KeSEBAE NEWS

Newsletter of the Kenya Society of Environmental, Biological and Agricultural Engineers

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Agricultural Water Storage in Kenya

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Kenya's per capita water is less than 600 cubic metres, which is below the global threshold of 1,000, making it one of the chronically water-scarce nations. Kenya's water problem is, thought-provoking: if millions are not threatened by severe drought, they are fighting to remain afloat amid raging floods. Water scarcity is one of the major challenges to sustainable food production the world over, and climate change experts warn that it will only get worse as the world's population continues rising. But local farmers can alleviate this situation by investing in water harvesting technologies and irrigation.

The existing climate variability, and insufficient capacity to manage that variability, lies behind much of the prevailing food insecurity and poverty. Many of the nearly one billion people who are food insecure, are so, at least in part, because of their dependence on **rainfed agriculture.** For many, their vulnerability is expected to increase with climate change.

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A fortnightly Newsletter touching on topical issues affecting our environment.

***KeSEBAE NEWS** is a Newsletter of the Kenya Society of Environmental, Biological and Agricultural Engineers (KeSEBAE).*

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Similarly, national economies, highly dependent on **rainfed agricultural production**, are exceedingly vulnerable to both intra-annual and inter-annual fluctuations in rainfall and hydrology.

Millions of farmers depend on rain fed agriculture. In sub-Saharan Africa 95% of cropland is rain fed. But in many places, this form of agriculture is challenged by climate change. By providing water when it is needed **small scale water storage** may help many farmers adapt to this challenge. Reservoirs, aquifers, soil and wetlands all store water. But not every option works in every context. In fact, the impact of different storage types on poverty and food security can vary drastically. To determine what this best option is, a number of variables need to be considered. These include the cost of the water storage, environmental and health risks, politics and social-economic factors

The Need for Water Storage

Decisions relating to water resources and water storage must be based on clearly identified needs. Assessing the demand for water, in relation to both local and national development goals, is a prerequisite for evaluating different storage options. At any location the need for agricultural water storage is a function of a wide range of factors.

However, in broad terms, the need for water storage can be anticipated to be the greatest in situations where:

i. Water is needed for agriculture (crop or fodder);
ii. Rural population density is high and thus likely to be vulnerable to climate impacts;
iii. The amount of rainfall per person on agricultural land is low (i.e., high population density and/or low rainfall); and
iv. There is high unpredictability in annual rainfall totals and rainfall is highly seasonal

Water Storage Options

For agriculture, dams are just one of a range of possible water storage options. Other options include: natural wetlands, enhanced soil moisture, groundwater aquifers and ponds/small tanks. In fact, agricultural water storage can be considered as an extensive continuum of surface and subsurface options (Figure 1 below).

Different agricultural water storage options include:

1. Reservoirs
2. Ponds and tanks
3. Aquifers
4. Soil moisture
5. Natural wetlands - Lakes, swamps and other wetland types

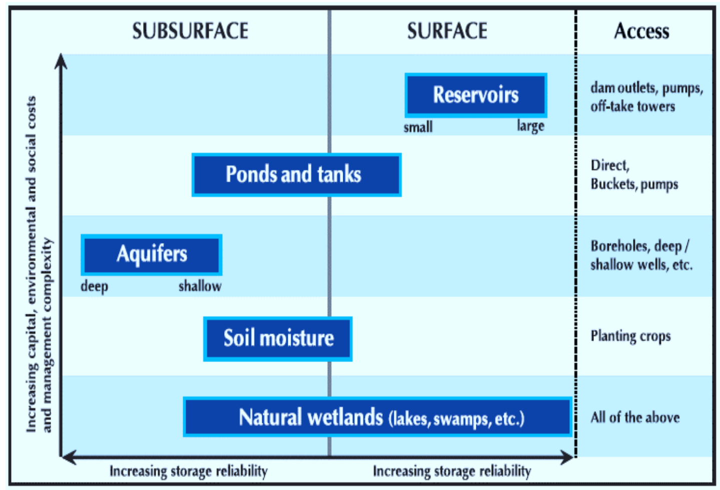

Figure 1: Conceptualization of The Physical Water Storage Continuum. [1]

Their effectiveness varies, but, broadly, the deeper and/or larger the storage, a more reliable water supply can be ensured; the more 'natural' it is, the less complex and less costly it is to develop and access. Modes of management also vary considerably. In some cases, decision making and responsibility lies directly with an individual whilst relatively complex institutional arrangements are required in other instances. Hence, in any specific situation, each option needs to be considered in terms of technical feasibility, socioeconomic sustainability and institutional requirements, as well as impact on public health and the environment.

In any given location, the impact of different types of storage on poverty can vary significantly, with some options being much more effective in reducing poverty than others.[2] In other words, boreholes may have a greater impact than

[1] **McCartney, M.P.; Smakhtin, V. 2010.** Water Storage in An Era of Climate Change: Addressing the Challenge of Increasing Rainfall Variability. Blue Paper. Colombo, Sri Lanka: International Water Management Institute (IWMI). 14p.

[2] **Hagos, F.; Jayasinghe, G.; Awulachew, S.B.; Loulseged, M.; Yilma, A.D. 2012.** Agricultural Water Management and Poverty in Ethiopia. Agricultural Economics 43(Supplement s1): 99-111.

small reservoirs in some circumstances and vice versa in others. It is not always clear why a particular option is successful in some instances and seemingly ineffective in others.

Water Storage and Climate Change

By mitigating the vagaries of climatic variability, **agricultural water storage** makes a key contribution to climate change (CC) adaptation. All storage options are potentially vulnerable to the impacts of climate change. By modifying both water availability and water demand, climate change will affect the performance, cost and adverse impacts of different types of water storage option.

Table 1: Climate Change Risks for Different Storage Types in SSA and the Possible Social and Economic Implications. [3]

Storage Type	Risks Associated with Climate Change	Social and Economic Implications
Reservoirs	• Reduced inflow, resulting in longer periods between filling. • Higher evaporation, increasing the rate of reservoir depletion. • Infrastructure damage due to higher flood peaks. • Improved habitat for disease vectors (e.g., mosquitoes). • Increased risk of eutrophication and salinization. • Increased siltation.	• Increased failure to meet design specifications (irrigation and hydropower generation, etc.). • Increased costs due to the need to redesign infrastructure (e.g., spillways). • Increased risk of waterborne diseases (e.g., malaria).
Ponds/tanks	• Reduced inflow, resulting in longer periods between filling. • Higher evaporation, increasing rates of pond/ tank depletion. • Infrastructure damage due to higher flood peaks. • Improved habitat for disease vectors (e.g., mosquitoes). • Increased risk of eutrophication and salinization. • Increased siltation.	• Increased failure to provide water requirements of the community and households. • Increased labour requirements and costs to repair structures. • Increased risk of waterborne diseases (e.g., malaria).
Aquifers	• Reduced recharge, resulting from modified rainfall intensities. • Reduced recharge, resulting from land-cover modification and increased soil moisture deficits. • Saline intrusion in aquifers near the coast.	• Falling water levels make it increasingly costly to access groundwater. • Poor water quality makes groundwater unsuitable for use.
Soil moisture	• Reduced infiltration, resulting from modified rainfall intensities. • Waterlogging, resulting from modified rainfall intensities and duration. • Longer dry periods, resulting from altered temporal distribution of rainfall. • Depleted soil moisture, arising from higher evaporative demand. • Soil erosion, resulting from modified rainfall intensities and duration. • Reduced soil quality (including water-holding capacity and nutrient status), resulting from modified rainfall and temperature.	• Decreased productivity – more frequent crop failures and reduction in yields.
Natural wetlands	• Reduced rainfall and runoff inputs, resulting in wetland desiccation. • Higher flood peaks, resulting in wetland expansion and flooding of fields and homes. • Improved habitat for disease vectors (e.g., mosquitoes).	• Increased failure to provide water requirements of the community and households. • Loss of water-dependent ecosystem services (including flow regulation and groundwater recharge). • Increased risk of waterborne diseases (e.g., malaria).

[3] **Matthew McCartney, Lisa-Maria Rebelo, Stefanos Xenarios and Vladimir Smakhtin. 2013.** Agricultural Water Storage in an Era of Climate Change: Assessing Need and Effectiveness in Africa. DOI: http://dx.doi.org/10.5337/2013.207

If the planning of water storage is not improved, it is likely that many investments will fail to deliver intended benefits. When it comes to storage, past water resource planning has focused mostly on large dams. While dams have made an important and significant contribution to human development, their construction is often controversial. In the past, there was often insufficient participation of local people in the planning process, consideration of alternative options often is not comprehensive, evaluation of environmental impacts is inadequate, and the impact on poor people living both upstream (in the area inundated by the reservoir) and downstream (where flows were modified) has rarely been addressed properly.

Hence, climate change necessitates a fundamental rethinking of the way water resources, and particularly water storage options, are planned and managed. In all situations, maximizing the benefits and minimizing the costs of water storage options will, as in the past, require consideration of a wide range of complex and interrelated hydrological, social, economic and environmental factors.

Household Irrigation Water Storage Programme - National Irrigation Board (NIB)

In 2016/17, 24 counties namely Narok, Kajiado, Taita-Taveta, Kilifi, Kwale, Tana River, Kitui, Makueni, Marsabit, West Pokot, Tharaka-Nithi, Samburu, Wajir, Mandera, Lamu, Laikipia, Isiolo and Garissa were hard hit by drought and experienced a decline in food and livestock production as well as water supply. This has been a recurring phenomenon that leaves the affected communities very vulnerable. There is need to provide localized access to water solutions to build resilience against drought for these communities as well as provide for their livelihoods and wellbeing [4].

One of the broad objectives of the programme is ensuring food security by supporting provision of water for agriculture and livestock at the local level and contributing towards the same at the national level. In addition, one of the specific objectives is Construction of 125,000 **localised water storage reservoirs** at **household level** to harvest 1000-3000m3 of rainfall runoff in 24 counties by 2022 to harness approximately 125million cubic of water.

To realize localized water access, **micro water harvesting and storage reservoirs** are required. The aim is to harness surface water resulting from intermittent rainfall. Reservoirs are positioned at locations where water is collected from natural depressions/drains and storm water is easily directed to maximize on the collection. In addition, the reservoirs are localized at household level, where there is ease of management and ownership. Water collected is used to support production of crops of choice through the use of **drip irrigation**.

Project Status

As at January 2021, the programme had achieved accumulative water storage capacity of 24,124,741 cubic meters from excavation of 17,753 household water pans.

Figure 2: Irrigation Reservoirs. Source: Aigües Segarra Garrigues

Galana Kulalu Irrigation Project - Water Need & Storage

The Galana-Kulalu irrigation project and food security scheme was unveiled in 2014 as a one-million-acre model farm. The irrigated farm and accompanying projects were to provide food security for Kenya and lead to marked increases in agricultural exports. The Galana-Kulalu deal was signed between the Kenyan government, through the

[4] **National Irrigation Board (NIB), 2020.** Household Irrigation Water Storage Programme. https://www.irrigation.go.ke/projects/household-irrigation-water-storage-programme/

National Irrigation Board (NIB), and Green Arava in mid-2014. According to reports at the time, the total cost of the Galana-Kulalu irrigation scheme was estimated at KES 260 billion. The initial, model project would cost USD 165 million, with the Kenyan government setting aside USD 40 million while the Israeli partnersagreed to provide the remaining USD 125 million. The model project was to pave the way for full implementation of the entire Galan-Kulaluproject.

Galana Kulalu Irrigation Project Water Needs & Challenges

What may have gone undetected by NIB and the pre-feasibility studies is the availability of water, or lack thereof, in this semi-arid region. Reports now indicate that abundant, reliable sources of water may either be unavailable or very expensive to pump. Although the diversion of water from the Tana River would irrigate another 469,000 acres, experts have argued that the distance to the Galana-Kalulu project and the topography it would need to cross would result in enormous water flow in both canals and pipes. Furthermore, pumping huge volumes of water through 2m diameter pipes is capital-intensive, as costs for pumps, steel pipes, reservoirs and running costs of pumping are high. Added to this, NIB recently announced the tender for the second phase of the Galana-Kulalu project that will see a firm contracted for the construction of dams.

These challenges have massive cost implications and represent major engineering challenges – especially the construction of the needed 2m diameter steel pipes for distances greater than 250km over difficult terrain. Studies now show that that the area designated for dam construction for **water storage** at the Galana-Kulalu project is unsuitable since it is impossible to utilise gravity flow, thus resulting in very high pumping costs. According to one report, the estimated annual pumping requirement is 492 million kW, with pump capacity ranging from 6,700kW to 13,000kW, resulting in a pumping cost of KES 6.2 billion, per year.[5]

Challenges Facing Water Storage in Kenya.

1. **Financing**

Smallholder farmers can't afford to invest in water storage structures. For instance, the whole rainwater harvesting system - from storage to irrigation and pumping is expensive.

2. **Capacity**

Farmers lack the technical know-how to place and build water storage structures.

3. **Policy**

Stronger support is needed from national and county governments. There is greater effort towards this from the Household Irrigation Water Storage Programme.

4. **Lack of Market Knowledge**

Farmers need to be better informed where they can sell their crops for good prices so that they're confident they can recoup the cost of investing in water storage structures

Conclusion

The planning of agricultural water storage has typically occurred with minimal planning and in a largely ad hoc manner. In some places water storage has considerably improved the livelihoods and well-being of rural communities, but in others it has not. In some cases, failure occurs as a consequence of poor technical design, but in others the socioeconomic context is such that increased water storage simply fails to bring intended, though often unspecified, benefits. Key to planning and management of water storage are determining current and future needs, and making appropriate choices from the suite of options available. In any given situation this requires an understanding of a range of biophysical and socioeconomic issues that influence different water storage types, both in isolation and in combination within a basin. the need to pay closer attention to the planning of future water storage. Careful consideration needs to be given to integrated approaches which maximize the complementarities of different storage options. Consequently, in contrast to the past, planning needs to be much more integrated across a range of levels and scales, with much greater consideration of the full range of possible options and the potential implications of climate change.

[5] **Dr. Brendon Cannon, 2016.** Unique Challenges face the Galana-Kulalu Irrigation Scheme. https://www.kenyaengineer.co.ke/unique-challenges-face-the-galana-kulalu-irrigation-scheme/

VIRTUAL TRAINING COURSES

In line with the South African Institute of Agricultural Engineers (SAIAE) Project on *"Growing Agricultural Engineering in Africa: Supporting the Operations and Implementation of the Strategic Plan for "AfroAgEng"*, the society is implementing the following virtual training courses:

No.	COURSE	COURSE BRIEF	DATE
1.	Environmental, Biological and Agricultural Engineers in the Fight Against COVID-19 in Africa	The course reviews and appreciate the roles of the relevant engineering disciplines and innovative practices in attempting to address the challenges of COVID-19 in Africa	Thursday, 27 May 2021
2.	Environmental Concerns in the Development of Agricultural Projects in Africa	Modernisation of agricultural systems in Africa brings with it several environmental challenges whose impacts are felt far beyond the sector. The course conducts an assessment of some of the main impacts caused by increasing intensification of agriculture in the continent and proposes ways in which government and other actors in the sector can adopt a proactive approach in addressing this challenge	Thursday, 24 June 2021
3.	Developments in Renewable Energy in Africa	Africa has a huge potential for renewable energy. This course will look at the prospects for the exploitation of this resources in a sustainable manner.	Thursday, 22 July 2021

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Please transmit the same to the **Editor: Ezekiel Oranga** via Email: info@kesebae.or.ke

NOTE: A payment will be made to the author of each selected article

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Priority in the selection of articles for publication is that the articles:

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c. Have not been previously published elsewhere, or, if previously published are supported by a copyright permission
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e. Have a 150 to250 words abstract, preceding the main body of the article
f. The abstract should be followed by the list of 4 to 8 “Key Words”
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