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MINISTRY OF WATER AND IRRIGATION

WHY DEVELOPING COUNTRIES NEED DRAMATIC INCREASE OF WATER RESOURCES PRODUCTIVITY

BY PROF. MARK J. MWANDOSYA, MINISTER FOR WATER AND IRRIGATION, UNITED REPUBLIC OF TANZANIA

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1.0 INTRODUCTION

1.1 General

Water is the essence of life and a catalyst to socio-economic development in all countries. Despite being a critical resource, around the world water resources are under threat mostly from pollution, overuse and catchment degradation. Developing countries have to direct their attention to water resources and allocate adequate financial and human resources required for its development and management. Other resources that also need attention are land and energy. There is a link between development and utilization of these other natural resources to water. Water is basic to all the other resources. This paper focuses on answering the question: *"Why developing countries need dramatic increase of water resources productivity"*. In doing so, the interactions amongst these resources are presented for developing countries with examples from Tanzania.

1.2 Socio-economic profiles of developing countries

Developing countries occupy about two thirds of the total global area, with a population of more than 5 out of 6 billion people. Many of the developing countries have poor economies, mostly dependent on agriculture. Trends in developing countries' *Gross National Product (GNP)* over the past 50 years indicate that progress in reducing poverty has remained the same or deteriorating. Income disparities between rich and poor both between countries and within them have widened over the same period. There are today estimated to be 1.2 billion people living on less than 1$ a day, and 2.8 billion living on less than 2$ a day, according to UNDP estimates of 2001.

2.0 WATER RESOURCES AVAILABILITY

Water resources availability in developing countries is varied in areal distribution and season. Large and frequent variations in rainfall present difficulties in planning for the development and use of the available water resources. Other factors, the major one of which is climate change and variability, have added a new dimension to the resources availability in various parts of the world. Agriculture is the most affected sector with such unreliable rainfall pattern.

Estimated annual renewable global water resources available are about 55,400 $km^{3.}$ Developing countries in Africa, Asia, Oceania and Central and South America contribute about 39,361 km^3. The breakdown by region is as shown in *table 1* below [1]. Tanzania's share is about 91 km^3. Due to high population growth in the developing countries, the average amount of water resources available per person per year by using 2005 estimates is as shown in *table 1.* For Tanzania the amount was about 2,400 cubic meters per person per year.

Table 1: Estimated Global Annual Renewable Water Resources [1]

Region	**Estimated Global Annual Renewable amount (km^3)**	**Estimated Annual Average Renewable per capita amount (m^3)**
Africa	5,724	6,300
Asia	14,371	3,865
Oceania	874	121,100
Central and South America	18,392	33,100

These figures keep on decreasing as populations grow and more water sources are polluted. This is because polluted water cannot be used, thus decreasing the

amount of water that otherwise would have been available for use for different purposes.

Other natural resources that are important for socio-economic development are land and energy. Most communities in developing countries depend on land for their livelihoods. Peasantry agriculture is their mainstay but their modes of production in many places are still very primitive. They require very large tracks of land for agriculture, which produce very minimal crops. With high population growths and dismal crop production, competition for land is fierce resulting into conflicts amongst farmers. Other conflicts are between farmers and pastoralists who also need large pieces of land for their livestock. The kind of livestock keeping in developing countries is not conducive to good and sustainable land management. Severe land erosion is prevalent due to overstocking resulting in land wastage and siltation of water reservoirs used to water their livestock. Even the quality of livestock raised is of low quality bringing dismal revenues to the communities.

For sustainable utilization and management of land resources there is need for good land use plans and modern agricultural practices. There is also need for rational distribution of land amongst competing uses especially with emerging large scale commercial farming, ranching and mining. The peasants should not be left out otherwise conflicts would arise. All development is land based. There is need therefore, for an integrated planning of land use with other sectors in order to optimally and sustainably use the available land for socio-economic development of our countries.

Energy is another essential requirement to our livelihood both, in urban and rural areas as well as in industrial production.

The main challenge has been the development of cheap and environmentally friendly energy sources to meet rising energy demands. The easiest energy source in the rural areas especially for domestic use is firewood, but this is creating serious environment problems. Catchments degradation accompanied with soil erosion, siltation and land wastage are on the increase affecting and even destroying the available water resources. However, many of the developing countries are endowed with different types of energy resources such as hydropower, solar, wind, tidal, uranium and the traditional oil and gas resources. In order for these energy resources to contribute meaningfully to the socio economic development of our countries, huge infrastructure investments requiring substantial financial resources are essential. This is lacking in most of these countries, necessitating seeking of external support in terms of finance and technology.

With the multiplicity of emerging new productive sectors of mining and processing industries in developing countries, there is need for comprehensive assessment of available energy resources and choice of best options for their sustainable development and utilization. This potential, if properly developed, can lead to industrialization of our countries. Needless to say, the potential has not yet been fully exploited. If hydropower is the choice then it will compete for water with other productive sectors. A rationale for allocating water for hydropower generation is easy since the water use is non consumptive. However, water use upstream of and by power plants should be properly regulated.

3.0 WATER UTILIZATION

3.1 Available resources to meet rising demand

The use of water varies greatly from country to country, region to region and different economic sectors. Total annual water use for developing countries by region is estimated as follows: Africa 213 km^3, Asia 2,189 km^3, Central and South America 265 km^3 and Oceania 0.17 km^3, giving a total of 2,668 km^3. This is out of a global total withdrawal of about 3,325 km^3 [2]. This water is used for various purposes such as domestic, industrial and agriculture uses. Average water use by sectors in developing countries by region is as shown in *table 2* below.

Table 2: Average water use by Sectors [2]

Region	**Domestic Use (%)**	**Industrial Use (%)**	**Agricultural Use (%)**
Africa	24	8	68
Asia	14	8	78
Central and south America	22	13	65
Oceania	37	26	37
United States of America and Canada	17	58	25
Europe	26	50	24

In all the regions of developing countries, the proportion of use of water for agriculture is highest. On average, highest ratio of water use in the developed countries is industrial, unlike in developing countries. The economies of developing countries are agricultural based requiring large amounts of water.

Water is also required for food production. With high population growths in these countries, more water would be required to ensure food security.

Many of developing countries are now diversifying their economies to processing industries in order to raise the value of their products. This is bound to raise the demand of water for industrial use. Mining is another sector whose water demand is increasing, like in Tanzania. The mining and industrial sectors are bound to raise the demand for energy. For countries that depend heavily on hydropower generation as their energy sources, rising water demands will put pressure on this energy source. Rising demand in all the productive sectors is bound to result in competition for water.

Many developing countries are not food secure. In an attempt to overcome this deficiency, much emphasis is being directed at irrigation to supplement rain-fed agriculture. By 2003 total irrigated land in developing countries was 207,965,000 hectares against a total world area of 277,098,000 hectares [3]. This area is about 17% of the world land area but provides 40% of the global food. With the current global food crisis, demand for water for irrigation is bound to rise. Tanzania for instance is planning to increase her irrigation land from the current 290,000 hectares to 1 million hectares in the short to medium term plan.

The country needs 405,000 hectares under irrigation for attaining self sufficiency in paddy. Studies undertaken for the National Irrigation Master Plan in 2002 have shown that, the total irrigation potential of the country is about 29.4 million hectares with different suitability levels. These include 2.3 million hectares of high potential, 4.8 million hectares of medium potential and 22.3 million hectares of low potential [4]. These potential levels were derived in consideration of land

potential, water potential and socio-economic scenarios. These factors were overlapped to come up with the irrigation potential.

Irrigation is preferred to rain-fed agriculture because with good irrigation efficiency, crop production can be 2 to 3 times more than rain-fed agriculture. In few selected projects in Mbeya and Ruvuma regions of the Southern part of Tanzania undertaken jointly by the World Bank and International Fund for Agricultural Development {IFAD), irrigation efficiency has been improved by an average of 30 to 40 % from 15% thus, substantially raising crop yields such as paddy from an average of 2 tons to 6 tons per hectare.

This and the fact that food prices are rising, is an incentive for many farmers to resort to irrigated agriculture, with a consequent increase in the demand for water resources. For development of 405,000 hectares to attain self sufficiency in paddy production, it is estimated that about 32 km^3 per annum of water will be required which is 35% of the total available renewable water resources in Tanzania [4].

Besides food production, developing countries have to deal with the problem of urbanization due to high population growth, economic development and changing regional values, intensifying competition over the available water resources. There is a constant migration of people especially the youth from rural areas to urban centers. This is brought about by perceived opportunities for employment available in urban centers. Coupled with the natural population growth rates which are high in developing countries, the resulting effect is a rise in water demand for domestic use and sanitation. Even small towns are now transforming into large towns, large towns into cities and cities into mega cities. A high concentration of people in

towns and cities requires reliable water supply and sewerage or sanitation services to avoid possibility of outbreaks of diseases.

3.2 Domestic use

Current status of water supply services in urban centres is beset with many problems, one of which is unaccounted for water (UfW) also known as non revenue water (NRW). Unaccounted for Water is water that has been produced and is "lost" before it reaches the customer. Losses can be real losses through leaks, sometimes also referred to as physical losses, or apparent losses to include leakage through theft, but also un-metered provision of public water such as fire hydrants, etc. High levels of NRW are detrimental to the financial viability of water utilities, as well to the quality of water itself, with fewer people having access to water.

UfW is always presented in percentage while NRW in monetary value for the volume lost. According to International Standards, UfW should be less than 20%. Some cities in Africa report losses of up to 50%. In Tanzania average unaccounted for water for the urban centres was approximately 50% in year 2000 and 46, 42, and 41 percents in year 2002, 2004 and 2006 respectively [5]. Currently, the average loss is 36% with some cities recording 26% (Tanga), 28% (Arusha and Dodoma), 29% (Mwanza) and 40% (Dar es Salaam).

The average water loss in some of the other Cities in Africa is; Nairobi (Kenya) 38%, Lusaka (Zambia) 51%, Kampala (Uganda) 36% and Johannesburg (South Africa) 32%.[6] However, these are the minimum losses that can occur and the status so far is due to the efforts by concerned Authorities in ensuring that water demand management is practiced.

Water availability for domestic use in the urban centers continues to be a crucial challenge when compared to quantity of water produced, highlighting the importance of efficient resource productivity in the water sector.

The total water production in urban centers in Tanzania for the fiscal year 2005/2006 was 99.9 millions cubic meters against the demand of 137.1 millions cubic meters. Whereas during the year 2006/2007 water production increased to 100.3 million cubic meters and demand increased to 137.9 million cubic meters. The average ratio of water production to demand in urban area for the two consecutive years remained constant at 73% [5].

Considering annual population growth rate of 3% in urban centers and the drastic intrusion of people to the cities due to urbanization, it is envisaged that by year 2015 the demand will rise to approximately 160 million cubic meters [5].

One of the greatest challenges faced by humankind is to improve the wellbeing of 2.6 billion people, which account for half the population of the developing world lacking access to basic sanitation. According to the United Nations report, an estimated 1.6 billion people must acquire access to improved sanitation over the period 2005 to 2015 to meet the MDG target on sanitation: *to halve by 2015, the proportion of the population without sustainable access to safe drinking water and basic sanitation [11].*

In Tanzania the coverage of sewerage services in urban areas is about 17% while improved sanitation in rural areas is about 55%. In order to improve sanitation services in the country, more water will be required hence, putting more pressure on the available water resources. Conversely, lack of improved sanitation could be a serious source of pollution to the water resources.

3.3 Industrial use

On average industrial use of water in developing countries is still low compared to developed countries. This is an indication of the level of development. Many of the industries in developing countries using substantial amounts of water are in food processing and textiles sub sectors. There are attempts in many countries to process products for export so as to add value to these products. With agricultural based economies, these countries have great potential of increasing the value of their exports through local processing. In so doing, there will be need for more water to meet rising industrial uses. Industrial expansion will also require more energy.

Mining is another rapidly expanding industry in developing countries. Many countries are opening up new mines especially, in metals such as coal and gemstones. A substantial amount of water is required for this purpose. Also, as more mines are opened up due to the rising prices of minerals, especially gold and nickel, water demand for this activity is bound to rise hence, putting more pressure on the available water resources. Mining will also increase demand for more energy. Energy requirement to meet demand for industrial and mining production will intensify competition for water for the various uses thus, requiring a judicial water allocation system. In Tanzania, where most mines are in the semi-arid regions of the country, groundwater is the main source of water for their production, using about 2% of the resource [7].

In respect of ground water, water resource productivity can be impaired by, among others, the following factors:-

- Over abstraction, that can lead to substance of land due to the creation of a vacuum in the sub-surface.

- Pollution of underground water reservoir, especially in shallow wells in populated urban areas.

- Intrusion of salt water in coastal based aquifers due to sea water rise, a climate change phenomenon. A case in point is the intrusion of salt water in fresh water aquifers in Dar-es-Salaam and Bagamoyo in Tanzania.

3.4 Agricultural use

Agriculture is the main user of water claiming more than two thirds of the water withdrawn from the Earth's rivers, lakes and groundwater aquifers. As populations and economies grow, water becomes an increasingly scarce and valuable resource. The use of water in many areas is still highly inefficient. In some places, as much as 85% of the water diverted or pumped for irrigation does not reach the crop. Wasteful irrigation practices not only entail the loss of precious water but also cause water logging and salinization. More than 10% of the world's irrigated land suffers from varying degrees of salinization [8].

Irrigation demands can be a major source of environmental degradation and the survival of water bodies. The case in point is Lake Chad. The lake was about 25,000 sq. km. in 1963. In 2007 the lake had shrunk to 1,850 sq. km., about $1/20^{th}$ of its size in 1960s, mainly due to irrigation demands and partly due to climate change [9]. The lake is shared by Chad, Cameroon, Niger and Nigeria.

The Aral Sea, shared by Uzbekistan and Kazakhstan is another example of man-made environmental disaster. In 1960 it covered an area of 68,000 sq. km. By 1998 the lake had shrunk to 28,687 sq. km. In 2004 it had been reduced to a mere 17,160 sq. km. The main cause of the disappearance of much of the sea is the diversion of

the rivers flowing into the sea for irrigation purposes. These rivers are the Amu Darya and Syr Darya [10].

The existing irrigation infrastructure in Tanzania is still poor and inappropriate causing the overall water use efficiency to be very low at an average of 15-20% as the losses in the systems are enormous amounting to 80 to 85% [4]. This is because irrigated agriculture in Tanzania is mostly undertaken by smallholder farmers who do not produce crops substantially due to improper infrastructure. There are however, a few large-scale farmers who undertake commercial agriculture using high efficiency pressurized irrigation systems such as drip, centre pivot and rainguns. The government is gradually intervening in rehabilitating infrastructure to improve water use efficiency and also to promote water saving technologies.

Despite the existing enormous irrigation development potential in Tanzania, it is only 290,000 hectares of the area which is under irrigation and about 79% of which comprises of small holder farmers [4]. Irrigation offers a wide range of crop production avenues starting with increased yields per hectare to an overall crop intensification.

It is widely acknowledged that crop production under irrigation is 2 to 3 times more than that of rain-fed farming. Irrigation is important as it provides food security, improves rural community livelihood and minimizes rural to urban migration especially, for the youth in developing countries.

The dominant system or method widely used in Tanzania like in most other developing countries is surface irrigation. It involves abstracting water from the

source and moving it over the soil to wet it completely or partially. The water flows over or ponds on the soil and gradually infiltrates to the desired depth.

Surface irrigation is the predominant irrigation method throughout the world and is characterized as being very inefficient. The inefficiency may result from poor infrastructural design and or construction, lack of maintenance and limitation of operation related to water availability, and organizational aspects of communal irrigation schemes. However, with good design and maintenance of high levels of uniformity and minimum deep percolation, some effective management for crop maximization can be attained.

The technologies in place for smallholder farmers include drip and sprinkler systems, pumps driven by solar and wind energies, and treadle pumps. In addition to that shallow wells are being used along rain water harvesting systems. These avenues are meant to ensure that water is used efficiently.

In Tanzania, absence of storage structures has greatly affected agriculture, since the country is faced with periodic drought and floods. In this regard farmers have been experiencing heavy losses in their crop production. This is why the government is putting more emphasis on irrigation as a countermeasure against vagaries of weather. The challenges facing Tanzania and other developing countries, especially those with majority of their population being smallholder farmers is lack of on-farm water management knowledge and sound agricultural practices, necessitating greater need for capacity building in improved water management.

There are several challenges in irrigation development which slow the overall attainment of food security and poverty reduction targets. The challenges include;

poor and inappropriate irrigation infrastructure, low use of water saving and appropriate technologies, minimal use of groundwater, absence of water storage structures, low investment in irrigation, climatic change and variability and weak institutions responsible for irrigation water management such as irrigation water organizations.

4.0 SUSTAINABLE UTILIZATION AND MANAGEMENT OF WATER RESOURCES

In order to address the emerging challenges of competition for water to meet the rising demands for various needs, developing countries need to institute and implement a comprehensive set of measures some of which are enumerated below:

4.1 Water demand management

4.1.1 Domestic Water Supply

Water supply services in urban centers in Tanzania and in developing countries are beset with many problems, one of which is unaccounted for water. As mentioned earlier, some cities report losses of up to 50%. Measures for mitigation include:

- Combating of bypass, illegal connections and water theft,
- Extending metering to 100% coverage (universal metering). This is best suited in urban centers where there are centralized water systems. Utilities can monitor how much of the water produced has been actually supplied and billed. Revenues due to the utilities can easily be traced.
- Controlling water supplies and distribution through such measures as water rationing.

In Tanzania, the current metering ratio in urban areas ranges from 26% (Lindi) to 48% (Dar-es-Salaam) and 100% (Arusha, Dodoma, Moshi and Tanga) as shown in [5]. These measures together with sensitization of the community on proper water utilization and effective use of this scarce resource complements to the reduction of the UfW and NRW in urban areas.

There is need for substantial investment in water supply and sewerage infrastructure to curb such losses. New infrastructure is required in many places to replace old ones. Public and private partnership in this area should be pursued where possible. Besides investing in new infrastructure, there is also need for setting a robust operation and maintenance system and raising adequate financial resources to meet requirements. Realistic tariffs to raise the requisite finances should be set. Water savings from these measures would be allocated to other productive sectors.

Another water saving technique that can be used is the installation of appliances and fixtures in households that are water efficient such as sinks, toilets, baths and showers. For example old toilets use 16 – 30 litres of water per flush while newer models use less than 6 litres which is at least 60% less water per flush. Legislation, regulation and the setting of standards could assist in this endeavoir.

Another approach that should be considered in water resource efficiency is recycling. Waste water especially if mixed with storm drainage can be recycled and eventually used in other productive sectors such manufacturing and irrigation which do not require water of high quality. Some countries such as South Africa and Zimbabwe have gone further by recycling waste water to drinking quality. More countries could explore this possibility.

However in many developing countries like Tanzania recycling of waste water is not possible at the moment due to the following reasons:

- The existing infrastructure was not designed to cater for recycling
- The cost of recycling is much higher than direct fresh water treatment

In order to utilize this opportunity, future designs of sewerage systems should incorporate provision for recycling. The requirement of adequate land in urbanized areas to construct stabilization ponds is a constraint. Shortage of land in urban areas could spur on development of water recycling systems in African cities.

4.1.2 Industrial water use

In the rapid growing economies of most developing countries where expansion of processing and mining industries is on-going, there is a danger of sacrificing efficient utilization of water resources and pollution control for economic gains. The inefficient use of water may result from over-use whereas pollution is caused by improper disposal of industrial and mining wastes. In order to curb the cited problems, there is a need to promote and use water efficiently and adopting cleaner and safe technologies.

4.1.3 Agricultural water use

As indicated earlier, in developing countries the sector which consume the largest proportion of water is agriculture. Despite this fact, many of these countries are prone to food shortages in times of droughts and floods.

One reason for this is the lack of adequate multi-purpose water reservoirs of various scales to store water during rain season to be used in dry season. Both public and private investments should be encouraged to address this situation.

Tanzania's irrigated agriculture being dominated by smallholders, has low irrigation water use efficiencies. Initiatives to improve the irrigation system infrastructure by modernizing the diversion headworks, conveyance systems and distribution systems along with proper water management have boosted water use efficiency to between 30 and 45%. Additionally, efforts are being directed to utilization of modern technologies especially pressurized systems which can attain higher efficiency of up to 90%. Modernization will play a major role in boosting irrigation efficiency.

This will shift attention from *more crop per drop* to *more crop less drop* implying that more output will be produced from lesser amount of water. Water saved from these initiatives can be allocated to other productive sectors of the economy including meeting the needs of the ecosystem.

Interventions done in Tanzania by rehabilitating and modernizing irrigation schemes have raised productivity of various crops substantially. Crops which have shown high production levels include; paddy increased from 2 t/ha to 4.5 t/ha (maximum 10t/ha), maize from 1.5 t/ha to 5 t/ha, onion from 5 t/ha to 26 t/ha and tomato increased from 8 t/ha to 25t/ha [4]. Other cash crops being irrigated include sugar cane, tea, coffee and cut flowers. Marketing and sale of these crops in the local market and for export contributes to growth of the national economy and poverty reduction.

Another avenue for reducing stress on available surface water resource is exploitation of groundwater which is increasingly being used in horticulture and floriculture. Rain water harvesting in marginal areas could also provide additional water to irrigated agriculture as widely practiced in south India.

4.2 Integrated Water Resources Management

Integrated Water Resource Management is a systematic process for the sustainable development, allocation and monitoring of water resource use in the context of social, economic and environmental objectives.

Many different uses of finite water resources are interdependent such as high irrigation demand and polluted drainage flows from agriculture results into loss of fresh water for drinking and industrial use. Contaminated Municipal and industrial waste water pollutes rivers and threatens ecosystems. These are examples of interdependence of and conflicting uses and demand for water, requiring an integrated approach to water management.

Integrated water resources management is an approach that has been accepted and adopted in many countries. In order for this approach to be effective, there is need for strengthening of human resources and monitoring capacity of the institutions involved in water resources management. Both adequate numbers of qualified personnel and requisite monitoring equipment are necessary. In order to mitigate against climate change and variability, there is now need for both public and private investment in the construction of strategic multi-purpose water infrastructure.

Integrated planning that takes due consideration of water requirements of all sectors is essential in directing the investments. Actual implementation of integrated water resources management is still a challenge to many developing countries.

In many developing countries, the scarcity of drinking water and its low quality has led to the evolution of bottled drinking water industry. Its impact on and its contribution to domestic water use in Tanzania has yet to be established. Clearly, it has led to the increase of empty plastic bottles littering the environment. Therefore, there is a need to address this issue so that water supply has a positive impact to the environment. A positive aspect of this water use has been the evolution of small and medium enterprises and individual initiatives in the collection, transportation, sale and recycling of plastic bottles.

4.3 Institutional strengthening

The establishment and strengthening of institutions responsible for irrigation and water resources management from national, basin, catchment to the end user is essential for sustainable implementation of integrated water resource management. This entails education, training and provision of equipment and working tools. The lowest level is the most crucial since it is here that custodians of water resources interact with the resources in their daily routine of livelihoods.

5.0 CONCLUSIONS AND RECOMMENDATIONS

- All countries, developing and developed should acknowledge the fact that water is an essence of life and a unique catalyst to their socio-economic development. It is a critical but scarce resource.

- Water resource around the world is under threat, mostly from pollution, catchment degradation and overuse. Environmental conservation is an essential aspect of water resource productivity.

- In developing countries, Tanzania included, more concentration has been given to resource development and water supply addition than to water demand management at the end-use. Equal attention should be given to efficient water resource productivity as well to water resource development, transmission, distribution and use. It is instructive to note that for Dar-es-Salaam, reduction of Unaccounted for Water from 40% to 20% could lead to additional 300,000 residents getting access to clean water.

- There is stiff competition in the use of water resource for socio-economic development between sectors such as domestic consumption, agriculture (irrigated and non-irrigated farming), production of energy (though hydropower generation), industrial production, and environment sustainability. Integrated Water Resource Management is therefore, essential.

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