to 1000mm. The dry season, has an approximate duration of 8 months, with the rainfall rather irregular, between the months of November to February, and some dry periods that frequently span across the rainy seasons.

The main water resource is from the Limpopo River. Besides the river the communities also rely on some boreholes and wells (mostly with brackish water), small dams that store rain water, and road ponds. Water supply coverage is low in all districts except Chokwe town where a water supply scheme that taps a regional productive aquifer system was recently rehabilitated. In other districts the population travel long distances (more than 5 km) to fetch water. In the dry season when the ponds dry up, some communities travel more than 30 km to the nearest water source.

The population density in the areas observed (Mapai-Macarretane) varies between 2.5 inhabitants/km$^2$ in Chicualacuala district to 3.5 inhabitants/km$^2$ in Mabalane.

## 4. Main findings

### 4.1 General

Roads construction and improvement is one of the priorities of the Gaza Province Government particularly in the northern districts, which include Mabalane and Chicualacuala. Currently, the main access to the region is the railway linking the city of Maputo and the neighbouring country of Zimbabwe, which ensures the flow of commodities to these districts. The railway is also vital to the local communities and provides opportunities for them to sell livestock and other natural resources-based products such as charcoal to Maputo and other urban centres.

The EN221 has a paved section between Chibuto-Macarretane with asphalt, and the rest is gravel alongside the rail-line from Macarretane to Chicualacuala (more than 350 km). Both the road and the railway cross numerous drainage channels running perpendicular to it towards Limpopo river’s main stream. Most of these stream crossings are box culverts usually with a depression between the two infrastructures, which accumulates rain water or small ephemeral streams. Along the EN221 there are several borrow pits from where materials used for road construction are taken (one every 15 to 30 kms), depending on the quality of materials found along the road. These borrow pits usually less than 50m from the road become points of water accumulation that turn into ponds and water sources for various purposes, including human consumption (see Figure 2).

Borrow pit is a selected site where soils for earth works are taken when high volumes of earth are needed. Generally the pits are sealed after being used for paved roads and only concrete asphalt is needed for maintenance with low earth movements. However, for unpaved roads, some borrow pits can be re-used for maintenance if there are still good soils and there is not too much work to re-clean. It is common practice in Mozambique for contractors to leave the pits unsealed after completing their work, which is the main reason for the formation of road ponds.

The road ponds were all as a result of road construction, which left borrow pits uncovered and not rehabilitated on completion of the roads. As mentioned earlier in section 1, only 4 of the 9 borrow pits observed were still actively being excavated for materials for road construction at the time of the visit. Generally, the communities do not use water in active pits until the contractor have completed their work and left and water starts to accumulate in the pits.

**Figure 2. Road ponds in use for different purposes**

## 4.2 Characteristics of the identified ponds

During the visit, the majority of identified depressions were dry, with cracks in the ground, with some moisture and plants at the bottom of the depression. There were also ponds with accumulated water being used by people living in surrounding areas. The main features observed are:

- **Soil:** there are layers of clay on very sandy soils. The clay deposit is probably linked to settling of fine materials.

- **Water quality**: turbid coloured water that ranged from brown to greenish-brown. In all pounds one could see pedestrian tracks and marks leading to the surrounding communities. It was also common to find animal faeces. Only 1 of the ponds had little aquatic plants, which indicate the presence of nutrients such as Nitrogen or Phosphorus that is likely to impact on the water quality. This type of environment can potentially become a breeding site for snails that harbour the bilharzia parasite. The presence of animal faeces could potentially contribute to water contamination resulting in diarrhoea diseases if the water is consumed without treatment.

**Figure 3. Examples of the region's soils and water reservoirs**

- **Access:** the slopes to the depression are generally steep, with some risk of landslides due to erosions and potentially silting up of the reservoir. Access can also be dangerous sometimes fatal, as confirmed by members of the community.

**Figure 4. Examples of the region's soils and water reservoirs**

Not much information was collected on land tenure and ownership in relation to the places where the road ponds are located. The road reserve for a national road is 30m on each side and 50m for highway[1] to facilitate future road expansions and even

[1] Assembleia da República, Lei de Terras, Lei nr° 17/97 de 1 de Outubro

when much space is needed, the Government can expropriate if it is justified for public interest. The majority of the road ponds are located about 50m or less from the road, and it can be assumed that if necessary, expropriations will be made bythe government to allow for community development. The community understanding and beliefs may differ from the general assumption and has not been covered in this first assessment. The issue of land tenure will be discussed in details with the government and the communities prior to selecting the road ponds to improve.

### 4.3 Availability of water and reservoir capacity

The ponds had dimensions ranging from 500m$^2$ to 2000m$^2$ maximum flooded area, and an average depth of between 1.5 to 6 m but the maximum depth during the visit was 1m. According to people living in the surrounding areas, the lakes reach their maximum storage capacity estimated at 10,000m$^3$ or more during the rainy season.

According to the users, the reservoirs store water from December to June/July of following year, which means that the ponds remain dry for three to four months of the year. The water storage capacity of the ponds depends solely on climatic and physical conditions rather than human activities. In years when there is high rainfall, the water lasts longer in the ponds and vice versa. This was also confirmed by the users who indicated that in years with high rainfall, some ponds retain water for the entire dry season. However, in dry years, these ponds remain dry for the duration the dry season, and when that happens, people seek alternatives sources of water supply including going to the river (up to 30 km for some communities) or purchasing water at prices ranging from 12 Mts to 20 Mts, for a 20 litre container (including the cost of transport). In some of the communities visited, the ponds are the main source of water supply. The details of the ponds observed during the visit is attached in annex 2.

### 4.4 Uses and management of road ponds

- The main uses identified are:
  - Human consumption
  - Livestock watering
  - Bath and laundry
  - Construction
  - Irrigation
  - Fishing
  - Production of clay utensils and playing for children

- Gender biases and use

During the visit, women and children formed the majority seen collecting water, bathing, washing clothes or kitchen utensils. This does not signify that men do not use water from the road ponds but relates more to the traditional roles and responsibilities. Women and children generally have the responsibility for collecting, transporting and storing water at home. Although the women and children collect water, men use the water from these reservoirs at home, which could explain the reason why few men where seen at the source.

- Water Quality

Unlike in Tete, in Gaza, the water from ponds is used for human consumption, often without treatment. This was raised by health authorities as a big concern. The analysis of water quality conducted periodically by the district health services indicates that the water is inappropriate for human consumption and believed it to be a major contributing factor for the recurrent cases of diarrhoea and dysenteries that have hit the populations of those areas. To address this, health authorities have developed awareness campaigns and water treatment to reduce the exposure risk. However, as this is the only available source for some communities[2] and due to the lack of resources, the Government's efforts are limited to raising awareness amongst the population. Government recognizes ponds as sources of water supply and there is a need for improvement to protect people against water bone diseases.

Interviews and discussions with the community and evidence from the 4th picture above indicate that water is consumed directly from these reservoirs without any treatment. During discussions, some of the community members indicated that they treat water by using chlorine or sedimentation to reduce turbidity, however this could not be confirmed and is doubtful given the remoteness of the areas and lack of financial resources and non availability of chlorine in the local market.

- <u>Management mechanisms</u>

Majority of the communities where there are road ponds organize themselves to manage the reservoirs, as was observed in the small community of Mugabe in Combomune village and in Niza. During the group interviews, users of the sources said that the head of the community leads the management of the ponds; he organises for the facilities to be fenced and also assigns responsibilities for monitoring. However, some animals manage to pass through the fence and drink water directly from the ponds, which is a common occurrence, as animals are allowed to roam freely. Some mechanisms of protection identified include: a) fencing the surroundings of the reservoir with large trunks of trees, and having someone permanently situated there to guard sources; b) allocating a location for bathing and washing clothes; and c) cleaning of the pits before the beginning of the rainy season.

The mechanisms for use and management of the reservoirs seems to be reasonably well organised considering that the communities using these water sources have not received any form of training. However, it appears that men are often in charge of managing the facilities although women are the main users of the facilities. Free access for women, as is currently the case could potentially become an issue when the ponds are rehabilitated and improved to store more water for longer periods, and managed by a semi-official body such as the farmers association. The management of the irrigation schemes have not been studied in detail to determine the level of access for everyone including women and children. This will be discussed in detail in the second phase and use and management will be agreed with the community and District Administration.

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[2] Or they have to walk more than 13 km to the river to collect water , or pay 20 Mts/20 l jerrican

### 4.5 Conclusion and potential for improvements

In Gaza, two types of reservoirs associated with construction of roads were identified. Similar to the situation observed in Tete, the culverts and borrow pits were not developed specifically for the storage of water, but resulted from the excavation of soils for road works. In general, the borrow pits visited that store water have an oval elongated geometry, with the profile that combines to form U at the bottom of U and V at the top of slopes. The slopes are quite steep, which makes access to users difficult. Some measures for improvement include:

- Improving the geometry of the borrow pits so as to facilitate access and increase capacity.
- Compress the base and sides so as to reduce the permeability and reduce water losses by infiltration.
- Planting of trees around the chambers to reduce the incidence of wind, reducing evaporation, or using pieces of wood over the water surface.
- Construction of wells for water extraction to allow for filtration and improve water quality. Monitoring and control of water quality. Chlorination periodically.
- Develop mechanisms to protect sources in order to have controlled access, and avoid conflicts between different uses and users.
- Develop community-based management structures, involve government departments (Education, Health, Infrastructure, Environment, etc.) for the protection and management of water supplies.

The box culverts, road crossing structures and other access routes are ideal places for storing water from rain, depending on the flow capacity of the hydraulic infrastructure. In Gaza, two water reservoirs were visited between two culverts and one was the largest reservoir identified during the visit. However, some measures must be taken into account to improve the water supply, but also to ensure the stability of the road. Such measures include:

- Improve both the geometry of the reservoir so as to facilitate access and increase capacity.

- Improving the geometry of the culvert system so as to facilitate easier access and increase water storage capacity.
- Compress the base and sides so as to reduce the permeability and reduce water losses by infiltration.
- Plant trees around the chambers to reduce the incidence of wind thereby reducing evaporation,
- Construction of wells for water extraction to allow for filtration and improve water quality.
- Also, develop community-based management systems, as mentioned earlier.
- In Gaza, it is proposed that a detailed study and monitoring of the reservoir identified in Niza be conducted, as it has the necessary technical conditions to be improved. This reserve in addition to having the potential to benefit more people due to the large number of users observed during the visit, it can also be improved into a small dam and the culvert can be used as a spillway. However, these conditions must be verified because the data was collected through observations and users reports during the visit.

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# Appendix 1.

# Characteristics of the reservoirs visited

| **Reference** | **Description** | | | | |
|---|---|---|---|---|---|
| | Site 1 | Site 2 | Site 3 | Site 4 | Site 5 |
| ***District/Posto /Village*** | ***Mbanhele/Chibuto*** | ***Mbanhele/Chibuto*** | ***Niza/Mabalane*** | ***Mugabe / Combomune / Mabalane*** | ***Mugabe / Combomune / Mabalane*** |
| *Name of road* | EN 221 | EN221 | EN221 | | |
| *Administrative headquarters* | District of Chibuto, Mbanhele Administrative Post | District of Chibuto, Mbanhele Administrative Post | District of Mabalane, Niza Administrative Post | District of Mabalane, Combomune Admin | District of Mabalane, Combomune Admin |
| *Characteristic of the road and structure* | paved, concrete asphalt | paved, concretee asphalt | Unpaved | Unpaved | Unpaved |
| *Distance to the nearest post* | 10m to Mbanhele Bus Stop | 500m to Mbanhele Bus Stop | 47km from Macarretane along, Macarretane – Mabalane | 105km from Macarretane along, Macarretane Mapai | 105 km from Macarretane along, Macarretane Mapai |
| | | | | | |
| ***Details for the body of the reservoir*** | | | | | |
| *Type of water source (reservoir)* | Borrow pit | Borrow pit | A pond between two box-culverts | Borrow pit | A pond between two box-culverts |
| *Dimensions (m); Length x Width x Height:* | 70x20x1 | 45x20x1 | 50x20x5 | 40x40x2.5 | 60x30x2 |
| *Tilt* | ≈ 0% | ≈ 0% | ≈ 0% | ≈ 0% | ≈ 0% |
| *Levelling visual* | Well capped | Well capped | bad capped | bad capped | bad capped |
| *Water level* | 0 | ≈.5m | ≈ 1 m | ≈ 1 m | 20 cm |
| *Excavated* | yes | Yes | yes | Yes | Yes |
| Material of body | Earth, clay | Earth, clay | earth, clay | earth, clay | earth, clay |
| Width of base | not possible | not possible | not possible | not possible | not possible |
| *Elevation associated with the passage of hydraulic* | nil | | 20 cm | | |

| **Reference** | **Description** | | | | |
|---|---|---|---|---|---|
| | Site 1 | Site 2 | Site 3 | Site 4 | Site 5 |
| Features of the discharge (type and dimensions) | No discharge | No discharge | 4 x 2m circular conduits | No discharge | 60 cm diameter conduit |
| *Disturbance* | Without disturbance | Without disturbance | Uneven road with pot holes | Uneven road with pot holes | Uneven road with pot holes |
| *Any modifications made to increase storage capacity? (Describe)* | No | No | yes, excavation | No | No |
| *Type of drainage into the pond* | rain water and surface run-off from the road. | rain water and run-off from the road and through a box culvert. | rain water and run-off from the road and through a box culvert. | rain water and surface run-off from the road. | rain water and run-off from the road and through a box culvert. |
| Coating of Slope | None | large and medium sized vegetation | small-sized vegetation | large and medium sized vegetation | small and medium sized vegetation |
| Ravine | on the right slope | None | none | None | none |
| Localized disturbances (empty shifts, erosions, fissures, depressions, slip or subsidence) | Cracks on the bed | None | None | Cracks in dry soils and cracks in the ground. | Cracks in dry soils and cracks in the ground. |
| Holes dug by animals | None | Yes | yes | Yes | yes |
| Vegetation of excessive size | None | Yes | None | Yes | none |
| Entrainment of fines by the action of rainwater | yes | Yes | yes | Yes | yes |
| Upwelling and wetlands | No | Yes | None | No | No |
| Means of access by beneficiaries | By the slopes | By the slopes | The slopes, with steep sections | By the slopes | By the slopes |
| *No of months it retains water* | 5 to 6 | 9 months | 9 months | 10 months | 6 months |
| *Main purpose of the water source* | Livestock watering | Livestock watering | Human consumption | Human consumption | Livestock watering |

| **Reference** | **Description** | | | | |
|---|---|---|---|---|---|
| | Site 1 | Site 2 | Site 3 | Site 4 | Site 5 |
| *Approximate no. of users during visit* | 1 child | 6 | 14 | 8 (from 34 living in the village) | 3 |
| *Time of visit* | 11:00 AM | 11:15 AM | 2:00 PM | 3:30 PM | 7:00 AM |
| *Types of uses (observed and from users)* | pottery, livestock watering, building | livestock watering and irrigation | human consumption, livestock watering, bathing. | human consumption, livestock watering, fishing, bathing. | Washing, bathing and livestock watering. |
| *General state* | good | good | good | Good | good |
| *Management and conservation activities* | None | None | Fence with gate to prevent entry of animals, newly rehabilitated, -assigned location for bathing and washing clothes outside the pond, there is one person responsible for monitoring the reservoir. | Fence to prevent entry of animals, with gate, newly rehabilitated, -2 borrow pits, one next to another, one for human consumption and another for other purposes. A special place for bathing and washing clothes outside the pond, - Local chief, Mr. Machava who is responsible for the management, lives 200 meters from the ponds. He controls and advises people on proper use the sources. | None |
| *Perception of value to users* | Important for building and it provides entertainment for the children who swim in it. | Important for cattle and for irrigation, easier access to water when compared with the distances to the river. | Very important, the only accessible source of water. | Very important, the only accessible source of water close by. | Very important for the livestock and reduces the distance people had to walk to the river |
| *General state, Water quality* | Wet but drying pond without visible water, some big plants and cattle feeding nearby. | Murky water, vegetation around, some aquatic plants, footprints and faeces. | Murky water, protected with tree trunks and spikes, signs of footprints and animal faeces. | Murky water, protected with tree trunks and spikes, signs of footprints and animal faeces. | Murky water, vegetation around, some aquatic plants, footprints and faeces. |

| **Reference** | **Description** | | | | |
|---|---|---|---|---|---|
| | Site 1 | Site 2 | Site 3 | Site 4 | Site 5 |
| *Other water sources* | Hand dug well nearby. | Hand dug well nearby. | Water from the river, 20 km from the village or they buy 20 Mts/ 20l jerrican. | Water from the river -13km from the village or they buy 20Mts/ 20l jerrican. | Water from the river, 13 km from the village or they buy 20Mts/ 20l jerrican. |
| *Water treatment methods* | None | None | None | Sedimentation to reduce turbidity and chlorination. | Chlorination. |
| *Potential for improvement* | | High. Possible excavation and improvements on the geometry to allow access for animals and reduces permeability of the ground and slopes. Possibility to divert water for irrigation through excavation channels | High. Possibility to increase storage capacity, reduce permeability by compacting the ground and slopes. The geometry can be improved in order to allow access to people. Possibility to reduce evaporation by planting trees around the pond or tree branches on the water surface. Improve water quality by in situ filtration and chlorination. Management scheme involving the district government and the local authorities at the community level | High. Possibility to increase storage capacity, reduce permeability by compacting the ground and slopes. The geometry can be improved in order to allow access to people. Improve water quality by in situ filtration and chlorination. Management scheme involving the district government and the local authorities at the community level | High. The same as site 5. Possibility to use these reservoir for animals and the one on the site 5 for human use. |

# Appendix 2.
# Result of water quality analysis from Niza (site 3)

Date of sample collection: 14:07:09

Date of commencement of the analysis: 21:07:09

Place of collection: Niza, Gaza Province

| Sample | Physical Parameters | | | | chemical parameters | | | | | | | | hardness (mg CaCO3 / l) | | | Total Alkalinity (mg / l) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Cations (mg/l) | | | | anions (mg/l) | | | | Total Hardness | Temporary Hardness | Permanent Hardness | |
| | pH | EC(µ/cm) | TURB | TDS | $Ca^{2+}$ | $Mg^{2+}$ | Fe | $NH_4^+$ | $SO_2^-$ | $CO_3^-$ | $HCO_3^-$ | $NO_3^-$ | | | | |
| Water | 7.1 | 310 | 106 | 210 | 70 | 36 | 0.89 | 0 | 6 | 16 | 99 | 0.188 | 323 | 112 | 211 | 136.64 |
| **COMMENTS:** The turbidity is high, iron exceeds the permissible limit and is very hard water, and water quality is slightly impaired. | | | | | | | | | | | | | | | | |

# Appendix 3.
# List of people consulted in Gaza

| Name | Position |
| --- | --- |
| Adelino | Technical staff, ANE |
| Brás | ANE delegate in Gaza |
| Cristina | Community member, Mugabe |
| Marcelo Nhampule | Chief of District Education Department |
| Rodrigues Vasco | Acting Director of District Health and Social Action |
| Sebastiao Armado | Community member, Combomumne |
| Sulttane | Technical staff, ANE |
| 14 Women from community of Niza | It was not possible to register their name and occupation |
| 4 men and 4 women from Mugabe | It was not possible to register their name and occupation |

# Appendix 5.Activity plan

<table>
<tr><th>Milestone</th><th>Activity/Task to achieve the milestones</th><th>Output</th></tr>
<tr><td>Identify two provinces for the construction of demonstration structures</td><td>Identify 4 provinces initially based on the following technical criteria:<br>• rainfall; water resources; access to water supply; site access; planned, ongoing and recently completed road works; means of livelihood (water-dependent e.g. cattle; goats; small farming, etc.)<br>• Hold stakeholders consultations (National, Provincial, Administrative Posts and communities) to discuss the project and help in the selection of the 2 provinces to work in.<br>• In conjunction with ANE and DAR, agree on the 2 provinces to work in.<br>• Gauge the interest of the two provinces by requesting for the following:<br>– appointment of focal departments/persons to work with the research team;<br>– suggest sites (two districts) and provide the required information about the sites within 1 month;<br>• Provide information on planned, ongoing/recently completed roads; locations of existing road ponds that are used by the communities.</td><td>• Four Provinces short listed with clear justifications.<br>• Notes of stakeholder consultation; list of two selected provinces.<br>• Short report outlining information collected from the provinces with the sites for demonstration.</td></tr>
<tr><td>Identify 2 districts for demonstration sites.</td><td>• Organise initial set up meeting with ANE at the 2 selected provinces to shortlist Districts for demonstration. The suggested criteria to use include:<br>- poor access to water sources;<br>- Livestock keeping as a the major means of livelihood;<br>- Borrow-pits with water (road ponds) and road crossing structures in use by the community;<br>- Population/potential n umber of beneficiaries;</td><td>• Notes of meetings with ANE and other stakeholders.<br>• Visit reports of the two shortlisted Districts with photos of the proposed demonstration sites.</td></tr>
</table>

| | | |
|---|---|---|
| | - Areas where opportunities/advantages outweighs threat/risks/disadvantages.<br>• Hold meetings with other key stakeholders such as DNA & MISAU.<br>• Visit the two shortlisted Districts to meet with the District Administrator (to assess interest) and to inspect potential sites. | |
| **Identify 4 sites in each the selected districts to facilitate the conceptual design for the improvement of borrow-pits and road crossing structures.** | ***1. Pre-selection visits;***<br>• visit potential sites with ANE District representatives;<br>• Assess demand and willingness to participate in the project by members of the surrounding communities;<br>• Discuss mechanisms for participation with the community.<br><br>***2. Post selection activities:***<br>• Hold discussions with the communities surrounding the selected demonstration sites to assess their perception of the intended project;<br>• Conduct a baseline study:<br>- Assess the potential for establishing maintenance and management mechanisms (including conflict management).<br>- Discuss land tenure and access to the improved facilities by all members of the community;<br>- Discuss the uses of water;<br>- Quantify use from the sources including domestic, agricultural uses;<br>- Identify months with the highest demand for water from the road ponds and road crossing structures;<br>- Identify other sources of water supply. | *1. For pre-selection visits:*<br>• Draft design of road crossing structures<br>• Draft design for borrow-pits improvements.<br><br>*2. For post selection activities:*<br>• Baseline report outlining conditions prior to the improvement of road pond and/or road crossing structures.<br><br>3. Site survey report |

| | | |
|---|---|---|
| | ***3. Site survey***<br>• Collect rainfall/climatic data for the district;<br>• Observe all the potential structures for improvement noting all the major technical, physical and social characteristics;<br>• Conduct topographical and geotechnical survey of the sites. | |
| **Conceptual design** | • Prepare a conceptual design for improvements of road crossing structures indicating its location, alignment, and height of the water retaining structure, approximate volume of water to be retained.<br>• Prepare a conceptual design for the improvement of existing borrow-pit improvements and suggestions for future methods of excavating borrow to maximise its water retention capacity.<br>• Review designs with ANE, and finalise design | • Conceptual designs for the improvements of road crossing structures and road ponds.<br>• Final designs ready for construction. |
| **Technical support for construction** | • Organise community meetings to explain the improvements and discuss their expectations prior to construction begins<br>• Provide technical advice during the construction of the facilities as per the design.<br>• Conduct water quality analysis of samples from the various improved road ponds and crossing structures | o Progress reports and recommendations.<br>o Results of water quality analysis. |
| **Community preparation for operation and maintenance** | • Research appropriate low-cost options for treating water at source or in the homes for people that may use the source for drinking water.<br>• Facilitate the establishment of representative community road pond management committees at each of the sites.<br>• These groups will represent community views concerning the design and operation of the ponds.<br>- Efforts should be made to have representative involvement in these project groups and extra effort may be needed to involve traditionally excluded members of the community, such as women and female heads of households. | o Documentation of low-cost water treatment options for the communities.<br>o Documentation of the process and experiences of establishing management committees.<br>o Guideline for the training of the management committees.<br>o Training reports with photo evidence. |

| | | |
|---|---|---|
| | - Present and explain the draft design to the management group and ask for their input. Modify the design if necessary.<br>• Organise training sessions to enhance the capacity of the committees to manage and maintain the improved facilities.<br>• Organise community sensitization sessions after completion of the structures to discuss water use and maintenance. | |
| **Monitoring** | • Develop and implement community level monitoring mechanisms.<br>• Monitor the behaviour of the ponds over two full rainy seasons, including their durability, their operation and management and their impact on the local environment, the local economy, social and community development, and the health and safety of the community and road users. | Clear monitoring indicators covering:<br>o Structures<br>o Institutional arrangements for the management:<br>- committees<br>- financial contribution?<br>- Benefits of increased access from the facilities |
| **Documentation** | • Document every step of the process during the implementation phase to facilitate the preparation of a guidance manual for improving road ponds and crossing structures.<br>• Costs versus benefits estimates | • Brief documentation of the processes.<br>• Cost –benefit analysis of improving water conservation through road works. |