Capacity building in Mozambique for Water Resources Development

Dinis Juízo
Eduardo Mondlane University
CP 257
Maputo
Moçambique

1. Introduction

Water is recognised all over the world as a key strategic resource for development. In both cases of scarcity or abundance, water resources development and management requires a balanced approach. Water is a finite resource, and in Africa growing water scarcity and misuse of freshwater poses serious threats to sustainable development.

Mozambique is vulnerable to large climatic variability. This vulnerability is further exacerbated by lack of technology, limited investments and also lack of access to knowledge. For some areas of the country water is scarce while others enjoy abundance. There are also recurrent droughts and floods that disrupt continued development of the country. Lack of research is also considered one of the key limiting factors to earnest the resource. It also hampers identification of strategies to mitigate impacts of extreme events related to floods and droughts.

In Mozambique, major issues related to water are: the occurrence of floods and droughts; the requirement of water to supplement agricultural water needs; the need for reliable drinking water supply and sanitation; access to financial mechanisms; access to markets; access to technology; access to knowledge and information. The rather large number of constraints affecting the development of the country shields the importance of water as key development factor. Experiences from the developed world show that intensive water management is required to support a vibrant economy. The Government of Mozambique, has thus recognized, the need to promote research and knowledge development about this vital resource for its sustainable development. The objective is to identify and act on key aspects of water management required to support the future development of the country.

During the floods that hit the country in early 2013 the need to build more hydraulic infrastructure in form of dams and dykes was emphasise and is now being promoted higher-up in country's agenda. However, as indicated early building and managing large hydraulic infrastructure requires specialized and advanced knowledge in engineering, environmental economics and other associated fields.

The human resources training in the country is provided through the National System of Education (SNE), approved in 1983. The system encompasses five sub-systems (branches) and four levels of education in the development of the country's human resource base, namely:

A. **Sub-systems**: (i) General Education[1]; (ii) Adult Education; (iii) Technical and Vocational Education; (iv) Teacher Training; and (v) Higher Education.

B. **Levels**: (i) Primary/Elementary; (ii) Basic; (iii) Medium; and (iv) Tertiary.

It is within the above given framework that this paper discusses the existing situation in regard to human resources needs and knowledge gaps for infrastructure development and management of water resources of the country.

The paper draws from results of research work carried out by the author on Human Resource Capacity Gap Assessment for the Water, Sanitation and Hygiene (CapWASH) as part of the human resources needs assessment to meet the Millennium Development Goals. That research was generously funded by USAID, implemented through the Cap-WASH project by the International Water Association (IWA) (Juizo and Souto, 2012).

Thus the paper is not a comprehensive assessment of the capacity needs and gaps of the country on the specific area of storage development but an overview of the situation based on the long experience and involvement of the author with the education sector in Mozambique.

[1] Which comprises Primary Education with its two levels, the first five years (EP1) and the additional two years (EP2) and Secondary Education also with two levels, i.e., from 8th to 10th Class (ESG1) and from 11th to 12th Class (ESG2).

2. Background

Mozambique lies on the East Coast of southern Africa with an area of 799,380 km2 and 2,800 km coastline of the Indian Ocean. The total population of the country is 21 million with an average density of 26 inhabitants per square km (INE, 2009). Mozambique is part of the SADC region that comprises 14 states including the islands of Mauritius and Madagascar. The most prominent feature of this region is the number and the area extent of transboundary rivers: 15 rivers are shared between two or more countries and some 70% of the region's mainland area falls within a designated transboundary catchment area. Mozambique shares nine of these and is a downstream country in eight of them; except for the Rovuma River which forms the border with Tanzania.

Over the past 20 years Mozambique' water sector has managed to plan and implement a number of reforms to align itself with Integrated Water Resources Management concepts (Gallego-Ayala and Juizo, 2011). In this context, following the approval of the National Water Law in 1991, the National Directorate of Water started a process of decentralization, de-concentration and devolution of its core activities in crucial areas of responsibility. This process meant creating water resources management institutions at river basin level. Except for the case of the large Zambezi Regional Water Authority that only serves one catchment the rest of the four Regional Water Authorities (ARA's) cover three or more river basins (see Figure 1). There are other four ARA's: ARA-Zambezi (along the Zambezi river basin), ARA-Centro (central region of Mozambique), ARA-Centro-Norte (area linking the central and northern regions of the country) and ARA-Norte (northern region of Mozambique). These ARAs are responsible for water management in their designated area of operation and each has subdivisions in form of River Basin Management Units (RBMUs), designated for specific river basins within its particular region. In principle infrastructure development at river basin is the responsibility of ARAs the objective of the infrastructure development is to improve water resources management for economic development and poverty alleviation in the designated region, table 1 gives an overview of existing water storage facilities and their primary uses and operational conditions.

Water resources management for economic development is implemented jointly with other government sectors. For example the irrigation sector falls under the Ministry of Agriculture while hydropower is the responsibility of Ministry of Energy.

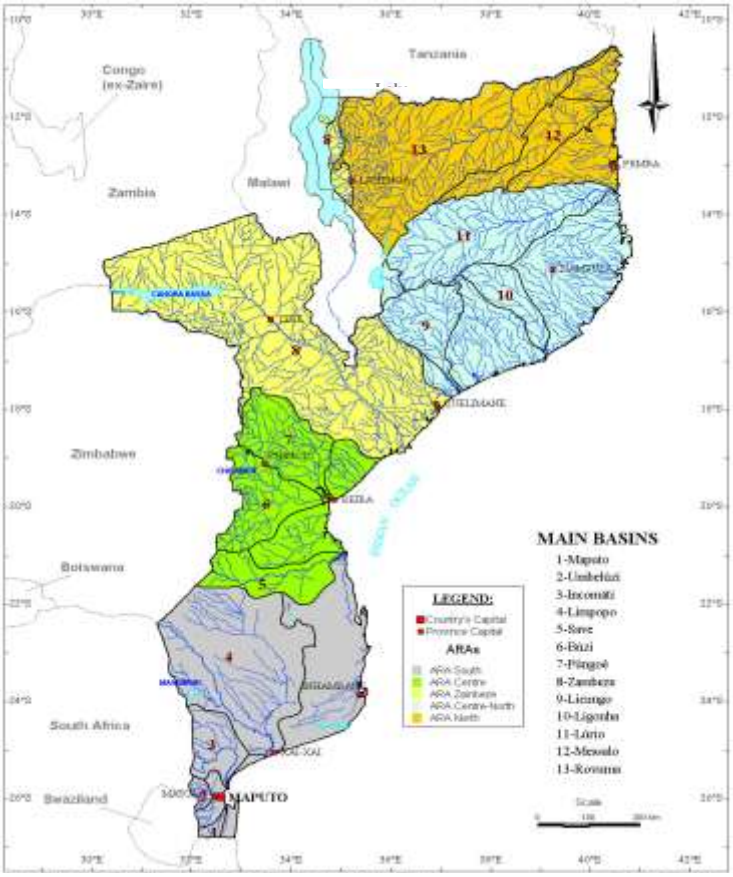

Figure 1 Mozambique Water Resources Administration Units. Source (DNA, 1998)

Table 1 Summary information on existing storage dams in Mozambique

NAME OF DAM	RIVER	NEARBY TOWN/ VILALGE	CURRENT CAPACITY (MM^3)	MAIN PURPOSE	CURRENT SITUATION
Pequenos Libombos	**Umbeluzi**	**Maputo**	**360**	**Urban Water Supply, Irrigation and hydropower (1,7 MW)**	Operational
Corrumana	**Sábie**	**Moamba**	**884**	**Irrigation and hydropower (14,5 MW)**	Operational, flood spillway gates not installed and fuse dyke
Macarretane (Divertion dam)	**Limpopo**	**Chokwé**	**4**	**Irrigation**	Operational, requires intervention in downstream energy dissipation structure
Massingir	**Elefantes**	**Chokwé**	**2.836**	**Irrigation and Hydropower (40 MW)**	Operational, bottom outlet damaged requires rehabilitation.
Mavuzi	**Revué**	**Chimoio**	**1,2**	**Hydropower**	Operational
Muda - Nhaurire	**Muda**	**Nhamatanda**	**60**	**Irrigation and urban water supply**	Operational
Chicamba	**Revué**	**Chimoio**	**1.820**	**Hydropower and Urban Water Supply**	Operational
Chimoio	**Mezingaze**	**Chimoio**	**0,3**	**Urban water supply**	Silted, not operational
Cahora Bassa	**Zambezi**	**Tete**	**39.200**	**Hydropower (2775 MW) and irrigation**	Operational
Nampula	**Monapo**	**Nampula**	**4**	**Urban water supply**	Operational but heavily silted.
Monapo (Banana)	**Messica**	**Namialo**	**33**	**Irrigation**	Operational
Nacala	**Muecula**	**Nacala**	**4,4**	**Urban water supply**	Operational under rehabilitation
Cuamba	**Lúrio**	**Cuamba**	**3**	**Hydropower and urban water supply**	Operational
Chipembe	**Montepuez**	**Montepuez**	**24**	**Irrigation**	Out of service with serious operational problems
Locume	**Lucheringo**	**Lichinga**	**1,9**	**Hydropower and Urban water supply**	Operational

Mozambique's total runoff is estimated at 214 000 Mm^3 of which nearly 60% is generated outside country in the international river basins (Vaz and Pereira, 2000). It is within this context that water storage and management becomes important for the sustainable development of the country's economy. Currently additional water storage is required in two important sectors (i) the hydropower production and (ii) irrigation, with industrial and urban water demand planned to increase in the near future as the country increases its investment for the development of mines and associated business.

In total there are 16 new dams planned in Mozambique with concrete uses identified. Feasibility studies are required for large part of these, some are already in an advanced planning stage such as the case of Nhacangara (200 Mm^3), Mphanda Nkuwa (840 Mm^3) and Moamba Major (600 Mm^3).

2.1. Water resources development in Mozambique

Mozambique has total hydropower production potential of 12 GW the majority of it in the Zambezi, Pungoé and Buzi river basins. At the moment the production capacity of the country is around 2.3 GW majority of it in the Cahora Bassa scheme in the Zambezi River (circa 1.8 GW), complemented by the Chicamba, Mavuzi and Corumana schemes. There are other medium sized potential sites mainly in the northern parts of the country. Mozambique also produces gas-fired power through its Temane plant with 5 MW and Ressano Garcia with 107 MW installed capacity.

According to Mozambique's National Strategy for the Development of New and Renewable Energy 2011-2015 (Ministry of Energy 2011), the country has one of the lowest energy coverage in the Southern Region with 80% of its energy consumption relying on biomass (charcoal and wood) and only 17% of the population with access to electricity. Of the 128 country' districts only 95 are connected to the national grid. Although the total installed generation capacity would be sufficient to meet the demand, large parts of the country remain unconnected given that only recently the grid started to be extended to remote rural areas. There are also contractual obligations to supply energy to the neighbouring countries most of these obligations were established at the time implementation of the Cahora Bassa Dam before the country independence in 1975, this situation reduces the amount of power available for distribution in Mozambique.

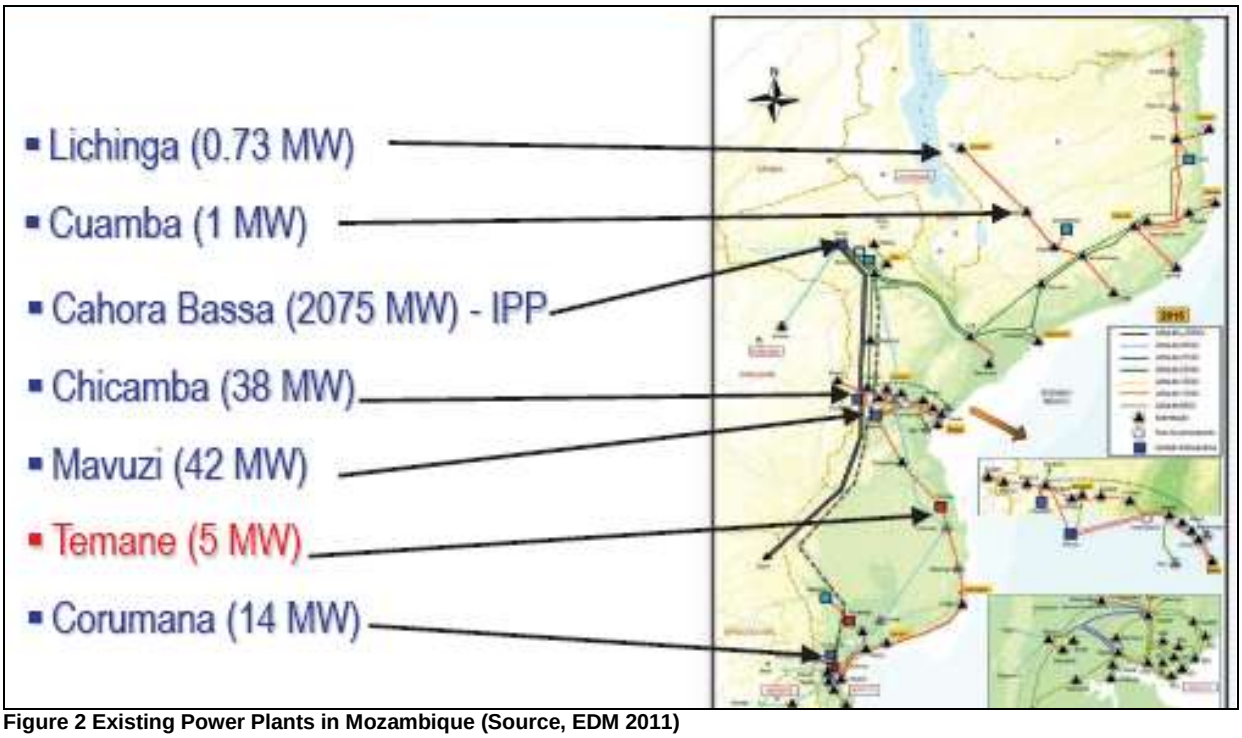

Figure 2 Existing Power Plants in Mozambique (Source, EDM 2011)

There is a number of planned new hydropower plants some of them already under negotiation for implementation in the near future.

Table 2 Summary of Planned Small to Medium Hydropower Projects in Mozambique. Source: EDM, 2010.

Name of Project	Capacity
Tsatse	50 MW
Muenezi	25 MW
Mavuzi	10 MW
Alto Ligonha	40 MW
Alto-Molócue	40 MW
Mugeba	175 MW
Lucite	180 MW
Buzi – Miracuene	300 MW
Pungoé – Pávua	150 MW
Pungoé – Blue Maria	80 MW

Mozambique's constitution considers agriculture a priority sector for its development and a strategic activity for its poverty alleviation strategy. However, looking into the realised agriculture potential of the country many questions can be asked as to why the intentions are not materialized on the ground. The table bellow illustrates the pattern observed in the agriculture sector of the country.

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Table 3 Country statistics in the agriculture sector. Source: CPI(2008) - High-Level Conference on: Water for Agriculture and Energy in Africa: the Challenges of Climate Change (2008)

Irrigation potential	2007	3072	1000 ha
Water Management			
Area equipped for irrigation: full control - total	2001	118.120	1000 ha
Equipped lowlands	2001	0.000	1000 ha
Total area equipped for irrigation	2001	118.120	1000 ha
• Area equipped for irrigation as % of cultivated area	2001	2.7	%
• Annual increase rate		1.3	%
• Power irrigated area as % of area equipped for irrigation			%
• Area actually irrigated as % of area equipped for irrigation	2001	33.9	%
Non-equipped cultivated lowlands and flood recession	2001	0.000	1000 ha
Total agricultural water managed area	2001	118.120	1000 ha
• Agricultural water managed area: as % of cultivated area	2001	2.8	%
• Drained cultivated area as % of total cultivated area			%
Typology of irrigation schemes			
Small-scale schemes (< 50 ha)	2001	6.39	1000 ha
Medium-scale schemes (50 – 500 ha)	2001	19.647	1000 ha
Large-scale schemes (> 500 ha)	2001	92.084	1000 ha
Irrigated crops			
Rice	2001	4.130	1000 ha
Maize	1998	5.000	1000 ha
Sugar cane	2001	23.858	1000 ha
Vegetables	2001	7.011	1000 ha
Citrus	2001	0.370	1000 ha
Tobacco	2001	0.445	1000 ha
Other perennial crops	1985	2.000	1000 ha

The most dominant irrigated crop is sugar cane mostly owing to the existing preferential markets agreement between the African Caribbean regions and the European. There are many other schemes planned in the near future for sugar cane production.

2. Capacity building needs

In order for the country to realize its potential there is a need for intensive capital investment in the development of infrastructure in form of storage facilities followed by the expansion of utility service infrastructure such as electric grid and irrigation schemes. Human resource capital is fundamental component if the country' is to sustain the infrastructure development.

This section of the paper presents the existing capacity of the education sector to deliver the qualified and needed professionals to support intensive development of water storage in Mozambique. The review concentrates on the following categories of competences:

(i) **Water engineer**: a person who is qualified or professionally engaged in the branch of engineering specifically related to the provision of water and sanitation facilities or infrastructure (i.e. civil/environmental engineers).

(ii) **Engineer (other)**: a person who is qualified or professionally engaged in another branch of engineering that is required in the planning, design or operation of water and sanitation facilities or infrastructure (e.g. hydro-geologists, geotechnical engineer, mechanical/electrical engineers).

(iii) **Management and Finance**: a person who is qualified or professionally engaged in management and finance (e.g. Managers (finance, HR, strategic) and office manager (administrative functions)) as well as a person who procures goods and services or a cost planner.

The analysis of information in the education sector for these categories of professionals will enable an assessment on what is required to produce the very specialized professionals that can work in the dam engineering field. In order words these professionals are the necessary raw material that the education system should produce to feed into the specialized course designed for the dam engineering.
Currently for Mozambique, most of the education and training is done inside the country with a relatively small proportion, mainly at the tertiary level and certain forms of selected non-formal/informal education and training, being done abroad.

The following sections will present the current situation regarding training of the potential professionals to support water development projects in Mozambique. It should be noted that given that dam construction and rehabilitation in Mozambique is very sporadic since independence, it is not possible to clearly predict the percentage of potential graduates in these key areas indicated above, that are likely to end up interested in pursuing carrier in the area of dam engineering. For that purpose a specific programme would have to be developed to support any comprehensive capacity development to support intensive water storage development with substantial involvement of Mozambicans.

2.2. Higher Education

In the past decade the Higher Education subsector has seen an unprecedented increase in student numbers, number of institutions, and diversity of programs offered. Between 2000 and 2011, tertiary education institutions have increased rapidly from around 12,000 students in 2000 to more than 101,000 in 2010. There is a combination of public and private institutions with the latter having increasingly more institutions and students. Figure 3 below shows the growth of number students in the last 11 years (MINED, 2011).

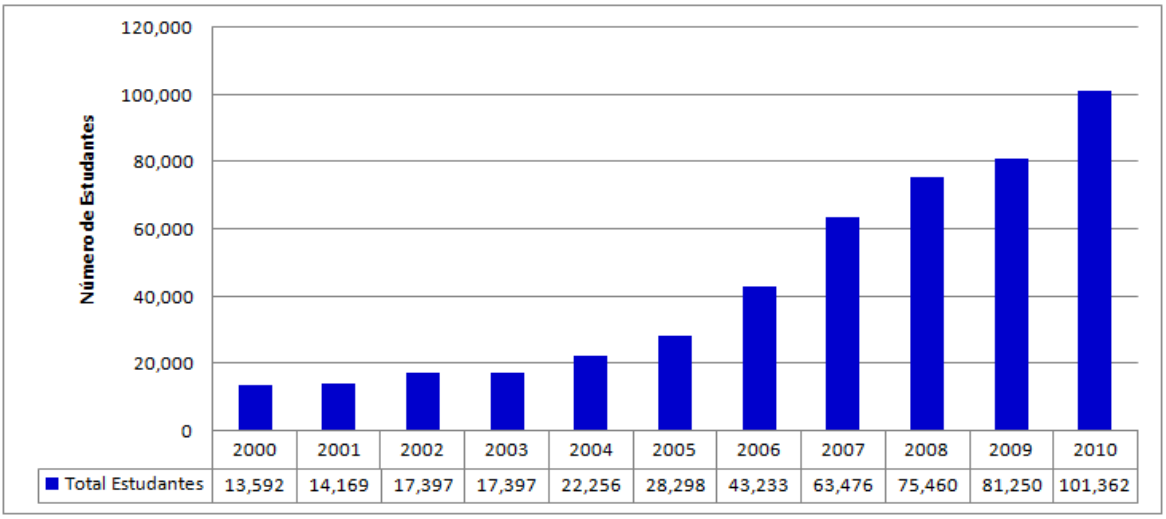

Figure 3 Growth of number of students in higher education in the last 11 years

It should be noted that the main areas of growth in the number of higher education students have been those requiring relatively smaller investment such as humanities and arts, management and law. Natural science and technology courses are still very limited in number. At the moment only four of the existing tertiary institutions offer civil engineering courses with an option for specialization in water and sanitation, namely Eduardo Mondlane University (UEM), Higher Institute for Transport and Communication (ISUC) and Higher Polytechnic and University Institute (ISPU). One other tertiary institution, namely Mozambique Technical University (UDM), has been offering environmental engineering courses with yet a new institution having started (2011) to offer the same courses (Instituto Superior de Tecnologias e Gestão/- Higher Institute of Technologies and Management). The little interest shown in starting up environmental and engineering course in most institutions has to do with the cost associated with their setting up, namely the laboratory and practical part that requires substantial investment. The Government is aware of the situation hence with help from the World Bank and the Swedish Government has started a competitive grant that can be acceded by both public and private institution to fund capital investment in courses of relevance to the development of the country. It is within this framework that some private institutions have now started planning to introduce technology courses in their curriculum e.g. Instituto Superior de Tecnologia e Gestão started in 2012 a course on Hydraulic Works and Sanitation.

A comprehensive assessment of data presented in Juizo and Souto (2012), indicates that engineering courses contribute with less than 5% of the total number of graduates in the higher education sub-sector. The number of those related with Water and Sanitation and eventually ending up working in this sector is even lower.

T he overall situation in the country is that post-graduate degrees at the level of Masters and Doctorate's degrees are usually obtained outside the country or in cooperation between local and foreign higher education institutions (HEIs). In more recent years local HEIs have been consolidating their ability to provide Masters Degree Programs. The faculty of engineering at UEM started in 2010 its first edition of Master Programme in Hydraulics and Water Resources Management first graduates are not yet our, a second edition started in 2012 and is on-going.

Collected quantitative and qualitative data in Juizo ad Souto (2012) indicate that, on average, for graduate studies (BA and Honors), existing tertiary institutions graduate close to 41 students per year (from 2007 to 2011) each per technical area, e.g. civil engineering/environment, mechanics/electricity. If that figure is multiplied by the five existing institutions delivering training in these areas, this translates roughly into 205 graduates or barely 0.20% of the total numbers of graduates from local tertiary institutions. Of these close to 75% go to feed the growing unemployment of graduates that characterizes Mozambican economy and society at present. Of the 25% that manage to get employment 5% go for education including lecturing, 10% join government institutions, 5% public companies and 5% private. Those being channelled to Water, Sanitation and Hygiene sub-sector are estimated to be around 2% of the total graduates from civil engineering/environment.

2.3. Other Levels of Education

There are around 97 technical and vocational institutions offering education and training in a wide variety of technical areas covering middle, basic and elementary levels. Data is usually available and mostly up to date. According to Juizo and Souto (2012), the technical and vocational subsystem had around 31,690 enrolled students in the period.

The analysis of data from that subsystem shows the predominance of traditional courses such as agriculture and livestock, commerce, construction, mechanics including auto-mechanics, etc. There are a few new areas gaining space such as IT, roads and bridges and hospitality and tourism.

In the analysis presented by Juizo and Souto (2012) it is seen that the basic and middle levels, if civil construction is not considered, there are only four institutions that offer typically WATSAN courses. Two at the basic level, namely Industrial and Commercial School in Beira (Sofala) and Professional School in Chingodzi (Tete) that offer plumbing courses and two at the middle level Geology Institute in Moatize (Tete) and the Maputo Industrial Institute that offer courses in geology and hydraulics, respectively. The number of those offering courses in civil construction is also significant, i.e. 8 institutions. It is a known fact that some of the graduates from civil construction enter the Water and Sanitation sector. Otherwise there is a certain proliferation of other technical courses (mechanics, electricity, etc.) and finance that in one way of the other fill positions in areas of interest in engineering and "Management and Finance" that are relevant in the infrastructure management arena.

The elementary technical and vocational training, which was very common before independence (i.e. up to 1975) was discontinued in 1983 when the national system of education was approved. This explains why graduates from this type of education are in a virtual process of extinction from the labour force as they get old and retire and are not replaced. As part of the technical and vocational education reform, coupled with the increased acknowledgment of the informal sector of the economy as well as the importance of making education and training more responsive

to the really needs of socioeconomic development, this type of education was recently re-established in some areas such as carpentry, welding, mechanics, panel beating, iron smiths, etc.

2.4. Other forms of education

Training and education can also be acquired in non-formal ways such as learning by doing, on the job training and shortcourses. In the case of the professionals in the hydraulics and infrastructure development and Management in Mozambique the majority acquired their specialization through this king of training. The majority of experts that are still active in this field in the country have been trained during construction of major dams in Mozambique notable after independence when the Pequenos Libombos and Corumana were constructed. The small number of dams built in Mozambique after independence impacts on the number of qualified personnel that the country has in the field of dam engineering.

The Engineering Society of Mozambique, the Mozambican Engineering Laboratory and the Faculty of Engineering of Eduardo Mondlane University have jointly sporadically offered a short course for interested professionals in dam engineering and safety. The course has been offered at least three times in the past 10 years with a duration of a week and covered a wide range of engineering and dam safety issues. This short course is the only specialized or dedicated course that the country has ever run dealing specifically with dam engineering design and management. It is rather unfortunate that the course is not offered in a continuous basis nor it is clear what periodicity is adopted by the organizers.

Unlike in other countries Mozambique does not have a system of professional accreditation that is usually followed in most of it neighbouring countries. In this regard the engineering qualifications are those attributed by the training institutions such as universities and other higher education institutes.

3. Conclusions and Recommendations

Generally it can be concluded that Mozambique still needs significant inputs in training and capacity building and in all engineering areas and other related of water storage development and development. The countries has considerable prospect in terms of dam construction to meet the economic development needs associated with its booming mining sector, industrial and urban development.

Historical reasons explain that in Mozambique' Water sector is served by a significant number of people who have not completed any tertiary education. Graduates from tertiary education are concentrated at the central level. Overall the main challenge in the recruitment and retention of personnel in the public sector is attributed to low wages and lack of incentives that characterizes it.

Most Mozambicans go abroad to acquire their specialized training in most engineering areas. This situation is slowly changing with the M.Sc level courses starting to be offered in various tertiary education institutions in the country.

Professional training is still a challenge in the country, currently most of the specialized work is performed by expatriates or international consultancy and constructions companies hired to work on specific projects. Without systems in place that oblige these companies to hire and conduct training local staff the benefits in terms of capacity building are very small.

Solution to the problems identified in the paper require a concerted approach where actions are taken in terms of increasing investment in infrastructure development tied up with a capacity building process that involves formal and informal training. The need for new infrastructure in forms of dams and other hydraulics structures is unequivocal however, there is a need to develop a strategy that permits the country to gain more than simply the structures that might quickly deteriorate if qualified people to managed them are not trained and recruited, given incentives and attractive conditions to stay in the sector.

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The Authors (10pt bold heading)

Dinis Juízo holds a Ph.D in Civil Engineering specialized in Hydrology and Water Resources Management, based at Mozambique's Eduardo Mondlane University since 1993, he progressed in his carrier from trainee lecturer to his current position as Associate Professor. Dr. Juízo is currently an Associate Professor of Hydrology and Water Resources Management at the department of civil engineering. Dr Juízo was head of the Civil Engineering Department between 2008-2010. Dr. Juízo has been involved in lecturing, research and tutoring of young graduates in the fields of hydraulics and water resources management. Dr. Juízo has extensive experience in education; research and consultancy work in the field of water resources related subjects. Although, based at Eduardo Mondlane University throughout his carrier he has worked with several national and international organizations in missions or short period assignments.