



Water Harvesting & Food Security in Northern Tanzania

M.J. Salomons
 MCC Tanzania
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Introduction

The arid and semi-arid lands of Northern Tanzania form part of the traditional range of the pastoralist Maasai people. While unpredictable rainfall patterns and drought are no stranger to the area, in the last decade this area has been particularly hard hit, with the last major drought in 2007-2009 killing up to 70% of the livestock in some areas.

Sand dams have been used in East Africa to address issues of water scarcity since at least the early 1900's. To date, hundreds of these structures have been built: primarily in central Kenya, but also in Northern Kenya, Tanzania, and Ethiopia.

Proponents of sand dams claim that not only do they provide a source of water for the local population, but they increase the level of food security in areas surrounding the dam; both directly (by providing water for fruit trees, irrigated crops and livestock) and indirectly (by increasing a household's amount of time and energy, and increasing the amount of firewood for sale, wild greens for harvesting, and the amount of fodder for livestock).

In early 2011, a team from Utooni Development Organization (UDO), which has successfully built hundreds of sand dams over the past 40 years in the Machakos region of Kenya, conducted a

study tour to assess the possibility of building sand dams in Northern Tanzania. Accompanied by local government officials, community leaders, and two local NGO's, (Ujamaa Community Resource Team (UCRT) and Global Service Corps Tanzania (GSCTZ)) the UDO team identified a number of promising sites for sand dams. Plans were subsequently made to build two pilot sand dams in late 2011.

The funding to build the two pilot sand dams in Northern Tanzania was received from the Canadian Food Grains Bank (CFGB), an organization with the very explicit mandate to address food security issues. The issue for CFGB is not whether water is a problem in Northern Tanzania (it clearly is) or if these areas are food insecure in general (they clearly are). The more relevant question is instead, "does the building of sand dams represent a good strategy for achieving a higher level of food security for the residents of the arid and semi-arid lands in Northern Tanzania?"

This report will go on to try and address this question by looking at the general picture of agriculture and food security in East Africa, the specific situation in Northern Tanzania, and relevant experience with water harvesting and sand dams. It will then make some recommendations for future work in Northern Tanzania.

Food Security in East Africa

The currently dire situation in the Horn of Africa has focused the world's attention on food security challenges in East Africa. Unfortunately, this situation is not an anomaly, but part of a longer-term trend in the region. Tanzania, for example, could be a major food-exporting country but currently struggles to meet its own food requirements due to low productivity and the predominance of subsistence agriculture.

Several factors in the region have contributed towards a situation of declining agricultural production in the region, as evidenced by cereal crop production per capita (a decline from 145 kg in 1979 to 125 kg in 2005, and per capita harvested area (a decline from 0.15 ha in 1979 to 0.09 ha in 2005)¹:

- Population: already the most heavily populated region in Africa, East Africa also has the world's highest population growth rate.² This rapid population growth has put a tremendous amount of pressure on land resources, at the same time as it is increasing the demand for more agricultural yields.
- Environmental degradation: the expansion of agriculture into marginal areas; inappropriate agricultural methods; the reduction or elimination of the traditional fallow system of soil fertility management; and overgrazing have all contributed to high levels of soil erosion, environmental degradation, and a reduction in soil fertility.³
- Climatic change: The last twenty years have seen a 13% decrease in average rainfall (the average from 1979-1991 compared to the average from 1992-2005) across the East



A typical scene from Northern Tanzania

African region¹. While this trend of increasing frequency of drought and irregular rainfall patterns in particular is expected to continue⁴, impacts on agricultural yields are predicted to be highly heterogeneous across the East African region⁵. In general, crop increases are more likely to occur in the tropical highland mixed systems, while the arid-semiarid mixed crop-livestock systems are projected to see reductions in production⁶.

All of these trends taken together mean that Eastern Africa will likely face substantial and increasing food security challenges. If present trends continue, per capita cereal production in Eastern Africa is expected to decrease from an already low 131 kg per person per year in 2007, to a very low 84 kg per person per year in 2030⁷.

Northern Tanzania

Area overview:

Northern Tanzania's landscape is characterized by extensive arid and semi-arid rangelands where rural communities, (mostly pastoralists or agro-pastoralists) live in a climatically unpredictable environment. This area has a bimodal, but generally unreliable, rainfall pattern with an annual average rainfall of 500 mm.

Maasai market in Northern Tanzania



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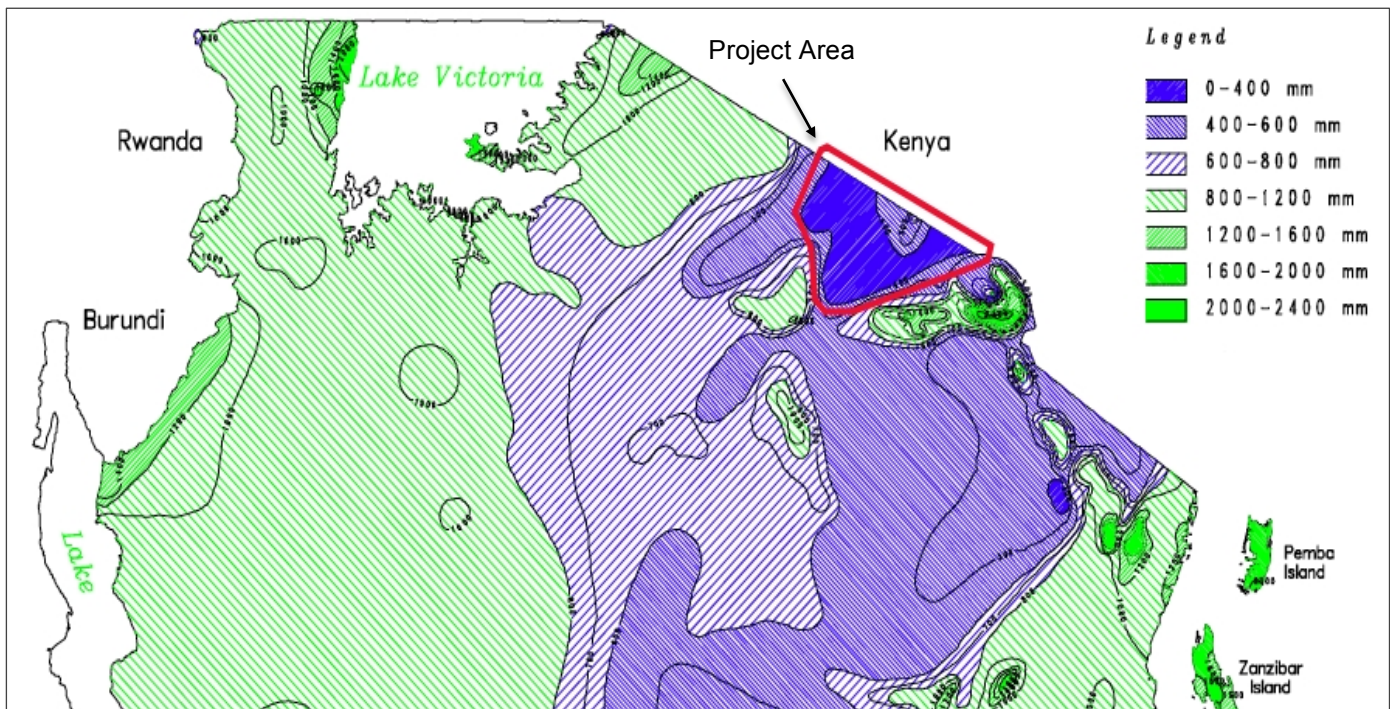
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Map showing rainfall in project area



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These lands, in keeping with their low agro-ecological potential, are generally sparsely populated, although the population has been growing rapidly, due in part to in-migration from other more densely populated areas. The majority of the population in these areas is made up of the pastoralist Maasai people and the agro-pastoralist Waarusha, both Maa speaking and very similar culturally. Other ethnic groups live mostly in the town settlements, and in cultivated areas permitting intensive agriculture.

Impoverishment in general, and privatization and enclosure of the rangelands in particular, are driving a massive cultural and economic shift in the area. While the predominant economic activity in the area remains extensive pastoral production, using herd mobility as the primary strategy to cope with and mitigate patchy and highly unpredictable rainfall, periodic drought, and disease⁸, many of the best dry season pastures and watering areas have been converted into wildlife areas, commercial farms (most owned and controlled by white settlers) and small plots controlled by an ever increasing influx of other tribes. Remaining rangelands are themselves increasingly privatized through allocation of rights for ranching, farming, or wildlife enterprises.

While livestock ownership remains the chief determinant of household wealth, and households rely on livestock sales as their primary cash source to purchase food and non-food items⁹, the current situation in the region is increasingly one of mixed pastoralism and agriculture. This expansion of cultivation into marginal areas that were originally used for grazing has been driven by a number of forces, including a long-standing government policy to settle pastoralists, the Maasai's desire to secure land tenure and capitalize on the cash market for grain, and in-migration from adjacent agricultural areas^{8, 10, 11, 12}.

A survey of Longido district in 2002 found that while 95% of residents own livestock, 7% of residents own half of all livestock. 67% of residents engaged in mostly smallholder cultivation, with 43% of income from livestock, 34% from non-farm activities, and 22% from cultivation. Incomes are on average very far below the poverty datum line of \$1/person/day¹¹.

Food Security in Northern Tanzania:

In general, Northern Tanzania is classified as borderline in terms of food security: able to meet annual food needs during normal years, but when are confronted by more than the usual production hazards, the poorest households will face hunger, while

others will be impoverished by the effort to buy enough food and may take years to recover sold assets, especially livestock⁹.

From 2008 to 2010, the Whole Village Project (a collaboration between a Tanzanian NGO and the University of Minnesota) collected food security data from 10 villages in Longido, and 4 villages in Monduli District of Northern Tanzania^{13, 14}.

All of the villages surveyed in Longido District suffered from high food insecurity and had households in general, and children under five specifically, consuming too little food and too limited a diet. In the four weeks preceding the survey, 6 of the 7 villages surveyed had more than 1/3 of households go one night and day or more without food (in one village it was close to 2/3 of households). In both Longido and Monduli districts, diversity of daily diets and consistent intake of recommended vitamins and nutrients is limited. While the situation in Monduli District was slightly better, specific circumstances varied considerably. Nearly 1 in 10 children under five in Engaruka are wasted and considered acutely malnourished. Severe wasting was not seen in any children in Migombani or Naitolia, but 3.5% and 4.4% of children under five in Engaruka and Selela, respectively, measured as severely wasted.

While most of these surveys were conducted in late 2009, during a severe drought when food insecurity was most acute, it is worth comparing this to a 2005 extensive survey of the Monduli and Longido Districts in March of 2005 – a survey conducted after a successful short-rains harvest¹⁵.

In 2005, of the 24,000 children under the age of five in Monduli district, 32% were found to be stunted, 11% were severely stunted, and 8% too thin for their height (wasted). Over 50% of the households surveyed stated that they often had food shortages in the 12 months preceding the survey.

While there is no one reason for the high levels of food insecurity in the region, most of these reasons need to be understood within a context where the Maasai people are struggling to survive in

the driest, most desolate part of their former range. Periodic and episodic drought is not new in this part of Tanzania, but the pastoralists livelihood strategy relies on mobility, and without access to adequate grazing reserves during time of drought, pastoralists are extremely vulnerable to any shock in the system.

Within this context, the lack of water is now one of the major issues in this area:

- In dryland ecosystems (such as Northern Tanzania) water is the major limiting factor in agricultural production systems, and the performance of landscape functions relies heavily on the availability of water¹⁶.
- Inadequate rainfall is the main hazard in northern Tanzania, affecting livestock health, reproduction, and milk production as well as crop yields⁹.
- Access to water – for drinking purposes, irrigation and livestock – is central to more than half of the villages surveyed in Longido and Monduli districts and will need to be addressed in order to improve overall quality of life and health; food security is better in the villages with greater access to water and the largest villages with the most water tend to be best off, eating more types of food per day^{13, 14}.

The high variability of rainfall – and frequent dry spells and drought – compound the general lack of water in the region:

- Like most of the semi-arid regions of sub-Saharan Africa, droughts and dry spells result on average in yield reductions four or five seasons in ten, and complete crop failure two to four years out of ten¹⁷.
- Herds of pastoralists have been declining following shortage of pasture and water during prolonged drought. During droughts animal condition deteriorates and milk production is reduced in terms of volume and duration. Prolonged severe droughts trigger abnormal movement of pastoralists in search of pastures and water, causing conflict with crop farmers, animal disease spread and livestock deaths. Milk intake at the household level is reduced as herds

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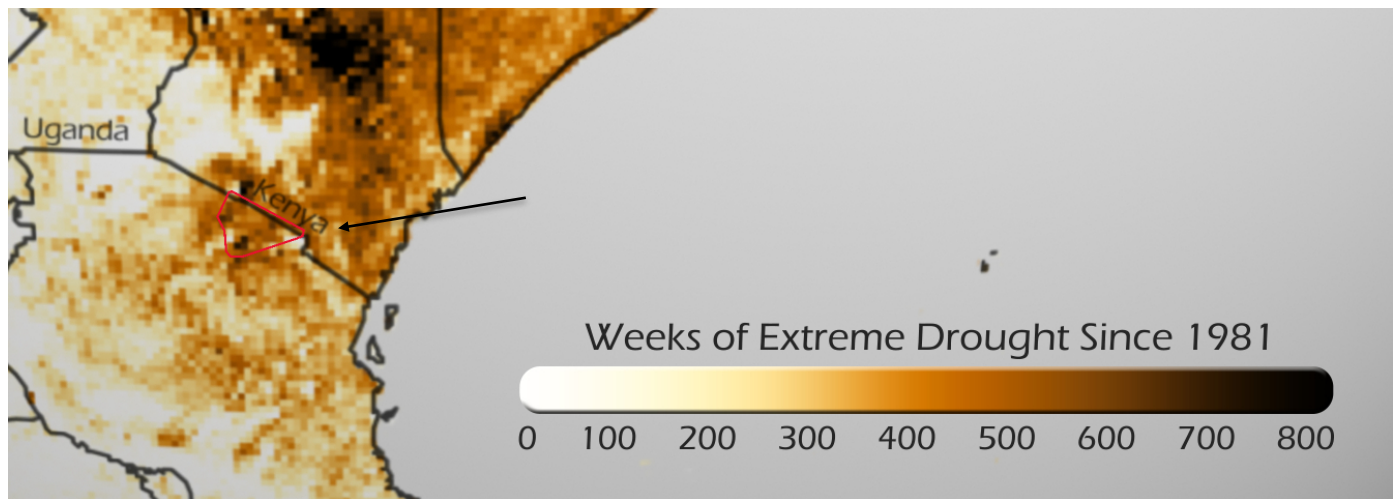
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Wasting - a measure of weight-percentage - is an immediate indicator of acute malnutrition, or short-term malnutrition.

Stunting - a measure of height-percentage - is a consequence of long term malnutrition and is commonly associated with poor economic conditions and chronic or repeated infections.

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Source: NOAA



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move away from families. Also during drought terms of trade are unfavorable to pastoralist as livestock prices are low and cereal prices are high. This limits pastoralist income and food purchasing power¹⁸.

- The National Oceanographic and Atmospheric Administration shows that this region of Tanzania has suffered between 400 and 800 weeks of extreme drought since 1981, and much of that in the last decade¹⁹. There is currently a minor drought in the area, and there were two periods of intense drought within the last decade (2005 – 2006, and in 2009). The 2005 – 2006 drought killed many cattle, and government relief was received. The 2009 drought was, however, the worst in 40 years. The pastoralists lost up to 70 per cent of their livestock to this drought.
- In villages surveyed in Longido district, over 90 percent of households have lost livestock to either drought or disease. Such high loss exacerbates the financial security of a household since it depends mainly on that livestock for income¹⁴.

Other contributing factors to food insecurity in the region:

- Land degradation in both pastoral areas (from overgrazing) and marginal agriculture areas (where natural vegetation has been removed by plowing) means that even when rains are favorable vegetation regeneration is limited. Soil erosion is a serious

problem throughout the area, along with high levels of water runoff, poor water infiltration and greater evapotranspiration^{9, 14}.

- Post-harvest crop losses of food crops from mishandling, lack of processing, spoilage and pest infestation is extremely high in the area^{13, 14, 18}.
- Crop and animal pests and diseases are reducing productivity. Although more livestock are lost to drought than disease, livestock (cattle, shoats, and poultry) are at a high risk of disease due to very low vaccination rates¹⁸.
- Low levels of agricultural extension and development support have had a number of negative impacts on the area. For example, farmers in the area have largely continued to grow maize in an area more suitable to drought tolerant crops such as sorghum, millets, or pigeon peas. As a result they have experienced repeated crop losses even when rains would have supported growth of drought tolerant crops¹⁸.

Water Harvesting

Water harvesting is the accumulation and storage of rainwater, and eventual use for household needs, livestock, or irrigated agriculture. In general, water harvesting has a high potential for improving food security, reducing rural poverty, and promoting broad-based agricultural growth in Africa^{20, 21}. The use of collected rainwater for irrigated agriculture in particular, generally increases farmer's yields, promotes diversified farming, enhances household food security and increases

household incomes: farmers who are on irrigation projects are more likely to be food secure than dry-land farmers^{22, 23, 24}.

Water harvesting, of course, is rarely exclusively for food security reasons. For residents of arid and semi-arid regions, where an adequate household water supply is not guaranteed, water harvesting structures generally serve multipurpose uses. In such areas farmers have been found to prioritize domestic water uses and not until these are covered, consider supplemental irrigation. The large water requirements in crop production also mean that harvested water is normally used only to supplement a crop during stress periods, or for small scale irrigation of higher value horticultural crops²⁵.

While water harvesting does provide for multiple uses (i.e. agricultural, domestic and livestock purposes) it also provides multiple benefits (i.e. economic, nutritional and vulnerability reduction)²². For example, a large scale survey of sub-surface dams in Kenya and Brazil found that while water from the dams is used for a combination of domestic water supply, livestock watering and small-scale manual irrigation, the benefits of the dams in terms of improving the community's quality of life can be very significant, as a result of the increased variety and quality of food that can be produced²⁶.

Water harvesting has also been found to be useful for pastoralists. The building of sand dams in the Sambura district of Kenya has "opened up underused rangelands and led to environmental protection and rising livestock productivity, despite poor rainfall"²⁷. Dams often have an important role in livestock watering and the production of dry-season animal forage, even where slightly brackish groundwater develops²⁶.

East African savannah scene



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The combination of agriculture and pastoralism in particular is relevant for livestock production when irrigated crops are used as animal feed, and when other water uses (e.g. livestock drinking) are considered, as the integration of livestock production and irrigation improves overall system productivity²⁸.

While there are benefits of water harvesting systems, there are also a number of important caveats that must be taken into account:

- For pastoralists who still have the option of mobility, the transformation of livelihoods from semi-nomadic herders to largely crop farmers, is counter-productive, if the objective is to improve their food security^{29, 30}.
- The social design of water harvesting schemes has to be done very carefully: community participation and awareness creation (empowerment) are essential to the success of the intervention^{31, 32}. A study of rural water points in Tanzania found that only 45% of them were functional and that the cause for the collapse was in almost all cases related to poor financial control and management³³. A similar study looking at small ground water retaining structures (such as sand dams) in Tanzania found that the effectiveness and contribution of such structures in improving agriculture, livestock or wildlife was marginal due to the lack of local participation or involvement in planning and subsequent implementation and management of these structures³⁴.
- Water harvesting schemes need to be backed by enabling policies²⁸, and the impacts on poverty reduction are larger if other factors such as land and water resources development, human resources development, rural

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A terraced hillside in Machakos region

infrastructure development, agricultural and labor markets, and the communities ability to access critical institutional, financial and social resources are favorable^{22, 23}.

The Machakos Miracle

As early as the 1930's, Machakos was considered one of the most environmentally degraded areas of Kenya³⁵. British colonial scientists wrote about the eroding, treeless hillsides of the drought-prone region, where the local Akamba people "are rapidly drifting to a state of hopeless and miserable poverty and their land to a parched desert of rocks, stones and sand"³⁶. Since that time, the population of Machakos has grown from 250,000 to more than 1.5 million³⁷, while only about 1/3 of Machakos receives the 750 mm of annual rainfall that is the minimum for cropping in a bimodal rainfall area³⁵. Drought and semi-drought conditions remain a chronic problem³⁶.

However, rather than resulting in a cautionary tale of the perils of overpopulation in an agriculturally marginal area, Machakos is now used as a textbook example of environmental & agricultural improvement with increasing numbers of people. The hills of Machakos are generally green, less eroded, and more productive today than in the past. Farm output per hectare is ten times what it was in the 1930s and five times what it was in the 1960s³⁶.

One of the benefits of more people is more resources, and these resources have been leveraged into the building of hundreds of sand dams. These sand dams, say the organizations that promote them, have been an important factor in the re-greening of Machakos and subsequently on

increasing agricultural production. Of course, these resources have also been leveraged into the building of massive numbers of terraces and in the planting of large numbers of trees (which are, coincidentally, an important part of sand dam construction, done to reduce the chances of the sand dam becoming filled with silt instead of sand). This is further complicated by the complete absence of references to sand dams (even though they have been built in the region since at least the 1970's) in much of the literature explaining the 'Miracle of Machakos'.

In reality, there is no one reason for the changes in Machakos, and it is difficult, if not impossible, to completely separate the impacts of building sand dams from other interventions and improvements in the area. For example, while Tiffen et al's landmark study in 1994³⁸ remarked on the huge investment in terracing in the region, it also pointed out that there are probably dozens of different incremental, adaptive changes which resulted in the huge aggregate change in the region. A recent UN report also rejects the notion of a simple explanation for the changes in Machakos, instead pointing out a number of complex socio-cultural, political, historical, economic and environmental factors that came into play³⁹. Other reports have also pointed out the introduction of numerous agricultural-technological innovations such as improved maize production; introduction of horticultural crops; the ox-plough, the use of compost and manure; a trend towards stall-feeding and fodder growing, and tree planting and bench terrace construction⁴⁰; the huge increase in the number of agricultural extension workers over time⁴¹; the switch in the region from herding cattle to settled farming³⁷; and increased urban markets and

Sand dam in Machakos region



windfall profits from the coffee boom in the late 1970's⁴².

Sand Dams in Machakos

While it is clear that it is not possible to attribute all – or even most – of the changes in Machakos to sand dams, in addition to the anecdotal evidence, there is a small but growing body of scientific research pointing out the role of sand dams in the transformation of the area, and the positive impacts they have had on local people's lives.

In particular, surveys done in the Machakos (and neighbouring Kitui) districts of Kenya over the last 10 years have repeatedly demonstrated a strong linkage between the building of sand dams and increased levels of food security:

- Isika et al, 2002⁴³: Interview data showed that households owning land adjacent to the sand dams are now earning significant amounts of money in the three dry months of August, September and October from bucket irrigated vegetables, and that income from horticultural trees is also increased, while fishing (which was uncommon in the area) and brickmaking (which requires large amounts of water) are also on the rise.
- Foster & Tuinhoff, 2004²⁶: The building of large numbers of sand dams in the Kitui region of Kenya In Kenya, has increased crop production and improved the hygiene and nutrition of the people. It has also increased numbers of livestock and poultry and increased income for inhabitants, especially during the dry season. This effect is also noticeable in livestock and poultry, which further increases nutritional intake and economic income.
- Lasage et al, 2006⁴⁴: In the Kitui district of Kenya, the building of hundreds of sand dams over the last two decades has resulted in a situation where "the increased availability of water boosted agricultural production of the region and has significantly helped

communities adapting to unfavorable climate conditions". Improved access to water had led to an increase in domestic water use and a doubling in the percentage of households growing irrigated crops.

- Hoogmoed, 2007⁴⁵: Sand dams effectively increase the volume of groundwater available for abstraction as well as prolonging the period in which groundwater is available.
- Pauw et al, 2008⁴⁶: On average sand dams prolong the water availability of primary water sources by on average 2.5 months. "Increased water use and saved time [as a result of sand dam construction] bring about tremendous positive social and economical changes, most of which are agricultural. The households without dams all saw their harvest of rain-fed crops decrease; many had no harvest at all in the dry year of 2005. At the same time, the households with a dam increased their harvest and diversified their income: they increased the number of different crops they grow and many also started irrigating. The percentage of households with dam growing irrigated crops increased from 12% to 44%; the percentage of the households without dams stagnated at 18%. Furthermore, households with a dam planted more different species and a larger amount of fruit trees."
- Ertsen & Hut, 2009⁴⁷: A key food security and livelihoods impact is that households on land adjacent to a seasonal river with dams are able to irrigate their crops during the three dry months of August, September and October
- Quilis et al, 2009⁴⁸: The Kitui experience with the building of sand dams indicate that "sub-surface water storage is possible solution to overcome problems of drought and associated food insecurity in other regions".
- Maxson et al, 2010⁴⁹: The sand dams have improved food and water availability of the communities around them and have eased the usually adverse effects of hunger during the

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hunger gap period. This improvement is due to the raise of the water table level and a reduction of evaporation. A secondary impact is a reduction in the distance travelled and the time used to look for water, which frees up labor for other uses

Conclusions

The reality of agriculture in the African context is complex, with a number of distinct features that differentiate it from other regions of the world⁵⁰:

- Lack of a dominant farming system on which food security largely depends,
- Predominance of rainfed agriculture,
- Heterogeneity and diversity of farming systems and the importance of livestock,
- Key roles of women in agriculture and in assuring household food security
- Lack of functioning competitive markets,
- Dominance of weathered soils of poor inherent fertility,
- Underinvestment in agriculture research and development and infrastructure,
- Lack of conducive economic and political enabling environment,
- Large and growing impact of human health on agriculture
- Low and stagnant labour productivity and minimal mechanization,
- Predominance of customary land tenure

The complexity of the situation on the ground calls for complex, multi-faceted solutions. If decades of agricultural development work in Africa have shown us anything, it is that there are no easy answers, nor any single panacea that can be

reproduced everywhere on a large scale. Rather, approaches based on experimentation, innovation, testing, adapting, and shared learning will be essential for successful application of these technologies in ways that enable African farmers to improve their livelihoods and incomes⁵¹.

Sand dams are a useful technology for increasing the amount of water in appropriate areas; but the construction of a sand dam alone does not necessarily mean that a community will be food secure. The building of sand dams must be based in the context of an overall agricultural and food security strategy that includes a thorough analysis of livelihoods (including the socio-cultural, political and legal aspects of livelihoods)⁵²; a focus on both staple crop production on rainfed land and intensive vegetable gardens where possible⁵¹; and a greater investment in soil conservation, agricultural improvement technologies and land tenure reform¹⁰.

The advantage of the proposed sand dam work in Northern Tanzania is that it is being done in this very context. The two local partners involved both bring complementary experience to this process. The Ujamaa Community Resource Team (UCRT) brings much experience with community organization and management, and land planning and tenure. Global Service Corps Tanzania (GSCTZ) brings a wealth of information on sustainable agriculture and soil and land conservation techniques. Both organizations will be assisted in this work by local government workers and from Utooni Development Organization (UDO) and SASOL in Kenya, which each bring decades of experience in sand dams and agricultural development.