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Enhancing food and nutritional security through adoption and upscaling of sustainable technologies in the drylands of Kenya

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Abstract Drylands comprise of approximately 80% of Kenya's land mass and they are characterized by erratic and low rainfall, crop failure, reduced livestock carrying capacity, environmental degradation and recurrent droughts. The effect of climate variability has been more felt in these areas with communities having to contend with crop failures, death of livestock subjecting millions of people to starvation. Poor nutrition and food insecurity exemplified by famines are a common feature in these areas. Despite these hardships afflicting drylands in Kenya, a few farmers have over the years coped with the situation by using innovative technologies that have enabled them to raise crops and thus, be able to feed their families with augmentation of their income by selling the surplus. Some of these technologies involve rainwater harvesting, use of drought tolerant crop varieties, preparation of kitchen gardens by lining with polythene paper buried around 30 cm in the soil to reduce the loss of water through percolation, diversification of farming activities, among others. The team from the University of Nairobi and Kenya Agricultural Research Institute (KARI) identified these innovative technologies with the aim of validating and improving their effectiveness with the eventual objective of upscaling and outscaling to other areas with similar challenges. Appropriate methodologies for data collection such as development of family portrait, administering structured questionnaires, focused group discussions and key informant interviews were used to gather relevant data. The study was initially conducted in Kibwezi district and later outscaled to Kilifi, Kaloleni and Mwatate districts. The research team also introduced other techniques such as grass reseeding of the denuded areas with the purpose of improving pastures. Farmers were also taught innovative techniques in value addition especially preservation of vegetables. Farmers also learned how to identify various pests and diseases of cassava (*Manihot esculentum*) and cowpeas (*Vigna ungiculata*) and their management. The farmers were also linked with various outlets where they could market their produce including grass seeds. Farmers who adopted these techniques were able to meet household food requirements with diversification of farming activities thus, improving their nutritional base. Some techniques such as water harvesting contribute to land rehabilitation enabling the communities to cope with the highly variable climate in drylands. The inexpensive and locally adapted techniques can be used to harness the enormous potential that exists in dryland areas taking care of the fragile ecosystems through promotion of environmentally friendly and sustainable innovative approaches.

Key words: Conservation agriculture, farmer innovations, value addition, water harvesting

Introduction

Drylands are zones where precipitation is counterbalanced by evaporation from surfaces and evapotranspiration from plants. Drylands are characterized by scarcity of water and an aridity index of less than 0.65. Drylands cover 41.3% of the earth's land surface, in Africa they cover 66% of the earth's surface while in Kenya they cover close to 80% of the country (Mwang'ombe *et al.,* 2010). Drylands are complex with fragile ecosystems and their dynamic properties depend on many interrelated links between climate, soil and vegetation. On average, drylands receives annual rainfall of less than 1500 mm and they support around half a billion people (Winpenny, 1994).

Drylands are characterized by recurrent droughts and the situation is being rendered more precarious by climate change resulting to more variability and unpredictability in climate (Parry, 1990). They also have poor rainfall distribution where they receive intense rainfall for a few days and most of this water is lost as surface run-off and through evaporation due to the high temperatures. The problem is even made worse by the sandy soils which has very poor water retention capacity (Little *et al*., 2001; IIRR, 2002). In the Kenyan drylands drought events have become frequent occurring on average after an interval of every four years and these droughts are punctuated by occasional periods of excessive rainfall that causes a lot of devastation on the already bare landscape devoid of vegetation (Little *et al*., 2001).

Majority of the communities living in drylands are mainly pastoralists with a significant number engaging in agro-pastoralism activities. These people have been experiencing tremendous human suffering due to the high mortality of their livestock caused by lack of water and pastures and crop failures occasioned by the droughts (Knapp *et al*., 2001).

In response to these challenges, these communities have developed a raft of measures to cope with the vagaries of nature and alleviate the human suffering. Some of these measures includes traditional rain water harvesting, diversification of farming activities, use of drought tolerant crop varieties, innovative kitchen gardens with reduced rates of water infiltration, pasture improvement through reseeding programmes among others (Musimba & Nyariki, 2004; Nyariki *et al.*, 2005; Mude *et al*., 2007, Nyangito *et al*., 2008; Jama *et al.*, 2009). Other sustainable technologies introduced and upscaled by the University of Nairobi and KARI researchers were; production and use of disease free cassava planting materials, mixed cropping using cassava and cowpeas, identification of crop pests and their management and value addition of agricultural products such as lactic acid fermentation and drying of cowpea leaves, which can then be easily stored and used or sold later on.

These techniques such as improved run-off harvesting techniques have enabled these communities to produce crops when the neighbors who don't practice cannot harvest anything (Mwang'ombe *et al*., 2010). Apart from producing food for their subsistence use, some are even able to get some surplus for sale to augment household incomes. In addition, farmers are able to diversify their crops from the traditional maize and beans to include potatoes, carrots, onions, soya beans, millet, bananas and fruits. This diversity has contributed to food security and wider nutrient base (Nyariki *et al*., 2005).

These technologies have enabled these communities attain food security and reduce poverty, have tremendous contribution to environmental improvement. For instance water harvesting and grass reseeding has contributed to land rehabilitation thus improving the denuded areas (Mnene, 2004; Orindi *et al*., 2008).

The objectives of the study was to identify innovative and sustainable technologies that can be validated and upscaled in drylands to help communities feed themselves, generate income, arrest the environmental degradation and cope with the effects of climate change. Technologies that can be used in value addition were also targeted to address the issue of high losses and poor returns due to poor storability and market glut that characterizes bumper harvest of crops.

Materials and methods

Study area. The pilot study was carried out in Kibwezi district which is a semi-arid area located approximately 200 km South East of Nairobi. The district lies between the latitudes 2º 6´ S and 3ºS, and longitude 37º36´ E and 38º30´ E, respectively, and has a total area of 3400 km². It is inhabited by Akamba community who are mainly agro-pastoralists. The area is a typical semi-arid land characterized by low, erratic and unreliable rainfall. The average annual rainfall, evaporation and temperatures are 600mm, 2000 mm and 23°C, respectively. Due to its proximate position along the equator, the area experiences a bimodal pattern of rainfall with long rains from March - May and short rains from November – December. The short rains are more reliable in time than long rains and are therefore more important.

The sustainable technologies identified and validated were upscaled in Mwatate district of Taita Taveta County and Kaloleni and Kilifi districts in Kilifi county. All these districts are characterized by warm temperatures over 25^{0}C throughout the year with two seasons of moderate rainfall (about 800-1000mm). The long rains start around March and last up to July, while the short rains that start around October last until December. The study focused on farmer groups one each in Kibwezi and Mwatate, six from Kilifi and one from Kaloleni district.

Data collection

Individual interviews. Structured questionnaires were developed and pre-tested on a few households to ensure that the final questionnaire had only relevant and appropriately phrased questions. The questionnaires were administered by trained enumerators and information captured included historical trends of climate variability, its effects on crops, livestock, pastures, water resources, and the coping strategies or technologies adopted by the farmers, knowledge on pests and diseases, value addition, marketing strategies among others. A sampling frame which included 5 households per sub-location, 3 sub-locations per location, 3 locations per division, and 3 divisions per district was adopted to attain the sample size.

Family portraits. Ten households from Kibwezi district were selected, 5 of them who were practicing water harvesting techniques and five which were not and used to develop family portrait to give a description and analysis of how a given family collectively organizes its social and material assets in order to make a living. The portrait was to provide a great deal of detail on specific activities carried out by individual family members on a seasonal and historical basis, and highlighting the major constrains they face in their struggle to provide for themselves. It also helps to present an immediate human dimension to many of the issues surrounding livelihoods and climate variability and change. The family portrait also aids in generating an in-depth understanding of broader livelihood issues and dynamics at community and higher levels.

Focused group discussions. Focused groups' discussion sessions were organized for each of the farmer groups. Discussions involved over thirty farmers in all locations sampled purposively by invitation, and the scientists from University of Nairobi and KARI. The discussions were carried out with help of structured discussant questions, with the help of identified facilitators from attending scientists.

Data analysis. The collected data were analyzed using the Statistical Package for Social Sciences (SPSS) version 12. Most of the data was subjected to descriptive statistical analysis to generate means, frequencies, which were then presented in graphs. The narrative information from the family portraits was summarized and used to support discussion under respective sections.

Communication/dissemination of the research findings for up scaling and out scaling purposes. Appropriate dissemination strategies were developed including both formal and informal approaches. Informal approach involved meeting with households during project implementation to expose them to successful and innovative techniques among the peers. The most successful techniques were documented in DVDs and converted into easily readable materials which can be communicated by "farmer-to farmer". Formal communication approach involved communication packages such as scientific papers published in journals, and other documentation emanating from the project.

Results and discussions

The effects of climate change reported by majority of the respondents was increased frequency of droughts, floods, strong winds, changes in rainfall patterns and increased temperatures. The reported climatic events have resulted in the drying up of surface and sub-surface water sources, thereby complicating lives of communities in these areas. These events have affected both livestock and crop farming in the area. The main impacts on livestock production have been in terms of weight loss of the animals, increased diseases and subsequent death of livestock, reduced livestock fertility and milk production.

The coping mechanisms which include a raft of technologies and measures adopted differed slightly between the livestock and crop farmers. Measures adopted to mitigate effect of climate variability on crop production included purchase of grains from the market, storage of previous harvests, planting of drought tolerant crops, spraying crops against pests, terracing to conserve soil and moisture, early planting and early land preparation. Some of the most dramatic and innovative technologies that were identified and upscaled were the rain water harvesting technologies. Various methods of rain water harvesting have been used by dryland communities in an effort to cope with water scarcity in these areas (Madeley, 2009).

Some of the technologies devised by the communities to cope with water scarcity included rainwater harvesting using roof catchment, sinking of boreholes, and digging shallow wells in dry river beds. The water harvesting measures were being done at both household and community level for both agro-pastoralists and pastoralists communities. These water scarcity coping practices have been reported to be commonly practiced by communities living in drylands and the choice of method is dictated mainly by the resources available (Watson, 2003). Households that were using roof catchments to harvest rain water indicated that their efforts were hampered by lack of storage containers. Other studies have shown that, dryland communities are aware and willing to take up measures to cope with ravages brought by climate change (Hendrickx *et al.*, 2008).

Households adopted a number of strategies to mitigate the effects of unusual climatic events on their livestock. The measures adopted, in order of importance, were treatment of livestock diseases, stocking of drought tolerant breeds, purchasing of fodder, pasture conservation, and destocking. Water was reportedly to be a major constrain in both crop and livestock production and farmers had adopted different mitigation strategies for coping with this problem. This agrees with other findings by other researchers (Thornton *et al.*, 2009). Water scarcity is compounded by the fact that most of the rivers in the area are seasonal and the predominantly sandy soils allow very fast percolation of water with very low retention.

Maize was reported to be the most popular crop in these areas with all farmers cultivating the crop. This is despite the fact that the rainfall in these areas was inadequate to support the crop. In Kilifi county, the research team had gathered through the questionnaires that cassava and cowpeas were popular among the farmers with 95% and 68% of the farmers respectively cultivating these crops. Kibanda Meno and Tajirika were the most common cassava varieties grown by the farmers in the two districts. Only 2% of the famers were growing the variety Shibe while Karembo that tends to be bitter in some environments is used for alcohol production. Kibanda Meno was the most popular with over 45.5% of the farmers cultivating the variety.

Various insect pests and diseases were reported to be a problem in cassava production for both Kibanda Meno and Tajirika. White flies were the major insect pest reported and only 5.2% of the farmers sprayed against it while 87.9% of the farmers do not apply any management strategy. Farmers did not know that whiteflies were the vectors of cassava mosaic disease and hence did not bother to control it. Majority of the farmers perceived cassava mosaic disease (CMD) to be a very important disease but 90.6% of the respondents do not do anything about the disease. This could be explained by the lack of knowledge in the appropriate disease management strategies.

Majority (84%) of the famers cultivate local cowpea varieties since they are superior to new varieties in terms of cooking qualities, yields, seeds availability, early maturing and suitability for intercropping. Leaf borers was the most common (95.7%) pest reported on cowpeas, however 78% of the farmers do not do anything about it while 14.3% spray using insecticides. The other pests identified in cowpeas were whiteflies (*Bemisia tabaci*), semi-lopper (*Plusia orechalcea*, bean flies *(Ophiomyia phaseoli),* black bean aphids *(Aphis fabae),* leaf beetles *(Medythia quarterna)*, bean webworm *(Lamprosema indica)*, systates weevil *(Systates pollinos.* Leaf rust was reported to be the major disease on cowpeas by all the respondents interviewed. Septoria leaf spot was also reported on cowpeas but at low incidence. Insect pests were reported to be the most (84%) limiting constraints in production followed by unreliable rainfall (75%).

Majority (81%) of the farmers acquire planting materials from their neighbours. This acquisition of planting materials has contributed to the spread of the disease as most of these planting materials are diseased and disease indexing is not done. Unavailability of clean disease free planting cassava, lack of a sustained seed propagation system, low soil fertility, inappropriate cropping systems and lack of a viable functional value addition chain linking farmers to both local and international markets were identified to be the major constraints and this agrees with reports from other workers (Karuri *et al.*, 2001; Ntawuruhunga & Legg, 2007; Westby, 2008). Most of the cassava germplasm resistant to CMD has been found to be highly susceptible to cassava brown streak disease (CBSD) and these are materials that were being promoted for the management of the CMD pandemic. This has fueled the spread of CBSD as also reported by Ntawuruhunga & Legg (2007).

Most of the drylands are characterized by poor soil fertility due to overexploitation of soil resources without replenishing nutrients. Hence intercrops such as cassava/ cowpeas intercropping should be encouraged as also observed by Howeler (1991).

Farmers knowledge on pest and disease identification was wanting and this hampered effective management of such. This is compounded by the fact that a myriad of pests and diseases are known to attack these crops as reported by Mware *et al*. (2009). However many farmers could identify common diseases such as CMD due to the training received from extension staff as also observed by Njenga *et al*. (2005).

Symptoms of CBSD are less conspicuous and farmers are often unaware of the problem until the roots are harvested and the corky, yellow brown necrotic rot becomes evident and these complicates the management of the problem as also reported by Alicai *et al.* (2007). CBSD may be latent where some infected plants may be symptomless and some varieties express symptoms in roots but not on leaves Ntawuruhunga & Legg (2007). This makes the detection of the disease on planting materials impossible resulting to distribution of such materials to unsuspecting growers.

Farmers were found to have limited value addition of cassava and vegetables. Some farmers were processing cassava chips and crisps, grinding cassava into flour for baking bread and porridge making. Cassava has many other uses as reported by Karuri *et al*. (2001) and processed cassava stores longer that the raw cassava. However inappropriate storage facilities for both raw and dried cassava products and lack of technological knowhow and equipments have been hampering their efforts in cassava processing. Cassava can also be used as animal feed but farmers should be trained to avoid poisoning as it happens when a lot of peels are fed to the livestock as reported by Westby (2008). Lactic acid fermentation and drying of cowpea leaves was demonstrated to the farmers and they were able to try out the technology. Indeed the farmer response to the simple yet effective vegetable leaf preservation was positive. The agricultural extension staff followed with a demonstration of the technology at the agricultural show in Mombasa for wider adaption.

Conclusions

Sustainable technologies in coping with climate change exist among communities and the study found these technologies practical and effective and there is need to upscale and out-scale them. Most of these technologies are not capital intensive making them feasible for adoption by the communities in dry lands most of who are resource poor. However, training and demonstrations are prerequisite for their adoption. These technologies will go a long way in improving the livelihoods of the people and enabling them to be food secure. Farmers also need to be enabled to diversify their farming activities by provision of disease free planting materials. The value addition innovations in cassava and vegetables need to be strengthened to enable the farmers earn more from their crops and facilitate them to store the produce in a form that is easily storable without spoilage and subsequent loses. The farmers also require linkage with the various market outlets so as to address the marketing challenges that is a problem during good season when farmers realize a bumper harvest. Training farmers on disease and pest identification needs to be strengthened to enable effective management of these problems.

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