HURIA

Journal of The Open University of Tanzania
Volume 22 August, 2016 ISSN 0856 6739

Special Issue: Edited Proceedings of the 4th COSTECH Annual National STI Conference and Exhibitions held from From 24th – 26th June 2015 at the Julius Nyerere Convention Center in Dar es Salaam, Tanzania

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Editorial

The Tanzania Commission for Science and Technology (COSTECH) was established in 1986 by Act of Parliamentary No. 7 as a successor to the Tanzania National Scientific Research Council (UTAFITI) with the responsibility of coordinating and promoting research and technology development activities in the country. The Commission is an apex organ with the responsibility of advising the Government on the use of Science, Technology and Innovation for socio economic development.

One of the COSTECH's mandates is to coordinate and promote research in the country. Since its establishment, COSTECH has been providing various scientific platforms for researchers to meet and share experiences on various issues pertaining to research in the country. The Science, Technology and Innovation (STI) conference has always been one of those platforms.

From 24th – 26th June 2015 the COSTECH organized the 4th Annual National STI Conference and exhibitions held at the Julius Nyerere Convention Center in Dar es Salaam, Tanzania. The Conference was officially opened by His Excellency Dr. Jakaya Mrisho Kikwete, The former President of the United Republic of Tanzania. The conference theme was, *Fostering Innovations for Sustainable Development and Industrial Growth*.

During this scientific event more that 24 papers were presented by local researchers from academia and Research and Development (R&D) institutions. The conference was organized into panel discussions, six oral sessions that include Innovations for Industrial Applications; Commercialization of Research Results; Linking Science to Indigenous Knowledge; Climate Change and livelihoods; Diffusion/Adoption of Technologies; Emerging and Platform Technologies and exhibits of innovations and research outputs.

In order to make the information and ideas presented at the conference promptly and widely available, participants from academia and R&D institutions in the conference were invited to submit written papers based on their presentations for inclusion in refereed conference proceedings to be published in the HURIA Journal of The Open University of Tanzania.

Each paper submitted for consideration was peer-reviewed according to the requirements of the Scientific Editors which was comprised by Scientists from COSTECH, Academia and R&D institutions in Tanzania. These scientists independently provided a scholarly judgment on the paper's suitability for Annual STI Presentation publication. A total of 24 papers were submitted to

Huria Journal for Publication out which 14 papers were qualified for publication after undergoing peer review and editing process.

The COSTECH Management is grateful to first, the researchers who agreed to submit full written papers and second, to the Open University of Tanzania (OUT) for agreeing to publish them in HURIA journal.

COSTECH is also grateful to the Chairman of the Board of Commissioners and the Government of The United Republic of Tanzania to allow it to demonstrate its potential in supporting research that in turn will provide opportunities to Tanzanians to exploit National resources more effectively and sustainably.

With these few words, I sincerely hope that this journal, together with our website, and other knowledge products, will serve as a valuable source of scientific information to our esteemed stakeholders. It is also my hope that readers will be a dependable source of information for upcoming STI conferences.

I wish you all happy reading.



Dr. Hassan Mshinda
Director General
COSTECH

Why is the Red Spider Mite (*Tetranychus evansi*) a threat to Dry Season Tomato Growing in Tabora, Tanzania?

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Abstract: *Dry season tomato (Lycopersicon esculentum L.) growing is an important economic activity in semi-arid Tabora region of western Tanzania. However, red spider mite (Tetranychus evansi Baker & Prichard) has emerged as a threat to dry season tomato growing in smallholders' fields. A study was carried out in Tabora, Tanzania in order to discover factors leading to increased red spider mite infestation in tomato fields. A survey of dry season tomato growing fields was carried out in June through September in the districts of Uyui, Urambo and Tabora Municipality, for a period of three years from 2012 through 2014. Discussions with farmers and collection of pesticide containers left in the fields helped us to understand the existing gap for establishment of an effective strategy for red spider mite control. It was found that farmers lack a strong agricultural extension support to effect the integration of basic technical guidelines of integrated pest management and safe procedures of pesticide handling practiced in intensive outdoor tomato growing system. The results show that there was a high significant difference (P<0.001) in the severity of attack by red tomato spider mites among tomato fields. Red spider mites attack a wide range of alternative host plants including weeds and field crops. Profecron 720 gm/litre insecticide was used by most farmers (55.5%). Red spide mites significantly (P<0.001) attached tomato leaves than stems and dry flowers. They caused up to 100% crop loss in tomato. Use of inefective chemicals, poor field sanitation, dry climate and lack of agricultural extension support in agronomy and pesticide use were identified as factors contributing to farmers' inability to control red spider mites in the study area. Waging a war against red spider mites is urgently needed by stakeholders engaged in horticulture.*

Keywords: Dry season, *Tetranychus evansi*, tomato growing, Tanzania

INTRODUCTION

Tomato (*Lycopersicon esculentum* L) is an important vegetable crop grown in smallholders' gardens because of its high potential to address the food and income needs in Tanzania (Ngowi *et al*., 2007). Tomato is a common traded vegetable crop in Tanzania. The crop is produced by smallholder farmers under different agro-ecological zones in the country. One of the major constraints to tomato production is the high prevalence of devastating pests, particularly the red spider mites (Acari: *Tetranychus evansi* Baker & Pritchard). Spider mites are small (adult female are <0.5mm in size), cryptic

and easily transported hidden within commodities (Najavas *et al*., 2010). A single mated female has the potential to initiate a successful invasion due to its high reproductive rate (Sabelis, 1985; Moraes and McMurtry, 1987.

Bonato, 1999). *T. evansi*, possibly the native to South America, is a spider mite pest of Solanaceous crops and is currently considered to be an aggressive invasive species in the world (Boubou *et al*., 2010; Boubou *et al*., 2012). The modeling study results on the global distribution of *T. evansi* show that dryness and excessive moisture stresses limit the distribution of this pest (Migeon *et al*., 2008). The threat of invasive red spider mites is increasing in the world due to increased dryness (Navajas *et al*., 2010). The red spider mite is considered as the most difficult pest to control, causing significant crop yield losses in African countries, including Zimbabwe (Mariatou and Kwaramba, 1999; Saunyama and Knapp, 2003), Kenya (Onyambus *et al*., 2011) and Malawi (Nyoni *et al*., 2011). Studies on spider mites report increasing insensitivity of red mites to applied Imidacloprid insecticides (Szczepaniec *et al*., 2011; Raupp *et al*., 2004). In some studies successful control of red tomato mites using indigenous and synthetic pesticides has been reported (Muzemu *et al*., 2011). Mutation of red mite population has been found to increase their resistance to pyrethroids (Benjamin *et al*., 2011; Nyoni *et al*., 2011). Smallholder farmers lack appropriate equipment for spraying red mites that infest such plant cells behind the leaves (Sibanda *et al*., 2000). Vegetable growing and marketing is an expanding sector for smallholder farmers to diversify household incomes (Nyamwamu *et al*., 2012). But, spider mites cause significant economic losses of up to 90% of the crop (*Sibanda et al*., 2000). The main hosts of *T. evansi* are Solanaceae (De Moraes *et al*., 1987; Bolland *et al*., 1998; Jeppson *et al*., 1975).

The destruction of red mites on crops is exacerbated by increased temperature and dryness (Nyiira, 1980). Lack of adequate cultural practices for red mite control have been cited as the factors that increase their negative impact on crop destruction (Inoue, 1995). However, cultural practices are important in pest control in tomato production (Kumar and Sigh, 2000). Tomato growers in Tanzania intensively use insecticides to control various insect pests including red tomato spider mites (Ngowi *et al*., 2007) and fungal diseases (Lyimo *et al*., 1998). The problem of red mites on tomato has been reported to be increasing because red tomato spider mites are insensitive to common insect pesticides. Lack of water to effect appropriate irrigation has been noted as factor increasing red mite infestation in dry season agriculture in semi-arid areas of western Tanzania. It is important to study drivers of *T. evansi* infestation at field level with farmers' participation. The detailed analysis of cultural practices at farm level underscores the possibility of developing field management based interventions. This study was conducted on smallholders'

tomato growing fields to identify cultural practices, and management gaps leading to increased red tomato spider mite populations.

MATERIALS AND METHODS

Study area

The study was carried at Tumbi, Tabora, in Tanzania (E 032° 41´46.7´´ S 05°04´55.4´´ with an elevation of 1155m a.s.l.). The study was conducted for three years - 2011-2014. Tomato growing is a dominant occupation of smallholder farmers during the dry season in the months of June through September. Tomato plants are irrigated using underground water collected from hand-dug shallow open wells. Different soils are used for tomato growing, including Gleyic Arenosols, Eutric Cambisols, and Fluvisols in valley bottoms (Mitchell, 1984).

Seasonal rainfall distribution and wind speed in Tabora region

Red spider mites increase in population during the dry season between the months of June through September. The period of dryness is also characterized by increased wind speed that influences red spider mites' dispersal over long distances. The red spider mite attack on plants is influenced by dryness as observed in previous studies pest (Migeon *et al*., 2008).The long dry season and the associated increased wind speed in Tabora region support breeding of red spider mites. Red spider mites move under the aid of wind which increases from the month of June through September (Figure 1).

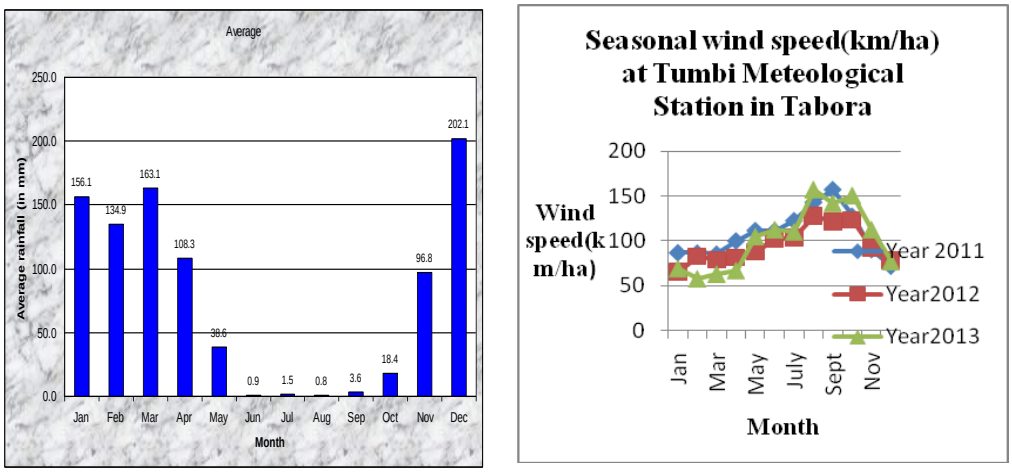


Figure 1: Seasonal rainfall distribution(Left) and Wind speed (Right) characteristics of Tabora region,Tanzania(Tumbi Agrometeological Station)

Assessment of red spider mite severity in tomato fields

Field sampling of 20 tomato plants was done and the level of mite damage of tomato leaves was assigned a leaf damage score of 1-5 (1= few yellow spots, 5= dried leaves, plant with webbings). Field observations were carried out to study the post-harvest infestation of harvested tomato plants by red tomato mites. The score on leaf damage of 1-5 was assigned to different harvested tomato fields. The data was organized and statistically analyzed using ANOVA procedures, and software tools - the GenStat Discovery Edition 4 and VSN International Ltd.

Alternative host plants species of red spider mites in Tabora region in Tanzania

Field observations and farmer experiences were used to identify plant spicies host of red spider mites. Identification of plants in local language was given by farmers. Botanical names were assigned to identified plant spicies using respective literature in Botany (Akobundu and Agyakwa, 1987; Ruffo *et al*., 2002).

RESULTS AND DISCUSSIONS

Red spider mites feed mostly on tomato leaves, but as the leave dries up they move to the reproductive parts of the plant that are considered to be mineral nutrient sink for the plant. Tomato leaves are most preferred for feeding, breeding and hiding places for red mites on tomato plants (Table 1).The progressive death of tomato leaves, cause red spider mites to move to different parts of the tomato plant. Fresh tomato stalks and dried tomato floral parts are used by red spider mites for feeding when the leaves dry. This emphasizes the importance of post-harvest sanitation of infested tomato fields to reduce red spider mites' populations and subsequent infestation of non-infested fields.

Table 1: Mean Red Spider Mites Attack Severity on Dried Tomato Flowers, Stalks and Leaves

Part of Tomato plant	Red spide mite severity (RSMS)
Tomato flowers (n = 30)	12.00
Tomato stalks (n = 30)	13.00
Tomato leaves (n = 120)	49.00
F-test	F = 18.26 , p<.0001
CV	127.9
LSD0.05	29.64

There was a high significant difference ($p<0.001$) of red spider mites infestation in tomato fields indicating that the control of red spider mites in

tomato fields was variable among farmers who had different knowledge and resources for controlling this pest (Table,2).

Table 2: Analysis of Variance of the Severity of Red Spider Mites in Post-harvested Tomato Fields

Source of variation	Df	SS	MS	Vr	Fpr
Tomato plants	19	10.6250	0.5592	0.82	
Tomato fields	5	178.1417	35.6283	52.05	<.001
Residual	95	65.0250	0.6845		
Total	119	253.7917			

Methods used by farmers to control red spider mites in fields

Farmers used different brands of insecticides for control of red spider mites (Table 3). The common insecticides used by farmers were Profecron 720gm/litre which constitute 55.5% of all the insecticides used by farmers in insect pest control in tomato plants. According to farmers' observations, broad spectrum insecticides were ineffective against the red spider mites. Similar observations are documented in other studies including, Szczepaniec *et al.* (2011) and Raupp *et al*. (2004). Broad spectrum insecticides were found to kill the natural enemies of the red spider mites thus promoting their population increase (ICIPE, 2003). Sibanda *et al*. (2000) observed that, smallholders in Zimbabwe lack appropriate chemical spray equipment for effective control of red spider mites which feed on the underside of the leaf. Farmers lack knowledge of using appropriate and effective pesticide for control of red spider mites. Use of ineffective chemicals for red spider mites control has been documented in different studies (Szczepaniec *et al*., 2011; Raupp *et al*., 2004). In this study different 92 ineffective chemicals are used by farmers to control red spider mites in Tabora, Tanzania (Table, 3).

Table 3: Insecticide Brands Used for Control of Insect Pest Among Tomato Growers in Tabora Region

SN	Trade name	Action	Active ingredient	Manufacturing company	Frequency
1	AmeCron 720 EC	Non-systemic fungicide and acaricide with contact and stomach action	Profenofos 720 g/L	Ametech International GmbH,Germany	1
2	ABANIL 18 EC	Insecticide for control of spidermites on fruits	Abamectin 18g/L	Farmbase LTD, Dar es Salaam,Tanzania	2
3	Amekan C344 SE	Systemic insecticide with contact stomach action	Cypermethrin 144g/L+Imidaclo prid 200 g/L	Ametech Chemicals Ltd, GmbH, Germany	6

4	ASCOMEC 1.8 EC	Broad spectrum insecticide	Abamectin,18 g/L	Sharda Worldwide Exports, Ltd,India	6
5	ATTAKAN C244 SE	A broad spectrum insecticide	Cypermethrin, 144g/L+ Imidacloprid 200g/L		1
6	BAMETRIN 2.5 EC	A broad spectrum pyrethroid insecticide	Deltamethrin 25g/L EC	Avestar Industrial Ltd	1
7	BANOFOS 720 EC	A foliar insecticide and acaricide with contact action	Profenofos 720 g/L	Bajuta International(T) Ltd	1
8	Confidor	A systemic insecticide used as a foliar and soil application	Imidacloprid 200g/L	Bayer Crop Science,GmbH,Germany	4
9	DICHLORVOS 100% EC	Insecticide	Dichlorvos 100% EC	Agrochemical Ltd Kampala	1
10	DUDU-ALL 450EC	A broad spectrum insecticide	Cypermethrin 10%+ Chlorpyrifos 35%	Hanghou Agrochemicals Ltd, China	3
11	Dume 40 EC	Insecticide with contact action	Dimethoate 400g/L	Nanjing Limin Chemical Ltd,China	2
12	FARMGURD 344 EC	A systemic insecticide for control of aphids, bollworm and sucking insects	Cypermethrin 144g/L+ Imidacloprid 200/L SE	Farmbase LTD,Dar es Salaam,Tanzania	3
13	FARMRIFOS 48EC (DURSBAN 48%)	Insecticide	Chlopyrifos 480g/L	NANJING LIMIN CHEMICAL(CO) Ltd China LTD.	1
14	KUNG FU 5 EC	Insecticide	Lambda cyhalotrin 50 g/L	Sulphur Mills Chemical Company Ltd,India	7
15	METAKAN SUPER 350 EC	A broad spectrum systemic insecticide with contact and stomach action	Cypermethrin g/L+ Imidacloprid /L SE		1
16	LAMBDASCOPE 5EC	Abroad spectrum contact and stomach acting pyrethroid insecticide	50g/L Lambdacyhalothrin	Cropstar(UK) Chemical Industry Limited	2
17	Profecron 720 EC	Broad spectrum insecticide	Profenofos 720 g/L litre	Nagarjuna Agrichem Ltd,India	35
18	Profit 720 EC	Foliar insecticide	Profenofos 720 g/L	DVA Agro GmbH,Germany	1
1	SUBA CHLO	Insecticide with	Chloropyrifos	Sulphur Mills Ltd,	5

9	55 EC +INSECTICIDE	contact action	50% +Cypermethrin 5.0% +Inert materials 52.0%	India	
20	SUPERCRON (Profenofos 500EC)	Broad spectrum non-systemic, contact,ovicidal and stomach acting insecticide	Profenofos 50%/L	Eximco Agro-Limited Hong Kong,China	8
21	Zetabestox™ 10%EC	Insecticide/Acaricide	Zeta-Cypemetrin 10%	Not indicated	1
	Total				**92**

Use of non-effective insecticides in the control of red spider mites (Table 3) was a big constraint to dry season tomato production. Most farmers used broad spectrum insecticides (Table 3) to control red spider mites of which Profecron 720 gm/litre active ingredient containing insecticides were common constituting of 55.5% of total number of insecticides used in tomato growing. Broad spectrum insecticides are less effective against red spider mites (Szczepaniec *et al*., 2011; Raupp *et al*., 2004). In this study Abamectin 18g/litre active ingredient containing insecticides were reported by farmers to be effective against red spider mites. However, these insecticides constitute only 9.5% of the insecticides used by farmers**.**

Importance of post-harvest field sanitation for effective control of red spider mites breeding sites

Cultural control methods such as field sanitation for destroying breeding sites have been neglected among tomato growers (Table 4). There was a significant difference of red spider mites' infestation in tomato fields and on post-harvested tomato fields indicating the farmers' negligence of conducting field sanitation on living post-harvested crops host to red spider mites (Table 4). Farmers in Tabora region, lack organization and training on tomato production and integrated pest management and handling of pesticides as documented in northern Tanzania (Musebe *et al*., 2014). The tomato production scale is small and in some cases it has the subsistence character as opposed to intensive commercial tomato production under adequate water supply (Musebe *et al*., 2014).

Table 4: Analysis of Variance of the Severity of Red Spider Mites in Post-harvested Tomato Fields

Source of variation	Df	SS	MS	Vr	Fpr
Tomato plants	19	10.6250	0.5592	0.82	
Tomato fields	5	178.1417	35.6283	52.05	<.001
Residual	95	65.0250	0.6845		
Total	**119**	**253.7917**			



Figure 2: Severe red spider mite attacked of tomato plants at Tumbi, Tabora in Tanzania

Tomato yield loss caused by red spider mites range from 20 to 100%. Late infestation of the crop has cause low yield loss as compared to early tomato plant growth infestation in absence of effective chemical control method and water scarcity to cause effective watering of tomato plants during the peak of the dry season in the month of July through September (Figure 2).

The spectrum of red spider mites alternative host species in Tabora, Tanzania

Plant species in the Solanaceae family have been reported to be most preferred by red spider mites in different studies (De Moraes *et al*., 1987; Bolland *et al*., 1998; Jeppson *et al*., 1975). In this study plant species outside the family

Solanaceae were found to host red spider mites. Plants in the families of Asteraceae, Fabaceae, Cucurbitaceae, Lamiaceae, Malvaceae and Poaceae were found to host red spider mites simultaneously with those plants in the family Sonaceae.

Table 2: Alternative Host Plant Spicies to Red Spider Mites in Tabora,

Botanical name	Family	Nature of plant
Nicandra physaloides (L.) Gaertn	Solanaceae	Common weed
Nicotiana tabacum (L).	Solanaceae	Field cash crop
Phaseolus vulgaris (L.)	Fabaceae	Field food crop
Cucurbita maxima Duchesne	Cucurbitaceae	Field food crop
Sida acuta Burm.f.	Malvaceae	Common weed
Acanthospermum hispidum DC.	Asteraceae	Common weed
Solunum incanum L	Solanaceae	Common weed
Solunum torvum Sw	Solanaceae	Common weed
Solanaceous aethiopicum (L)	Solanaceae	Field food crop
Hyptis lancoelata Poir	Lamiaceae	Common weed
Hyparrhenia rufa	Poaceae	Common weed

CONCLUSIONS

The problem of red spider mites infestation in dry season tomato growing is growing and is considered by farmers as a menace. Red spider mites pose a threat to dry season tomato growing. Farmers have little knowledge on the effective use of insecticides for red spider control. The use of broad spectrum insecticides is less effective for control of red spider mites. Abamectin 18 gm/litre active ingredient have significant control of these pests. However, the price of Abamectin containing insecticides is reported to be higher compared to other insecticides.

This study has showed that there are alternative plant species host to *T.evansi* outside the Solanaceae family such as Asteraceae, Cucurbitaceae, Fabaceae, Malvaceae, Lamiaceae and Poaceae. Integrated approach for red spider mites control is needed. This should include; the use of acaricides and other effective chemicals, chemical adjutants to improve the effectiveness of applied chemicals, water use efficient methods and increased agricultural extension support for dry season tomato growing farmers.

ACKNOWLEDGEMENT

The contribution of farmers in Mapula, Farm Mnyamwezi, Tumbi, (Tabora Municipality) Igombe (Uyui District) and Imalamakoye (Urambo District) is highly appreciated in supporting the field work throughout the study period.

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Decision Support Systems in Forest Management: An Integrated Approach

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Abstract: *Decision making process - especially in natural resources management, encounters myriad of challenges to objective decisions, significant decision depends on amount of information and capability of decision makers to handle massive data. In forest management, these challenges such as lack of enough data and cost associated with obtaining insitu spatial data, have been minimised with the use Geospatial Decision Support System (GDSS). GDSS has shown great capability of capturing, storing, analysing, retrieving and manipulating data for aiding spatial decisions. This technology proliferates quickly and as a result decision makers overlook other systems for forest governing. Following this situation, people living adjacent to forests have found it difficult to accessing forest resources - and their livelihoods, which depends on forests have been compromised. The continuing degradation of forest resources despite existence of different management strategies - such as (community based forest management and joint forest management), has made it necessary to assess decisions on forest conservation. Focus Group Discussion (FGD) strategy was applied to capture extent of use of Indigenous and Local Knowledge (ILK) and GDSS in forest management decisions, observation was applied to implicitly relate the narration from FGD and the reality while interview method was applied to forest officials to capture use of ILK in forest decision making. The results revealed that ILK related to forest management; however the uncovered ILK has been insignificantly used together with GDSS in making decision for conservation. This paper establishes the ignorance on ILK as one among other factors behind the continued forest cover depletion despite existence of conventional conservation strategies. The developed framework integrates GDSS and ILK to aid forest decisions which will ensure sustainable forest conservation and serves for forest needs of the communities adjacent.*

Key Words: Decision support systems, indigenous knowledge, decision making and forest management.

INTRODUCTION

The imperative to formulate good regulations for management of forests and enforce them is strongly reflected both in outcomes one and two of the UN conference on environment and development (Rio de Jeneiro, 1992 - the first outcome at balancing social economic dimensions by integrating environment and development into decision making by improving decision making processes. This outcome further called for integration of economic, social and environmental consideration in decision making at all levels. The second outcome aimed for conservation and management of resources for development in ways which includes integrated approaches to planning and management of land resources, combating deforestation, combating desertification and drought also conservation of biological diversity and promoting sustainable agriculture and rural development. The reality is that human ecological footprints are exceeding ecological capacity of the environment and this is the concern that calls for global efforts to forest management. This concern was firstly pointed out in a mission report titled "Limits to Growth" by the Massachusetts Institute of Technology for the Club of Rome (1972, 2004) and in Wackerngel and Rees (1996).

Since then there have been different development strategies in the world which have resulted in today's status of forest management - in the world, Africa, and particularly in Tanzania. However, in social practice these strategies have been facing challenges in their implementation. A serious challenge is in the area of decision making. Forest managers around the world find the use of geospatial data collection and analysis tools easier to use when making decision. This is because with geospatial tools, data manipulation is made easier hence aiding greatly the process of o decision making. Unfortunately, decision is not only independent to technical spatial data; other information like the socio ecological is also important. However this is hardly incorporated with spatial data when using geospatial tools in decision making process. A challenge arising from this argument is the possibility of making a decision which does not consider community needs from the resource.

To ensure decisions balance user's needs and conserve for future user's needs, there is a need of having massive data to accommodate different needs during decision making. Geospatial tools - in this case referred to as Remote Sensing and Geographical Information Systems, have manifested great capability of gathering spatial data, hence aiding forest decisions (Turban et al., 2001; Mc Connell and Burger, 2011). Indigenous knowledge has also - in several occasions, proven the ability to aid forest decisions by providing sociological data (Briggs, 2005, Brossius, 2005, Kajembe, 2009 and Cooper, 2010). Both tools are not self satisfactory in terms of other data. Geospatial data is rich in scientific ecological explanation but is lacking in socio ecological explanations.

The vice versa is true for indigenous knowledge. It is therefore the task of forest decision makers and managers to consider both tools to be able to gather multiple data for forest decision making.

Geospatial technologies which are referred in this context as Geospatial Decision Support Systems and ILK are both treated as decision support systems for forest management but in different levels. The challenges have been on the efficiency of the each tool in aiding forests management and whether one is superior to the other. The adoption of GDSS has changed many scientists and other decision makers thinking towards forest management. They have been impressed by the ability of GDSS in aiding forest decisions to the extent of stereotyping other tools like the ILK.

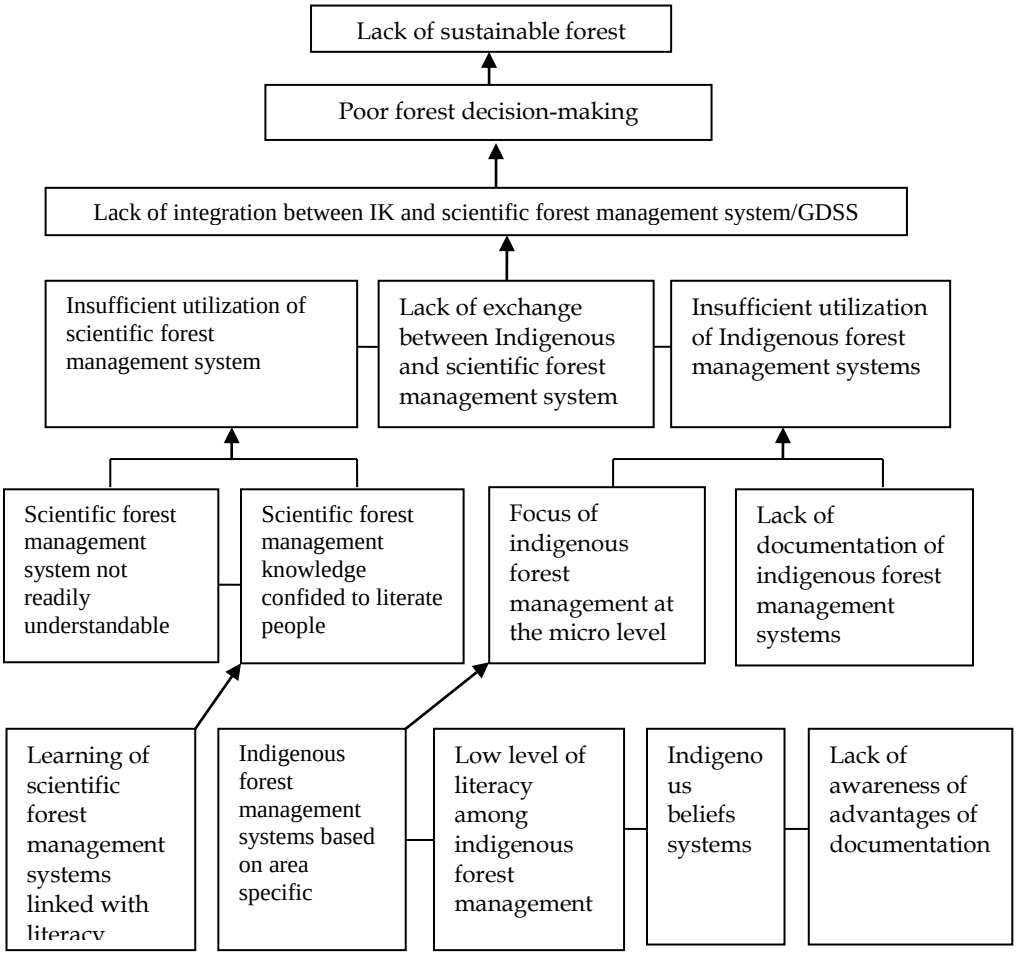


Figure 1: Challenges Associated with Non-Integration of Forest Management Decision Approach

This and the proliferation of forest-related science and technologies have led to erosion of ILK together with its consideration to forest management. Community forest needs are now compromised more than ever and forest sustainability has increasingly become jeopardized. According to McCall and Minang (2005) respect of indigenous knowledge is one of the key aspects of good governance and decision making. Further, it is a positive measure of local community capability, with potential to set community members on an equal status with outsider's experts, and maybe the only resources of which the local group, especially the resources poor, has unhindered ownership. Ignoring ILK in decision making is more of top down management from technological expertise, as the technology leaves much to be desired over the activity in question when it comes to implementation of the made decision. Figure 1 highlights shortfalls of each tool and challenges associated with non integration of IK and GDSS in forest decision making.

As per Figure 1, the use of scientific tools in forest management (RS&GIS) is based on literacy. This means that scientific forest management is confined only to literate people mostly forest experts. Furthermore, the use of scientific tools in forest management is not readily understandable to illiterate people. On the other hand ILK is area specific and confined more on indigenous people with indigenous beliefs. Furthermore, ILK is characterised with lack of documentation and awareness to the importance of documentation. The confinement of ILK to micro level of the community curbs its use in forest decision making. The same impact results on the use of scientific tools such as RS and GIS in forest management as it confined to only literate people. If indigenous and local knowledge does not link with science or vice versa, the result is lack of enough information to forest decision making. The scientific point of view lacks ILK and ILK lacks the technical scientific point of view. This generally results in poor forest decision making and eventually unsustainable forests.

There is a need, therefore, of integrating ILK with spatial data to aid in cross cutting decision making in favour of both community and the forest ecosystem. The two arguments uncover the pressing need to improve and regulate management of forests particularly on higher level of decision making. These also serve for appreciating the two decision making aiding tools (ILK and GDSS) by integrating them in order to mitigate the cost of forests decision making basing on one of the tools only. In case of GDSS tool, is more of top down orientation, while ILK is missing scientific analysed facts to improve and balance the management decision on forests. This paper was prepared to respond to the need for provisioning of possibilities of integrating GDSS and ILK in forest decision making process to enhance forest sustainability using Zigi river catchment in East Usambara Mountains as a

case. The attention is mainly on improving forest management decisions which do not compromise community needs and livelihoods while maintaining sustainable forest services.

Study area

The study was conducted in Zigi river catchment area which is located within the Eastern Usambara Mountains. The area has coverage of about 1050km^2 (Mwasha, 1989,in Mwanyoka, 2005). Recent study by Hepelwa (2010) shows the size the area being 1,100 km^2, located between 4°48'S and 5° 13' S, and 38°32' to 38°48' E in Muheza, Mkinga and Korogwe districts, Tanga region. It has an elevation of 1,265m and the mean elevation of about 355.44m. The area has a bi–modal rainfall pattern.The long rain period is from March – May and the short rain period is October – December. Monthly average rainfall stood between 30mm and 174 mm for the period between 1995 and 2005, On the other hand, the maximum temperature ranges between 28^{o}C and 35^{o}C and the minimum temperature between 17^{o}C and 23^{o}C. Apart from settlement, the area is characterized by six other land use cover and about 15 forest reserves (Figures 2 and 3).

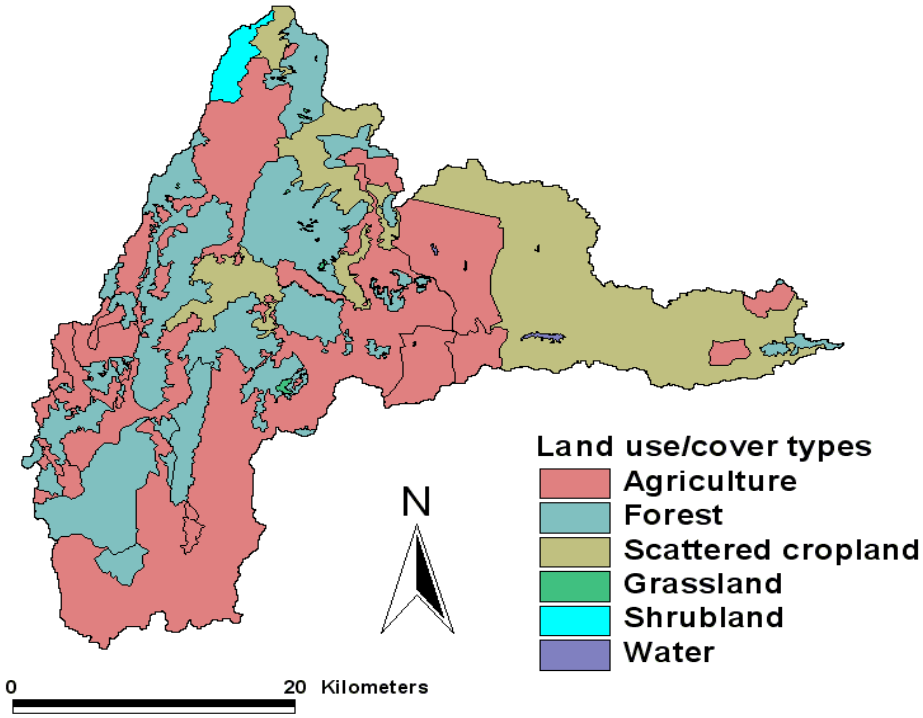


Figure 2: Zigi Land Cover

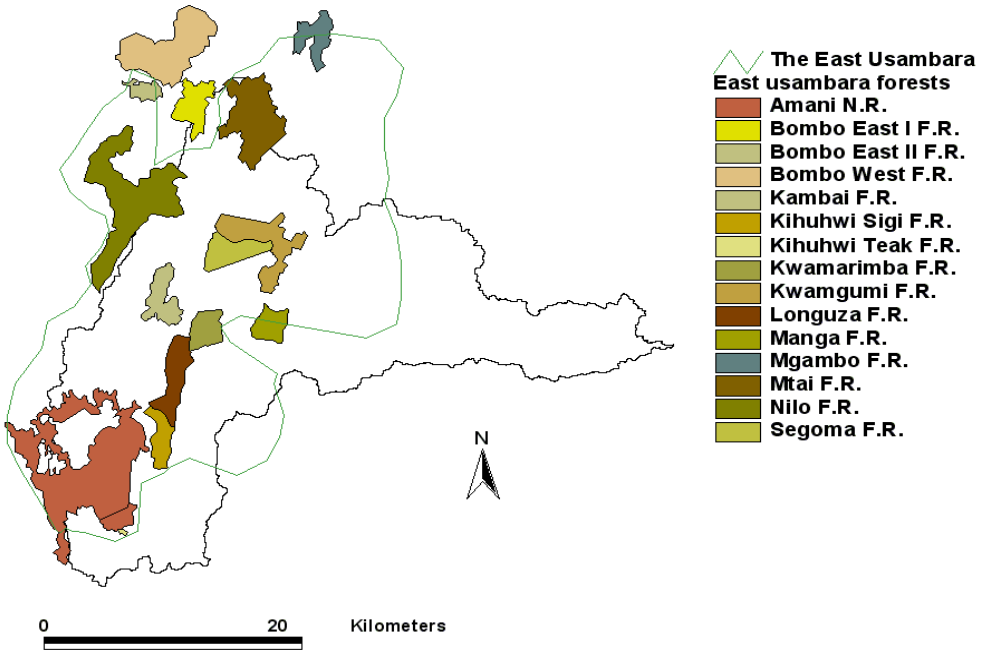


Figure 3: Forest Reserves in Zigi

The estimated population in the catchment area was about 204,461 in 2012, with 100,843 males and 103,618 females (NBS, 2012). Household size of 4.3 and a population density of 77 inhabitants/km^2 (NBS, 2012). About 41% and 5.6% of the people are aged below 15 years and above 64 years respectively (NBS, 2012). The population growth rate is estimated to be 2.2% per annum (NBS, 2012).

METHODOLOGY

Focus Group Discussions (FGDs) was used to assess the level of consideration of ILK in forest decisions in relation to the current conventional conservation strategies in place. Ten FGDS were conducted in ten villages with a group size of 8 to 10 participants. The groups comprised of men and women randomly selected from the villages. Discussion touched on issues of forest resources, use, and management at local levels using their non-conventional knowledge. The discussions also focused on the extent of the use IK in forests decisions. Face to face interviews were conducted with forest official at district, regional and national levels to assess the use of GDSS and ILK in forest decision. Forest officials at these three levels were purposively chosen basing on their nature of duties. The interviews further focused on the use of both ILK and GDSS in facilitating forests decisions. Content analysis and literature survey was used to asses ILK as systems that can aid decision on forest management. GDSS as secondary data was assessed in its capability to aid spatial decisions on forest

management. Researcher's observation on implicit link of forests and narrated ILK was used to establish a link between ILK and forest management.

RESULTS AND DISCUSSION

Integrations of GDSS and ILK in Forest Management

GDSS and ILK are both decision making aiding tools, the former being the most popular at present and used to aid decision making in several management sectors. On the other hand, ILK is considered informal and unpopular decision making aiding tool which have impacted or supported decision of various sectors including rural community forests. Concerning the forest management decisions which have for long been compromised with lack of enough information, the challenge is now solved with the use of GDSS. This is because GDSS has shown to have the ability to gather much data and information needed for forest management than ever before. The challenge is now on the capability by decision makers to organize the information so as to result into objective decision over forest management.

This challenge is also associated with erosion of other decision aiding tools like the ILK. The use of GDSS has relied more on data and information - Remote Sensing (RS) and Geographical Information (GIS) and forgot to consider non-GDSS tools in aiding forest decision making Process. ILK has for long - even before the use of GDSS, used by local communities in various areas to govern forests, local community's knowledge of interaction with forest had a great impact on the sustainability of forest and livelihoods. Many GDSS are resource or site specific similar to ILK, because each resource has kind of data to be used in a developing a decision support system. The same it is with ILK as each particular community has a different interaction type and level with resources they are living with and therefore different indigenous and local management knowledge (Pattison et al., 2004, ORAP. 2013). There are GDSS for marine resources, wildlife, agriculture, landscape, and forests - to mention only a few. In Lake Manyara, RS and GIS have been successfully used to asses water balance and provided significant information for decision makers. In this regard, RS/GIS are used as decision support tools for water resources management (Deus &Gloaguen, 2013). By this means, it is possible to provide timely and up to date water resources information to managers and operational decisions for sustainable conservation.

Mc Connell and Burger (2011) have also shown the use of GDSS in supporting conservation of agricultural land - by not only helping farmers creating buffers and overlaying different soil layers, but also by aiding farmers to make informed decisions regarding tradeoffs between production and conservation enrollment. Furthermore, GDSS aids farmers in comparing profitability of

crop production with conservation in a spatially explicit context by using profitability tool in Mississippi (Mc Connell and Burger, 2011). In additional to that with GDSS farmer conserve and produce while allowing them to identify more profitable field regions with compared to other field regions.

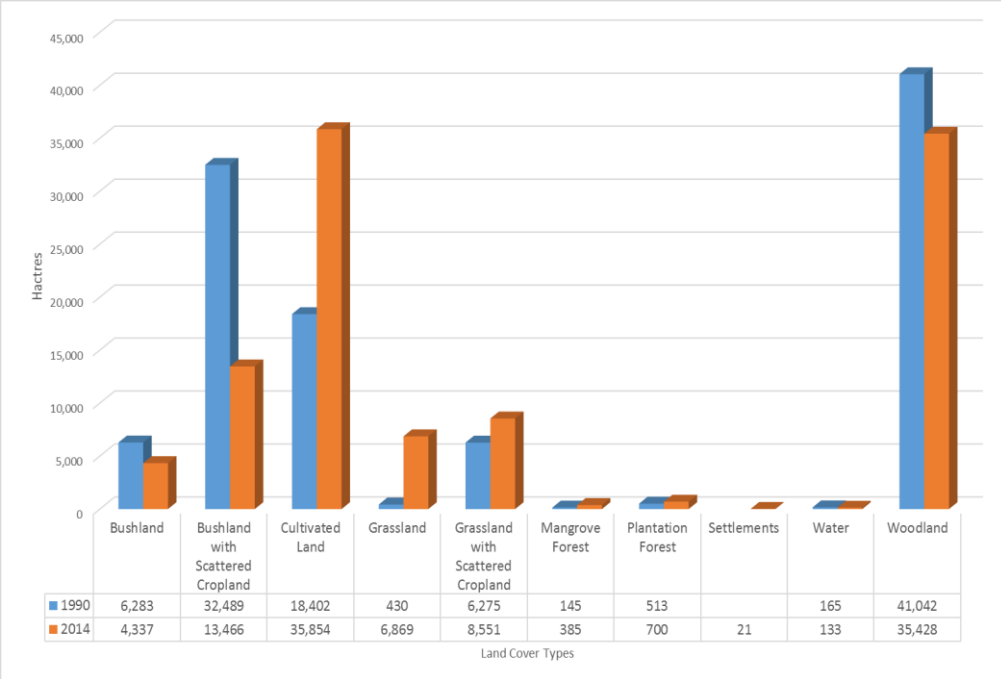


Figure 4: Zigi Land use Change by Hectares

Like in agriculture and in water resources management, GDSS have also aided forest management decisions in various ways inclusive the extent of encroachments, species distribution and disturbance for instance in the satellite analysis provided in Figure 4 showing a 1.8-18% decrease of bush land, 5.3% decrease of woodland, plantations and cultivation land increasing by 0.2 and 16.5% respectively. The land use cover change is provided in an average of twenty years' difference. The results are useful information to decision makers, because they can assess achievement or failures in conservation programs set for a decade or more. Unfortunately these results like any spatial results do not feature IK practices available in the community. Indigenous and Local Knowledge has for centuries been used to regulate community interaction with forests. In India, tribal populations of Andhra Pradesh are well known for their well-organized ILK in managing natural resources (Rao and Ramana, 2007), and Nimachow, *et al.* (2010). In line with this, a report by Africa Adapt (2011) has highlighted different areas that have used ILK in conservation and forest management in Africa. A number of authors (Catherine and Hoppers, 2002; Kweka, 2004; Meshack, 2004; William

et al. 2012; Rantalla, 2013) have documented ILK and its uses in natural resources management. A paper by Woodcock (1995) - more than two decades ago, have specifically highlighted the use of ILK in forests by people of the eastern Usambara. Woodcock acknowledged a highly manifested indigenous adaptive capacity to the changing environment that manages to sustain their livelihoods and forests management, by changing their reliance from forest derived foods to farms and bush land derived foods when access to forest resources is prohibited.

Although ILK may change with time, it is still important to recognize the wealth embedded in ILK on forest management. Consider these eminent roles of ILK in the community of Zaka in Zimbabwe which for years have been used to conserve environmental resources by regulating use of forests (Tanyanyiwa and Chikwanha, 2011). In this community some forests are set as sacred; harvesting of edible fruits is limited by defined days per week to access forest resources, clans are responsible for ensuring that they don't miss or go short of rainwater and other water supplies. With this responsibility, clans act like policemen to protect forest resources. In Zaka community, mixed farming has been practiced to conserve soils. Sacred wells have remained unpolluted and ensuring supply of clean water (Tanyanyiwa and Chikwanha, 2011; Risiro. *et al*, 2013). A lot of ILK and forest management skills have been documented to show the importance of ILK in aiding forests decisions hence management (Jackson, 2004, Stevenson, 2005, Kwame, 2007, Sharma *et al*., 2009, and Parrota, 2012).

ILK has proved its importance in systems in managing forests in various communities in Africa and outside Africa. It has managed to identify ways to minimize negative socio ecological cost in communities adjacent to forests. There is a need – therefore, to strengthen and recognize ILK to improve our forest. According to Woodwork (1995), in identifying ways to minimize negative social cost in conservation whilst maintaining and strengthening local people's entitlements, there is a need to understand the decisions made by local people in respect to their daily subsistence. Local people have a wealth of ILK which they utilize on a daily basis. They are also highly adaptive in many ways to their changing environments. Woodwork (ibid) was calling for not only recognition of IK but also for strong consideration of ILK in decisions that are influenced by other systems.

Currently there is a great use of Geospatial decision support systems tools in aiding forest conservation decisions. However, the use of these systems like - RS and GIS and other western superimposed forests conservation systems, have been in conflict as regards use and priority of use. ILK have been

considered primitive and unfit to manage natural resources in favor of western systems. The argument against ILK is put in its spatial difference from one location to another and therefore bringing challenges to conservation. ILK systems are considered subjective and as being needs specific than goal oriented. Briggs (2005), argued that it is not a big step to imagine that conservation can only emerge from the application of western knowledge and that of ILK has less to offer. Forest management has relied exclusively on one knowledge system, namely, modern western system (GDSS). Hence, the dominance of this knowledge system has dictated the marginalization and disqualification of IK.

This difference in perspectives on the ILK systems and GDSS (Western systems) use in forest management can therefore be put together to aid forest decisions because both - in different location and perspective, have shown great ability in forest management. Disregard to both systems superiority, both can be integrated and harmonized to get an integrated approach or framework for aiding forest decisions. This will eventually lead to attainment of sustainable forest management. This does not mean that the two systems have never been used together in aiding forest management decisions. Sustainable forest management planning with the aboriginal people in Australia included the ILK in decision making (Stevenson, 2005).

GIS and ILK was integrated in the micro level of forest management in India (Kuriakose and Pughazendi, 2005). These were few attempts to integrate the two systems in forest management decision making. In all of these attempts the results were in favor of both people's needs from forest and forest needs from people. The integration created a sense of ownership to local people in protection of their own resource rather than government owned resource.

Either of the decision-making systems (GDSS and ILK) would consider other decision-making factors such as political, economical and socio cultural factors in deriving a decision on forest management. Of course the latter have taken much more attention of the decision makers. Here the emphasis is on the use of the two systems in a complimenting fashion while considering other decision-making factors, (Figure 5, 6, 7 and 8).

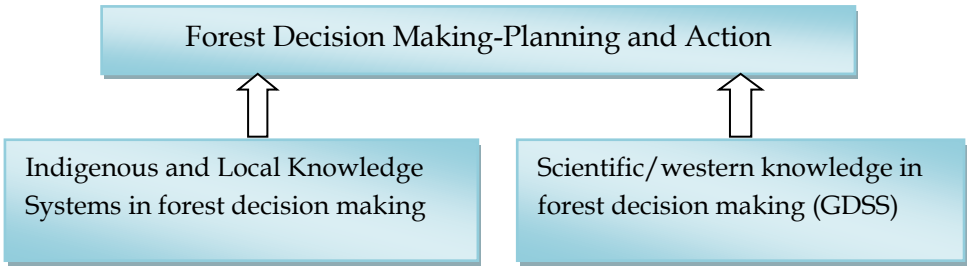


Figure 5: Forest Decision Making Model using Two Separate Approaches/Tools

In the above model (Figure 5), ILK is not merged with GDSS but both approaches are used in a separate way aiming at managing forest resources. The model presents the two approaches as non-antagonistic approaches and more complimenting one. However, this is not enough; there should also be a learning process from one another, or decision makers should learn from both of the approaches so as to gain much more decision factors and bases because learning will facilitate knowledge sharing. The process of learning from one another should start at the beginning of decision making process and build from there in order to facilitate discussions at the planning and decision making stages, (Figures 6, 7 and 8).

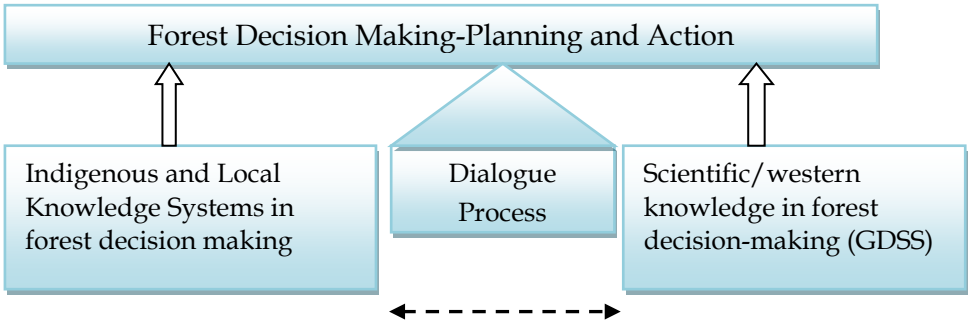


Figure 6: Dialogue process in decision-making

In this stage a dialogue process serves to take information from both ILK and GDSS for the sake of considering their integration. None of the two approaches operate independently; in reality however, decisions affecting the use of forest resources are rarely made in the absence of political and economic considerations. Indeed some would argue that, to date, the latter have enjoyed a much bigger role than "science" in forests decision making. The fact is that, in order to achieve sustainable forests management - which includes (ecological integrity, political certainty, social stability and economic viability) in forest management, serious consideration should not just be on

the forest ecology, but to political, economic, social and other factors, all of which are interrelated in figure 7. Following this understanding, therefore, both ILK and GDSS either together or in isolation, consider the ecological, economical, political as well as social cultural information as of essence in forest decision-making. In the attempt to integrate ILK and GDSS in forest decision-making this paper has provided an integrated approach to forest management which is provided in figure 8.

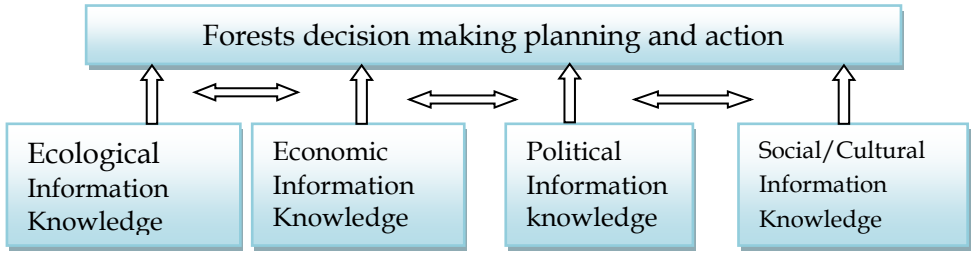


Figure 7: Factors for Forests Decision Making

The integrated approach shows

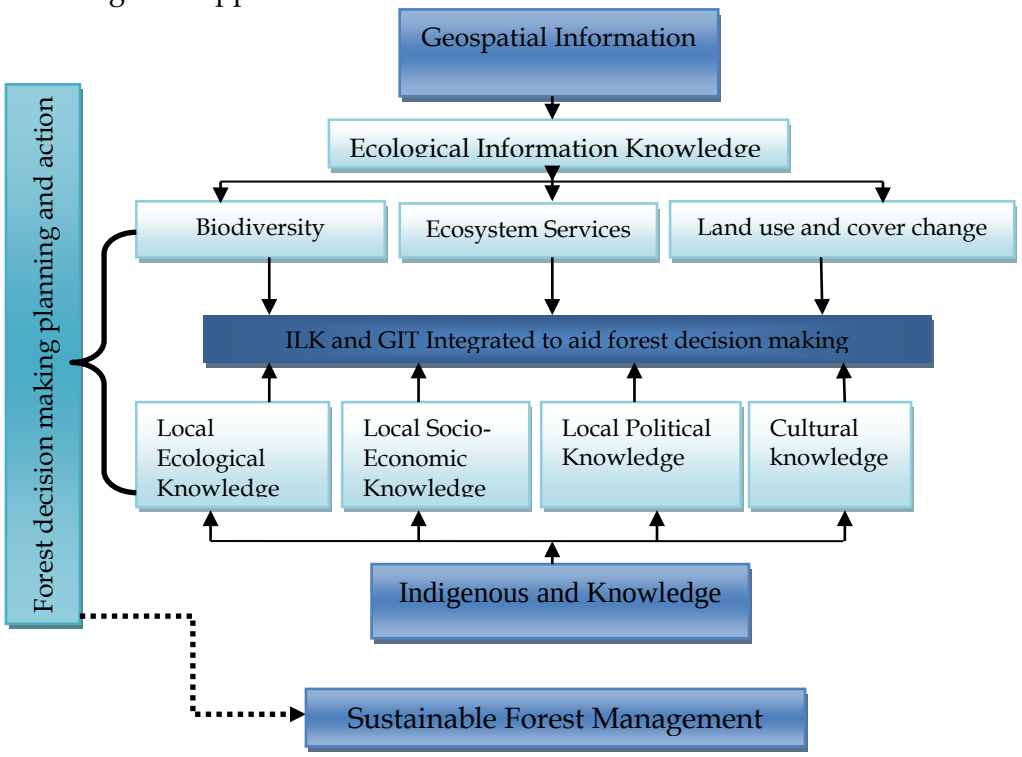


Figure 8: Framework for Integration of ILK and GDSS for Forest Decision-Making

Geospatial information technologies in this paper referred as GDSS collects data on biodiversity, ecosystem and land use cover and change. As opposed to GDSS, ILK can collect local ecological, economic, and political and socio cultural information of forest. The integration of the two therefore, makes an integrated forest decision making planning and action. The assumption made in this framework is that all ILK and GDSS are both utilised to their full capacities and both contribute data to forest decision making. Eventually this integration makes an integrated approach and lead to sustainable forest management - Figure 8.

To implement the framework, decision makers should follow the steps that may eventually allows the integration of GDSS and ILK into decision making.

(i) Gather all the indigenous knowledge related to forest resource use of the community adjacent to forest in questions. That is, to consult with Indigenous people about traditional forest use and critical habitats within their respective management areas in an effort to incorporate indigenous knowledge into forest plans and decision making. This is suggested to be the first thing forest managers should consider when in the process of deciding for forest conservation
(ii) Gather geospatial data of the forest in question using remote sensing and geographical information systems
(iii) Create a GIS database which includes spatial information of the forest in question and their associated Meta data including IK data
(iv) Map all of the significant ILK with spatial reference to spatial reference of the forest or even specific spot in the forest (e.g. Sacred/spiritual places, taboo tree species, preferred tree species for construction and other uses, wild edible fruits, medicinal plants etc)
(v) Incorporate ILK about forest variations and anthropogenic changes in a forest ecosystem to develop an alternative forest resource use and management practice
(vi) Analyse spatial forest data to get forest status information (e.g. forest cover, species content and dominance, extent of disturbance, land use etc) in association with the indigenous practice on forests
(vii) Apply ILK to forest management decision making process. However without involving the indigenous in planning and decision making process, these steps may cause problems for both parties relating to the ownership and use of the intellectual property and the forests. Unless, all these have well been pro-defined
(viii) Include the indigenous people into forest planning and the monitoring of valued forest ecosystem components and valued ecosystem would go a long way towards mitigating forest use associated problems

(ix) Incorporate indigenous people into the decision-making processes, commensurate with their needs, rights and interests. All these steps should consider the four decision making factors as stipulated in Figure 8.

The framework shows the importance of both approaches in aiding decision over forest management. However, the two approaches when used separately results into unsustainable forest management practice. Although not in all occasions the results may be worse but because IK have proven to be an important tool to manage forests it is high time now the two approaches (GDSS and IK) works in harmony. ILK has its advantages and disadvantages and so it is with GDSS. Combining them - as shown in Figure 8 above, is more advantageous than using the approaches in isolation. This is because ILK lacks technical scientific inputs to forest decision making and GDSS lacks indigenous technical knowledge to forest decision making.

Scientific approaches in forest decision making are confined to only literate people while indigenous systems are area specific so they cannot cross cut in all forest management. Because scientific approaches are confined to literate people it becomes harder to penetrate to majority local illiterate people thus leading to poor forest decision making - hence unsustainable forest management decisions. In isolation, both approaches/tools have some setbacks and if not integrated the results are unsustainable forest management.

CONCLUSION AND RECOMMENDATIONS

The extent of GDSS use in forest governance manifests itself at the central government level and with NGO's. Regions and districts face great challenges in applying the technology due to high financial costs associated with the technology and lack of enough and competent expertise. The financial challenge and lack of expertise is a national challenge hence making the use of GDSS in forest governance limited in all the forests of the country. However the little use that exists is also limited to some meta data such as ILK. There are several indigenous practices (rituals, tree species selection, and cultivation of spices) related to forest management, but these ILK's have a limited room in influencing forest management. The existing ILK needs to be verified, assessed and documented and eventually coupled with other data from GDSS on forests to aid decisions which will ensure sustainable forest management and livelihoods. The framework provided in Figures 5, 6, 7 and 8 suggests steps to be followed to integrate ILK into GDSS in forest decision making-planning and action.

Despite the challenges to integration of these two approaches (GDSS and ILK) to forest decisions, still the imperativeness remains significant so as to attain

sustainable forest management decisions. This is in line with the use of diverse information and participation of local stakeholders, minimising resource use conflicts and eventually boosting economic development. There should be a serious concern in studying ILK in resource use and document it from time to time. Efforts should be put forward to having enough GDSS expertise to ensure reliable spatial data availability and use. When the two approaches complement each other - instead of overlapping, decisions on forests will be environmentally and socially sound as well as economically viable.

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New Findings on Epidemiology and Management of Rice Yellow Mottle Virus Disease in the Southern Highlands of Tanzania

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Abstract: *Three studies were conducted at Kyela district with the objective of adding knowledge on epidemiology and management of rice yellow mottle virus disease. The contribution of different weed management practices on disease transmission and effectiveness of Alvirus ($C14H21O_3N_2$), a botanical pesticide in disease control were each evaluated in a randomized complete block experimental design with three replications under two lowland and one upland rice cultures. Twenty elite rice genotypes were also evaluated for resistance to the virus and farmer acceptance in the same sites and on station at Kikusya upland ecology. The results indicated that the first hand weeding in seed broadcasted plots (farmer practice) led to 90% increase in disease incidence compared to 6% and 2% with hand hoe weeding in row planting and use of herbicides (Rilo 250EC 1.5l/ha and 2-4Damine 4l/ha) respectively. Use of the latter resulted in 70 – 90% reduction of disease incidence and yield increase of 1.3 to 1.8t/ha or monetary gain of Tsh 614,000/= per hectare on average. Alongside capacity building, these practices were recommended to primary stakeholders. Alvirus achieved 100% disease control when used to soak seed 24 hours prior to planting followed by spraying 14 and 21 days after emergence or where only spraying was used. This new finding was useful for research purposes but warranted further studies to enhance applicability. Existence of differences in pathogen strains was evident between the locations where the genotypes were planted but nine appeared resistant across locations out of which 5 were new, highly acceptable and required promotion to farmers.*

Key words: Rymv, management, Tanzania, alvirus, Kikusya, upland rice, lowland rice

INTRODUCTION

Rice yellow mottle caused by a sobemovirus is a fairly recent but most devastating and fast spreading disease of rice in Sub Saharan Africa (Abo *et al.*, 1998; Banwo *et al.,* 2004). It was first discovered in Kenya in 1970 but up to mid 1990s it was reported from all the major rice producing countries in Africa including Tanzania (Bakker, 1970; Raymundo *et al.,* 1976; Luzi – Kihupi *et al*., 2000; Mabagala *et al*., 2001). Perennial wild rice species have been cited as primary hosts of the virus and other plants restricted to the Graminea and

Eragrostidae families (Bakker, 1974). About 12 insect species primarily chrysomelid beetles and grasshoppers are known so far to be vectors of the disease in Africa (Bakker, 1971; Abo *et al*., 2000; Mwilene *et al*., 2009).

Transmission is also through any mechanical injury to the plant in the presence of virus particles such as during transplanting, weeding operations, wind mediated leaf contacts and cattle damage (Abo *et al*., 2000). Characteristic symptoms are mottling or yellow orange discoloration of leaves, stunting and panicle sterility (Bakker, 1974). Its major economic impact is on lowland rain fed and irrigated rice cultures but upland cultures have of recent years suffered damage too (Awoderu *et al*., 1987). These ecologies respectively cover about 72%, 8% and 20% of rice produced in Tanzania mostly by small holder farmers for food and cash income (Banwo, 2003). About 1,334,000 metric tons of paddy are produced from a total of 904,508 hectares (Ministry of Agriculture, 2008). Over 30% of the premium crop is produced in the southern highlands of Tanzania (SHT) covering Iringa, Njombe, Mbeya, Ruvuma, and Rukwa regions where most severe epidemics and virulent strains of the virus have been reported (Mabagala *et al*., 2001; Luzi – Kihupi *et al*., 2000; Mwalyego *et al*., 2003). The average yield from this regions is low and varies from 1 to 2t/ha instead of the achievable 4t/ha (ECARRN, 2006). Consequently the volume produced is insufficient to meet demand of the fast growing population, 60% of which depend on rice for livelihood (ECARRN, 2006).

Varied factors in drought; weeds, insect pests, low soil fertility contribute to low productivity (ECARRN, 2006), but a reduction in yield from 10 – 100% can occur as a result of RYMV infection (Reckaus, 1986; Mabagala *et al*., 2000; Mwalyego *et al*., 2003). The loss from RYMV in the SHT can be estimated at between $ 5m and 57m annually. Ever since epiphytotics of the disease erupted international and regional collaborative research efforts have dramatically increased what is known about the virus at structural and molecular levels (Pinel *at al*., 2000). Generated information so far on host genetic resistance which is a control strategy affordable by resource poor farmers have shown that there is virtually no source of sound resistance to RYMV in the agronomically desirable rice varieties intensively grown in Africa (Awoderu *et al*., 1987; Fomba, 1988).

Nevertheless, use of single control measure cannot be effective for this virus which shows variability and a number of transmission mechanisms. A combination of different control methods in an integrated approach is advisable so as to exploit synergistic interactions. To date, there are still a lot of quantitative and qualitative knowledge gaps existing in our understanding of the epidemiological processes essential for devising appropriate

management interventions. Surveys carried out in the SHT (Ndunguru *et al*., 2012) revealed that certain cultural practices such as time of planting, weed management, field sanitations, seedling and crop management influence disease occurrence and spread. The objectives of these studies were to evaluate the effects of different weed management practices on disease epidemiology together with varietal and chemical components which may be used directly by farmers or breeders in the management of RYMV.

MATERIALS AND METHODS

Weed Management

Five weed management practices comprising of hand weeding, pre and post emergence herbicides (Rilo 250EC. 1.5.2l/ha, 2-4Damine 4.0l/ha) singly combined and hand hoe in row planting at 20 x 20cm were evaluated using a randomized complete block design (RCBD). The experimental trial was replicated twice under two lowland and one upland rice ecologies in Kyela district during 2014/2015 growing seasons. Glyphosate 360EC at rate of 4l/ha was applied in the entire field 4 weeks prior to ploughing to control perennial reservoirs of RYMV. Rice varieties Saro5 in lowland, Zambia and URO1 in upland rice cultures were used. Fertilizers were applied according to blanket recommendation of 20kg P_2O_5 and 40kg N/ha. Plot size measured 4 x5m^2 and a uniform seed rate of 40kg/ha, 20kg/ha were used in broadcasted and row planting respectively. Hand weeding was supplemented in herbicide applied plots as necessary. Incidences and severity of RYMV were recorded two weeks after emergence, three weeks after hand weeding and thereafter at two week intervals to end of grain fill. Incidence was measured by counting number of infected plants/plot while severity of RYMV and other diseases was rated on 1 – 9 scale (IRRI, 1996) where 1 – 3 denoted very mild infection or resistance, 4 - 6 moderate and 7 – 9 quite severe infections accompanied by plant death. Cost of inputs, all field operations, yield and components were also recorded. Treatment effects were analyzed using GENSTATI3 statistical package.

Efficacy of 'Alvirus'

The chemical product was evaluated in a RCBD with three replications on station at Kikusya, Kyela district during 2014 growing seasons. Zambia, a local rice variety susceptible to RYMV was used for testing. Five treatments were evaluated where 1. Chemical used to soak seeds overnight at rate of 1ml/200ml water/250g. 2. Seed soaking was used as in No 1 followed by spraying 5ml/l water at 21 and 30 days after emergence (recommended practice). 3. No seed soaking but chemical applied as above. 4. No chemical applied. 5. Control (Water applied). Except for the last treatment, all others

were inoculated with the virus sap from surrounding fields 5 to 6 days before chemical spraying or visual symptom development. Incidence and severity of RYMV and data analysis were evaluated as above.

Host Resistance

Germplasm for testing was obtained from Sokoine University of Agriculture (SUA) and Uyole Agricultural Research Institute gene banks. The resistance of 20 most promising genotypes including resistant and local susceptible checks was verified on farm with farmers at two lowland and one upland rice ecologies. Six rows each 3m length at spacing of 20 x 20cm per entry were planted by direct seeding, 3 seeds/hole. Triple super phosphate (TSP) and Calcium ammonium nitrate (CAN) were broadcasted at rates of 20kg P205 and 60kg N/ha respectively in planting furrows followed by top dressing with urea at 60kg N/ha. Three rows of each entry were inoculated by farmers with virus strain from surrounding area a month after germination leaving other set of rows as un-inoculated controls. Inoculums' was prepared by crushing 200g disease infected leaves per litre of water and suspension inoculated by firmly touching and squeezing the seedlings from base of leaves to the top with hands soaked in the inoculums. Disease incidence and severity were rated as previously narrated at 21, 45, and 60 days post inoculation. Farmers rated the entries at flowering and grain maturity for RYMV as resistant, moderately resistant or highly susceptible. Height and desired agronomic traits were rated as highly acceptable, average and unacceptable.

RESULTS AND DISCUSSION

At all locations, use of herbicides significantly controlled weeds and reduced incidences of RYMV (Table 1). Combined use of pre and post emergence herbicides Rilo and 2-4Damine respectively achieved the highest weed control and recorded the lowest incidences of RYMV. No hand weeding was supplemented before grain fill in this treatment, hence reduced chances of mechanical transmission. Weed dry matter was highest where row planting was used as spacings left between rows and plants favoured vigorous weed growth, supporting the findings of Johnson (1996). The highest RYMV incidence and severity occurred where only hand weeding was practiced undoubtedly due to mechanical transmission enhancement through close contact between plants under broadcasted seed plantings used by most farmers.

Table 1: Effect of five management practices on mean weed control RYMV and yield across three locations

	Treatment	Weed densities plants/m²			Weed dry wt (g)	RYMV incidence infected plants/plot)	RYMV severity (1-9)	Yield kg/ha
		Grasses	Broad leaves	Sedges				
1.	Hand weeding	18.8a	69.8a	60.4a	452.3ab	47.7 a	9a	1844 a
2.	Pre emergency herbicide (Rilo)	1.1b	17.8b	5.1b	392.3ab	8.7 b	9a	3028 bc
3.	Pre-Post mergence (Rilo +2=4Damine)	1.3b	3.8c	4.0b	255.3ba	4.4 b	8a	3344 c
4.	Post emergence herbicide 2-4Damine	41.5c	18.6b	45.1c	266ba	12.9b	8a	3200 b
Hand hoe in row planting		49.5c	92.4d	72.8d	891.3a	14.4b	7b	3689d
Mean		22.6	40.6	37.6	451.4	17.6	8.2	3021
CV %		112.5	46.1	40.7	47.8	57.9	4.9	5.4
LSD		11.84	12.0	13.73	618	20.39	1.1	293.7

Disease incidence was highest in this treatment after the first weeding which increased by 90% compared to a mean of 2% and 6% with herbicides and hand hoe weeding respectively (Figure 1). This finding confirms farmer's observations that their fields were turned yellow due to rapid and severe infection two to three weeks after weeding (Ndunguru *et al*., 2012). In the latter treatments the number of infected plants showed slow increase throughout the season attributed to insect vector and limited mechanical transmissions between plants. Overall yields were significantly higher with hand hoe weeding in row seed drills but lowest in the hand weeded or control treatment attributed to optimum plant populations, reduced RYMV incidences and weed competitions.

The results indicate that adoption of row planting and use of pre and post emergence herbicides to ease weeding can reduce incidences of RYMV in fields by about 70% to 92% resulting into average yield increase of 1.3 to 1.8t/ha equivalent to net monetary gain of Tsh. 614,733 per hectare. Means followed by same letters in a column are not significantly different.

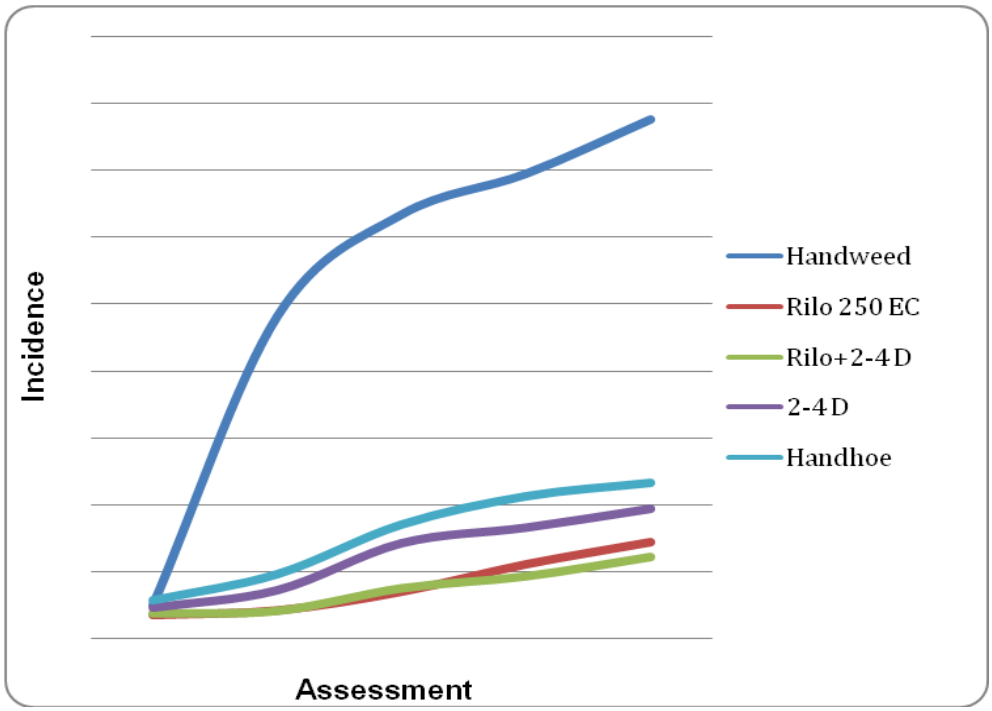


Figure 1: Progress of RYMV disease in weed management treatments across three locations in Kyela district

CHEMICAL CONTROL

Highly significant differences in RYMV disease incidence, severity and yield were observed between the treatments (Table 2). Highest incidences, severity and lowest yields were recorded in the control where no chemical was applied. The chemical product was not very effective when it was used only as seed soak since the results did not differ significantly with the control. On the other hand it was quite effective when it was used as a preventive spray before symptoms of disease were observed or when it was used to soak seed followed by spraying as recommended by manufacturers. No disease incidence was noted where the chemical product was applied as recommended whereas plots inoculated with RYMV in absence of chemical spray were almost wiped out. Yield was highest where the disease was significantly controlled as a result of increased number of effective panicles and kernel weight. The number of plants infected under natural field inoculums was quite low, as such inoculation of plants before chemical spray assured effective control. Possibly the chemical inhibits entry of the virus into the plant or boosts immunity system of rice plants to overcome the virus. The results suggest that the chemical can be used for RYMV disease control for research purposes. However, further research is necessary before appropriate recommendations can be made.

Table 2: Effect of Al Virus on RYMV disease control and yield of Kilombero rice variety

S/N	Chemical Treatment	RYMV incidence (%)	RYMV Security 1-9	Plant Height (cm)	Tillers /plant	Panicles /plant	Yield kg/ha	1000 kemel wt (gm)
1.	Seed soak	80 [a]	8 [a]	110 [a]	9 [a]	6 [a]	310 [a]	26 [a]
2.	Seed soak + spray	0.1 [b]	1 [b]	117 [b]	10 [a]	9 [b]	2050 [b]	29 [b]
3.	Spray only	0.1 [b]	1 [b]	116 [b]	10 [a]	9 [b]	2000 [b]	28.6 [b]
4.	Water spray (Control)	100 [a]	9 [a]	105 [a]	8 [a]	2 [c]	101 [a]	25.5 [a]
5.	No chemical, natural infection	11[b]	9 [a]	116 [b]	8 [a]	6 [a]	1410 [c]	28.2 [b]
Mean		38.6	5.6	112.8	9	6.4	1418.2	27.4
CV %		41.8	31.4	13.3	15.1	28.3	27.8	3.9
LSD (5%)		36.9	1.67	9.3	2.11	2.72	221.3	0.87

Figures followed by same letters in a column are not significantly different

Host resistance

Most of the genotypes showed differential reactions to the isolates, showing susceptibility in some locations but resistant reactions in others implying existence of different virus strains in different locations (Table 3). About 9 entries scored resistant to highly resistant scores (1 – 3) across the four locations while only 4 were susceptible across locations. Strains at Lugombo and Mpunguti lowland areas appeared to be more virulent compared to Kisale and Kikusya upland strains. Even Kalalu, a resistant check from previous years succumbed to infection by the Lugombo strain. Gigante, which is claimed to possess the recessive *Rymv 1 – 2 gene* conferring high resistance to the virus reported to be resistant to the virus in West African countries was quite susceptible to the strains at all locations observed also in Uganda (Ochola *et al*., 2011).

Most of the resistant genotypes had other agronomic traits that were acceptable to farmers but Salama varieties M55, 19, M57, M35, Mwangaza, IITA 235 were highly acceptable and in high demand at all locations. Promotion of these varieties is recommended while the resistant but

unacceptable genotypes such as Moroberekan, Lunyuki, Faro II, IRAT 252 can be used in breeding to improve the very susceptible local checks.

Table 3: Performance of 20 rice genotypes inoculated with RYMV strains from 4 locations in Kyela district

	SEVERITY OF RYMV (1 – 9)						
	Rice genotype	**Mpunguti**	**Kisale**	**Lugombo**	**Kikusya**	**Mean scores Category**	**Farmer * acceptance**
1	Salama	1	1	1	1	1-HR	HA
2	Moroberekan	1	1	1	1	1-HR	A
3	Nerica 1	4	8	9	1	5.2 = MR	A
4	Kalalu	4	1	7	1	3.2 R	A
5	SSD – 5	2	1	8	7	4.5 MR	A
6	Gigante	7	8	7	8	7.5 HS	A
7	Salama M1	7	7	7	5	6.5 S	P
8	Lunyuki	3	1	1	1	1.5 R	P
9	IRAT 256	3	9	7	4	4.8 MR	A
10	Bonake	6	4	7	6	5.8 MR	P
11	Salama M55	4	4	1	6	3.8 R	HA
12	Salama M57	1	1	1	1	1.0 HR	HA
13	Rangi Mbili	8	8	7	7	7.5 HS	P
14	Mwangaza	1	1	1	1	1.0 HR	
15	BG 380-2	9	3	7	7	6.5 S	P
16	Faro II	2	2	1	1	1.5 HR	VP
17	Salama M35	7	1	3	1	3.0 R	A
18	Nerica L-25	8	7	8	6	7.3 HS	VP
19	IRAT 252	2	1	4	1	2.0 R	A
20	IITA 235	3	2	4	1	2.5 R	HA
Mean Local check		9	9	9	8	8.8 HS	VP
Mean entries		4.2	3.6	4.6	3.4		

Ha = Highly acceptable
A = Acceptable (average)
P = Poor, not acceptable
VP = Very poor , not acceptable

ACKNOWLEDGEMENT

This research has been funded by COSTECH, Tanzania through NFAST fund 2012. We express our deep gratitude to the Commission, Uyole Agricultural Research Institute (ARI Uyole) management for supervision of the research and all stakeholders who participated in one way or another.

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Detection Rats Technology for Diagnosis of Tuberculosis in High-Risk Populations

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Abstract: *Prevalence of tuberculosis (TB) in prisoners in Tanzania and other sub-Saharan African countries is considered to be higher than in other populations thus prisons are important source of TB transmission. Control of TB in prisons through appropriate screening and diagnosis is challenging in most low-income countries such as Tanzania that is among world's 22 countries with high burden of TB. Commonly used TB diagnostic test (smear microscopy) have low sensitivity, and most advanced GeneXpert method is rather expensive for developing countries. SUA-APOPO TB detection rats' technology is most promising and increases TB case detection by over 40% in hospitals in Dar es Salaam Tanzania and Maputo Mozambique. This paper reports on improved TB detection in a selected prison in Tanzania using TB detection rats. Sputum samples (n = 11,424) were collected from 5,840 patients whom 3,491 were men, 2,349 were women. Of these, 386 patients were children altogether seeking diagnosis of TB at Ukonga prison dispensary from January 2013 to October 2015) and Keko prison dispensary from February to October 2015). Samples were routinely examined by Ziehl Neelsen (ZN) staining and later tested by rats APOPO TB laboratory, Sokoine University of Agriculture, Morogoro. Rats' positive samples were concentrated and confirmed by fluorescent microscopy (LED-FM) or ZN microscopy. A total of 709 individuals (12%) were diagnosed as smear-positive TB by the prison hospital, whereas rats detected an additional 302 TB patients. This increased the case detection in the prison population by 43%. The use of rats' technology increased the prevalence of smear-positive TB in prisons from 12% to 17.3% (n = 1,011) that is higher than prevalence reported in prisons elsewhere using microscopy. This finding shows that detection rats' technology can help reduce the burden of TB in developing countries. There is need to expand application of this technology to other risk populations including miners. This technology can improve workforce, livelihood and socio-economy by reducing TB related expenses.*

Keywords: smear-negative TB, prisons population, trained rats, source of transmission.

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INTRODUCTION

The prevalence of tuberculosis (TB) in prisoners in sub-Saharan Africa is considered higher than in the general population (Nyangulu *et al*. 1997; O'Grady *et al*. 2011). Prisons are also generally considered as reservoirs of TB transmission. Control of TB in prisons through appropriate screening and diagnosis is challenging in most low-income countries such as Tanzania that is also among world's 22 countries with high burden of TB (WHO 2015). The most commonly used TB diagnostic test in these countries is the direct smear microscopy which its sensitivity is low ranging between 20-60% (Urbanczik 1985; Mfinanga *et al*. 2007). Thus around 40% of TB cases remain undetected by this method. The sensitivity of smear microscopy drops further in populations with high prevalence of TB and human immunodeficiency virus (HIV) co-infections (Elliott *et al*. 1993, Johnson *et al*. 1998; Perkins & Cunningham 2007). Sub Saharan Africa has the largest proportion of TB/HIV co-infections hence many TB cases are not diagnosed (WHO 2013). There are new and more sensitivity diagnostic tools such the GeneXpert MTB/RIF which can give results in two hours and detect drug resistance (Boehme *et al*. 2011). However, Xpert MTB/RIF test is rather expensive for most developing countries (Pantoja *et al*. 2013) and the roll-out to-date is limited to few hospitals. SUA-APOPO TB detection rats' technology is the most promising low cost diagnostic technology which can increase TB case together with smear microscopy to over 40% (Poling *et al*. 2010; Mahoney *et al*. 2011). The use of these rats as second-line screening tool after smear microscopy in hospitals in Dar es Salaam, Coast Region and Morogoro Tanzania and Maputo in Mozambique shows similar findings indicating the potential use of this technology to reduce TB problems in high risk populations. This has not yet been determined therefore the aim of this study was to determine the impact of TB detection rats in a prisons population in Dar es Salaam over a 3-year intervention period. The proportion of TB in prisons hospital was also compared to that in general hospital to determine the magnitude of differences.

Materials and methods

Sputum samples were collected from prison inmates, prison staff and family members and other presumptive TB patients seeking TB diagnosis at Ukonga and Keko prisons dispensaries in Dar es Salaam.

Samples were first evaluated by smear microscopy at prisons DOTS centres and thereafter were securely transported in sealed containers packed inside cool boxes to APOPO TB detection laboratory at Sokoine University of Agriculture, for rat re-evaluation. Samples were heat inactivated at 100^{o}C for 30 minutes to kill microorganisms before evaluating by rats as biosafety

precaution. Samples were randomly arranged in bars (Fig. 1) and presented to rats in special training cage. Demonstration of rat TB detection rat evaluation can be viewed on this website link (http://www.youtube.com/watch?v_KoRvdyuHxdE). Rats were rewarded when they correctly identified a TB positive control sputum sample. All other indications of unknown samples was recorded and those samples were pre-concentrated by centrifuging to obtain sediment for concentrated smear microscopy which is more sensitive than the direct smear microscope (Uddin *et al*. 2013). Samples indicated as TB positive by rats and confirmed by concentrated smear examined by LED fluorescence microscopy or ZN were reported to hospitals for tracking the patients and initiating treatment.



Figure 1. Heat-inactivated sputum samples arranged in bars ready for presentation to rats

DATA ANALYSIS

The proportion of smear-positive TB detected by rats in prisons hospitals (17.3%, N =5840) was compared with previous proportion (23.1%, N = 6500, *unpublished*) obtained from a general hospital population also in Dar es Salaam. Comparison was done using MedCalc utilizing the "N-1" Chi-squared test according to Campbell (2007) and Richardson (2011) to determine whether the difference is statistically significant at $P < 0.05$.

RESULTS

Sputum samples (n = 11,424) were collected from 5,840 patients whom 3,491 were men, 2,349 were women. Of these patients, 386 were children.

A total of 709 individuals (12%) were diagnosed as smear-positive TB by the prison hospitals whereas rats detected an additional 302 TB patients yielding a total of 1,011 smear positive TB patients. This increased the case detection in the prison population by an average of 43% (Fig.2). The increase in case detection decreased from 66% recorded in 2013 to 23% in 2015 (Fig. 2).

The use of detection rats' technology increased the prevalence of smear-positive TB in prisons from 12% to 17.3% (n = 1,011/5,840). Rats evaluated 140 sputum samples for 20 minutes.

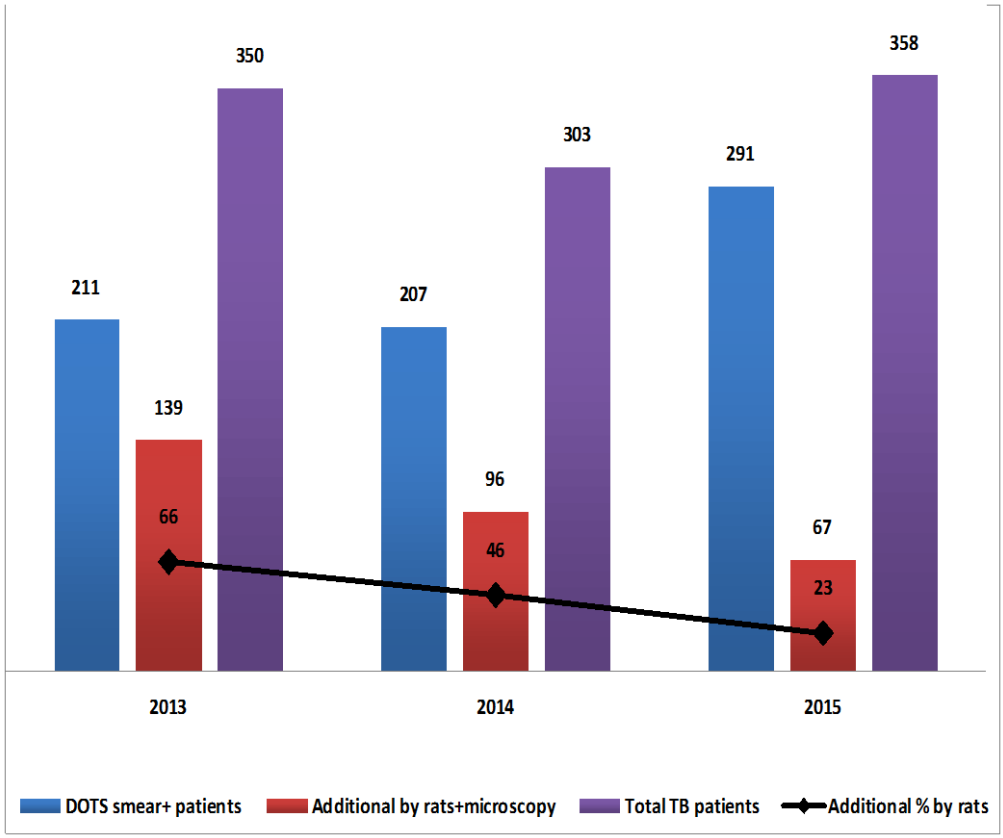


Figure 2. Tuberculosis screening in prison hospitals by microscopy and detection rats. Significant increase in case detection obtained by using rats

Comparisons of proportions of TB

The observed proportion of smear-positive TB in prisons hospitals (17.3%) was not statistically significant from that previously obtained from general hospital (23.1%) (unpublished) whereby the difference was 5.8, 95% CI -11.5300 to 23.1315 Chi-squared = 0.095, DF 1, P = P = 0.7584.

DISCUSSION

Detection rats improved TB case detection in prison populations by 43%. The rats detected more TB cases than smear microscopy and raised the proportion of smear-positive TB from 12% detected by microscopy to 17% in two prisons hospitals. This is based on confirmation by concentrated smear microscopy which has a higher sensitivity than the direct smear microscopy (Uddin *et al*. 2013) used in hospitals. Confirmation by more sensitive diagnostic methods such as the Xpert MTB/RIF could provide different findings as this methods detects nucleic acids of *Mycobacterium tuberculosis* pathogens which may be present in sputum containing very few bacterium below the detection limits of microscopy. Such scenario may reveal more TB positive patients as rats are targeting specific volatile odour compounds produced only by *Mycobacterium tuberculosis* (Mgode *et al*. 2012 *a, b, c*). These trained rats have also high ability of distinguishing clinical sputum with *M. tuberculosis* from those with other mycobacteria and related pathogens (Reither *et al*. 2015). There was a decrease in the percentage of case detection from 66% recorded in 2013 to 23% in 2015 (Fig. 2) although the average percent increase in TB case detection is 43% that corroborates previous reports (Poling *et al*. 2010; Mahoney *et al*. 2011). The two prisons hospitals started using Xpert MTB/RIF hence many cases were detected by this method in the hospitals. Comparative studies of rats and this technology are much needed as well as determining other causes of the observed decrease which may also be associated with improved performance in the hospitals since rats are kind of re-check up tool after smear microscopy.

Findings of this study show that use of detection rats can reveal more TB patients and enhance treatment of a significant number of patients missed by hospital thus help prevent deaths due to TB infection and prevent transmission of TB to other people living or in contact with misdiagnosed patients. In this case, the 302 patients detected by rats could have transmitted TB to 3,020 up to 4,520 individuals in the prison surrounding given than 1 undetected TB patient can transmit the disease to 10 up to 15 persons per year if remains undetected.

The high sample throughput whereby rats can analyze an average of 140 sputum samples in 20 minutes that is faster than available conventional methods such as microscopy with which a technician can examine an average of 20 sputum samples per day (WHO 2005); reasonable accuracy, and low operational costs makes the detection rat technology suitable for scaling up and mass screening of high-risk populations in countries with high TB burden.

On the other hand, the observed 17% smear-positive TB by rats indicates that prisons may not be the major source of TB transmission as reported elsewhere (Nyangulu *et al*. 1997; O'Grady *et al*. 2011). Previous evaluation of smear-positive TB in a selected DOTS clinic in Dar es Salaam that serves the general population showed a prevalence of 23.1% which is not statistically significant (P= 0.7584). Further studies utilizing detection rats, Xpert MTB/RIF and culture methods are needed to explore the actual proportions of TB in prisons and general population. Multi-spacer sequence typing of the *M. tuberculosis* isolated from such study may provide insights on actual TB sources by assessing genotypes and transmission patterns. Recent study reported 10 genotypes of *M. tuberculosis* in Dar es Salaam (Mgode *et al*. 2015) where the present study sites are located. These can be explored in prisons hospitals to further unravel questions of actual TB burden in prisons population.

With these findings we can conclude that there is high potential of reducing TB problems by using detection rats technology that improve TB detection yield rapidly.

ACKNOWLEDGEMENT

Cooperation from the Tanzania prisons authority, National Tuberculosis and Leprosy Program (NTLP) is much appreciated. We also thank the prisons hospital workers and SUA-APOPO TB staff for their contribution in lab analyses. UBS Optimus Foundation and Carraresi Foundation funded this study.

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Challenges in the Management of Road Safety in Tanzania: The Need for an Integration Framework

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Abstract: *Tanzania is hardest hit by daily accident deaths and casualties on the roads. Although various measures have been taken by the government, enforcement agencies and NGOs, accidents and fatalities keep growing at a rate above that of killer diseases like malaria, tuberculosis and HIV. The main causes observed were that road safety has multiple key autonomous stakeholders having different fragmented information systems which are not inter-operable because of being proprietary in nature, thus inhibiting the timely and coordinated sharing of information among them. This paper presents the lessons learned from different stakeholders following a series of workshops and meetings with these key stakeholders to understand the problem from their institutional contexts. Hence, an integration framework is developed and implemented to facilitate enforcement of road traffic regulations and to enable the different stakeholders cooperate and share information efficiently and with transparency in sustained road safety regulations enforcement. It is envisaged that if the integrated platform is successfully adopted, it can reduce the heavy duplication of efforts and investment in incoherent data systems by individual stakeholders in terms of hardware, consumables and personnel resources. The integrated platform for the road safety management system is in place, however, it needs a policy direction from the government to galvanise the major stakeholders.*

Keywords: integration framework, road safety, stakeholders, fragmentation

INTRODUCTION

Globally, there has been no overall reduction in death rates arising from road accidents, with losses standing at1.24 million deaths per year (Toroyan *et al*., 2013; WHO, 2013). However, there are countries which have successfully reduced the number of deaths on roads while for the others this number is increasing (Steininger and Bachner, 2014; Hughes *et al*., 2015). The developing countries, particularly the African Region like Tanzania, are the hardest hit by accident deaths at (24.1 per100,000 population) with the European Region being the lowest hit at (10.3 per100000). Recent reports and studies indicate that among other factors, human factors andvehicle conditions account for most road accidents in Tanzania, with human factors dominating at approximately 76.4 % of all causes of road accidents (SUMATRA, 2007). The human factors include impatience, stress, reckless driving, over-speeding,

driving while drunk, using phones while driving, ignoring traffic signs such as pedestrian crossing, wrong overtaking and parking, driving while in stress, obstructing other drivers, etc.Distracting activitieswhiledriving includetexting,talking onthephone anddrinking behind the wheel (Ramasaamy *et al*., 2009).

There are various measures that have been adopted in Tanzania to curb this worsening situation, including driver training, public awareness campaigns, improvement of roads, increasing fines to unruly drivers, setting speed limits depending on categories of roads, deploying traffic police with speed monitoring devices, mandatory check of vehicles road worthiness and increase of vehicles inspections by the police force (SUMATRA, 2007; Chiduo and Minja, 2001). The measures taken are dynamic but there is no effective and efficient coordination facilitation in place for such efforts with concentration being on accidents while traffic rule violation is a very important factor. Hence, the adopted measures have not produced a significant positive effect in terms of reducing the number of accidents and associated consequences (Baher and Lina, 2004). The impact of these adopted measures is low because of the basic underlying concept which was used in developing an implementation strategy and tools. Firstly, there are multiple key stakeholders in road safety management with full autonomy, operational policies and having different and non-interoperable fragmented information systems even within the same institution. Hence, the stakeholders are unable and/or unwilling to share timely information among themselves or with the public for non- sensitive data and to coordinate their activities and functions. Secondly, the existing systems and associated technologies are proprietary in nature because the specification for such systems were driven by vendors rather than needs to solve particular challenges and means to realize effectively intended objectives (Team, 2007). Therefore, most systems are not interoperable, creating little ownership to the end users, and difficulty in the integration of data and manageability. Thirdly, there is a heavy duplication of efforts and investment in incoherent data systems in terms of hardware, consumables and personnel resources that are poorly managed policy-wise and in execution (Rechnitzer *et al*., 2000).

The existing fragmentation has led to various challenges including inability to track traffic law offenders, processes of renewal of driving/car licenses not linked to previous traffic offences committed and/or fine payments, use of fake number plates and licenses and renewal of business licenses not linked to offenses and fine settlements. Other challenges are lack of effective and efficient means of capturing traffic offences and timely access to information across the stakeholders involved, verification of fraudulent data, and

handling of road accidents in coordinated manner, and citizens' participation in prevention of road accidents and violation of road traffic regulations (Joumard and Gudmundsson, 2010).

The global report on road accidents (WHO, 2013) stressed the need to have an integrated routine system for reporting road traffic accidents and handling post-crash care to save the lives of the victims (WHO, 2013). Given the disparity between countries in different regions, in terms of the number of vehicles on the roads, quality of the roads and vehicles, and the methods of traffic regulation enforcement, the need for international benchmarking on road safety has also been stressed (Shen *et al*., 2015). At the same time achieving integrated systems can be very challenging because of mismatch between the higher level government policies and information management in the field (Bax *et al*., 2014). Various models aimed at improving road safety by addressing the effects of road traffic accidents have been developed, mostly from developed countries, and each with its own merits (Hughes *et al*., 2015). Given the severity of the road safety problem, the researchers mounted a project with the goal of reducing human injuries, losses and suffering; material and infrastructure losses and damages, social and health impact resulting from road accidents in Tanzania. As part of this project, the researchers conducted a study to investigate the existing challenges in the management of road safety and determine how an effective intervention to these challenges can be realized.

METHODOLOGY

A workshop involving personnel from all key stakeholders was held on 3rdDecember, 2013 at TCRA conference hall with four key factors in mind; creating awareness of the road safety project in progress, getting stakeholders involvement from the start so as to build sense of road safety project ownership in all of them, to share experiences with stakeholders in the area and to get everyone involved in the road safety project. This was important to the project since it was essential to understand clearly what was on the ground to properly embed local context in any solution developed, avoid duplication of efforts and make acceptability and adoption by the relevant authorities easier. The workshop itself was not enough to realize the goals set for involving all stakeholders since they all had different roles (although some of them overlapped). Hence, several follow-up brain storming sessions and meetings with multiple key stakeholders were necessary and were conducted from July to September 2014 to understand clearly the status of road safety in Tanzania, supporting infrastructure in place, existing systems, plans, underlying operational policies, practices and challenges. Based on the

findings from these meetings and in-depth literature review, several challenges and solutions were identified to address the problem.

Brain storming sessions and meetings were conducted at the stakeholders' localities in order to formulate methods to address the identified challenges. The stakeholders were requested for official appointments leading to meetings with 5-10 officials of the respective institutions. These institutions were SUMATRA, Police Traffic Division, Ministry of Works, Ministry of Transport, TEMESA, NSSF, Ministry of Home Affairs, TANROADS, COSTECH, Ministry of Communication, Science, & Technology, e- Government Agency, Dar es Salaam City Council, and TRA. The authors also wanted to know more about the existing systems and how these systems exchange data within and across the road safety stakeholders.

In order to tackle the primary challenge of information being collected by one stakeholder which needs to be accessed by other stakeholders but not being made available to them, it was considered necessary to develop a modality to integrate the information from the segregated different stakeholders' information systems to facilitate availability to them all. One such challenge was enabling the accidents information to reach all the relevant stakeholders for fast and effective response. For this, it was considered necessary to develop a solution based on smart phones owned by the authorities and stakeholders for collecting and sending the information. This was seen to be a prudent approach since smart phones are increasingly becoming accessible and owned by many citizens and becoming cheaper by the day. Another important area of study was in capturing information on vehicles especially on the roads when traffic regulations and rules violations occur, which necessitate developing methods and a system for automatic monitoring, detection and registering. This is an extensive and challenging area since it presents a wide-ranging scenario. Another important dimension in collection and dissemination of information on road safety aspects is on verification. Hence, simple but reliable methods for the verification of the information sent to the relevant authorities, especially if it was sent by the public, have to be developed.

The implementation of the integration framework was made possible by using open source technologies to ensure interoperability with existing systems and development was based on evolutionary prototyping approach to ensure scalability and flexibility to meet continuous needs and demands of all stakeholders involved. Furthermore, a road safety site web portal for public sharing, updating and uploading accident incidences has been developed.

RESULTS AND DISCUSSIONS

The study has shown that every part of the community is affected in one way or another by road safety, be it in the developed or in developing countries. However, the most affected are developing countries although they have fewer vehicles and driving hours on the roads. The primary factors for these are poor or none existence of cities emergency services, weak policy enforcement mechanisms in coordinated manner, many actors having not coordinating umbrella, data systems with related data which cannot talk to each other, lack of systems in place to support enhancement of enforcement of traffic regulations, rules and procedures, etc. Close observations made in some of the areas that are prone to violations that result in accidents has shown that enforcement has a much higher impact in addressing road accident problems than increasing fines several folds.

Existence of Fragmented Systems Managed by Different Stakeholders

Although road safety management needs to be coordinated in an integrated manner, as shown in Figure 1, various key stakeholders manage their own systems that do not share data. The Tanzania Revenue Authority (TRA) for example, manages three separate systems for car registration, road license payments, and a system for issuance of the road license. The traffic police dealing with traffic regulation enforcement cannot easily access the driver's license number or car registration number for verification purposes. At the sometime, there is an accident reporting system being implemented by the Ministry of Works under the Directorate of Road safety that is not interoperable with other systems managed by TRA. Such systems are not linked to the citizen information systems such as National Identity, voter's registration owned by National Electoral Commission, or birth/death registration systems owned by RITA making it difficult to verify the authenticity/validity of the driver's license, in case of any forgery.

The existing systems hosted by different stakeholders do not see each other since most of their specification were vendor-driven without integration focus even for database systems under one entity. There is a strong sense of ownership by each stakeholder making the integration a significant challenge. This has made traffic regulation and laws offenders get away with any violations and renewal of licenses to have no link to traffic offences or violations committed by the driver or the car owner. Drivers are very impenitent and have very low respect for traffic rules and regulations in the absence of police monitoring, effective booking of offenses, and payment of fines. However, the small police force cannot be everywhere twenty-four hours a day all days. Enforcement has therefore been a problem since information on accident incidents rely on that collected by a sole police officer

manually when they arrive at the scene of the accident physically. It is not easy to access records of activities of any particular officer assigned to a particular road stretch or location. To approach the interactive complexity faced by stakeholders presented in Figures1and 2, there must be efforts to bring the stakeholders under one umbrella.



Figure 1: Fragmented Active Road Safety



Figure 2: Fragmented Stakeholders

Key Stakeholders Involved in Road Safety Management and their Roles

The typical stakeholders involved in road safety management at the minimum include:

- *Law enforcers* (Traffic Police Force, TANROAD, SUMATRA, TBS) who deal with enforcement, accident and violation reports, quality inspections, revenue collection, business licensing, inspection certificates, road worthiness of imported vehicles and driver's testing certificates;
- *Fire Brigade dealing* with fire incidents related to accidents on the roads;
- *Hospitals* dealing with attending to accident victims;
- *Drivers* related to driving behavior mind set, driving licenses, offences, and penalties;
- *Citizens/community* related to road usage, reporting incidents, accident and violations;
- *Tanzania Revenue Authority (TRA)* involved with issuing car registration numbers, road licenses, driving licenses, and tax identification numbers (TINNo);
- *Tanzania Road Agency (TANROAD)* linked to setting speed limits, road condition/ improvements, road infrastructure, overtaking status;
- *Insurance Agencies responsible for issuance of insurance covers, compensating deserving clients;*
- *Drivers Training Agencies* (NIT, VETA, JKT, etc.) responsible for training of drivers and issuance of qualifying certificates;
- *Government Ministries* (Ministries of Home Affairs, Health, Transport and Works & Ministry of Local Government and Regional Administration) dealing with policy setting, legal framework, funding of enforcement entities, monitoring and evaluation of existing systems; and
- *Citizen Information Systems* (NIDA, Immigration Department, RITA, NEC): These actors have some interrelationships with the road, drivers or cars, but they work in a Very fragmented way at the periphery to the higher level

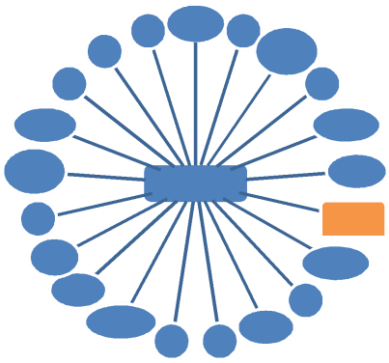


Figure 3: Road Safety Stakeholders



Figure 4: Key Functions in the System Intergration

All these stakeholders are responsible in one way or another in road safety administration and in attending road accidents incidents. They are independent administratively with the same status and autonomy. This makes collaboration and cooperation a very significant factor when addressing road safety issues.

The Interrelationships between Key Actors

Road safety involves the management of roads, cars, and drivers and key actors are involved in this process which is traffic police, Tanzania Roads Agency (TANROADS), Tanzania Revenue Authority (TRA), SUMATRA, Fire Brigade, and the Government Ministries.

Figure 5 indicate some variables and functions associated with each key actor. While ANROAD, Fire Brigade, TRA, SUMATRA, and Traffic Police interact in one way or another in their daily routine handling of traffic offences and road accidents, their electronic systems hardly exchange data or receive data from the citizen/community. This close working relationship at the ground level suggests the need for an integrated system to enable the actors to manage properly the road safety. The key actors have some interrelationships with the road, drivers or cars, but they work in a very fragmented and uncoordinated way with each actor managing their own information systems.

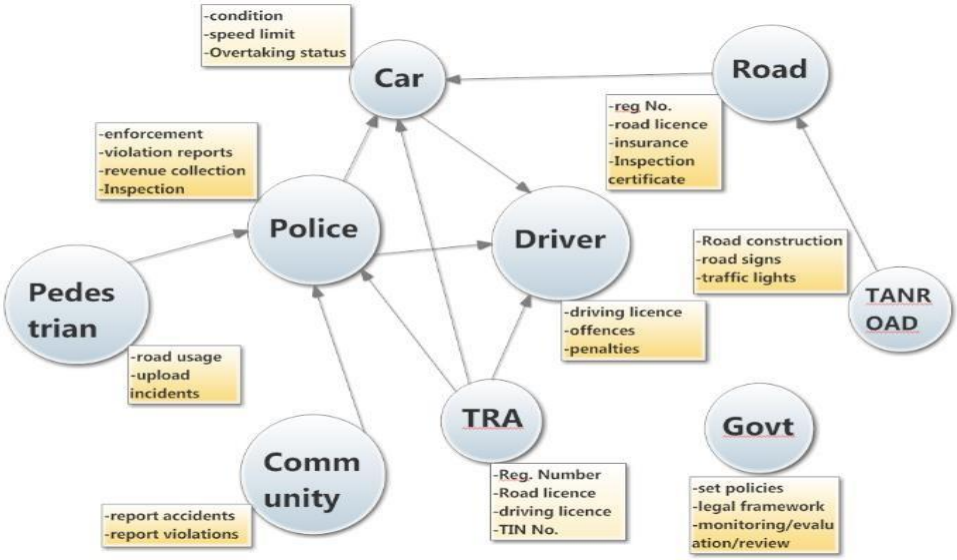


Figure 5: The Interrelationship between Key Actors

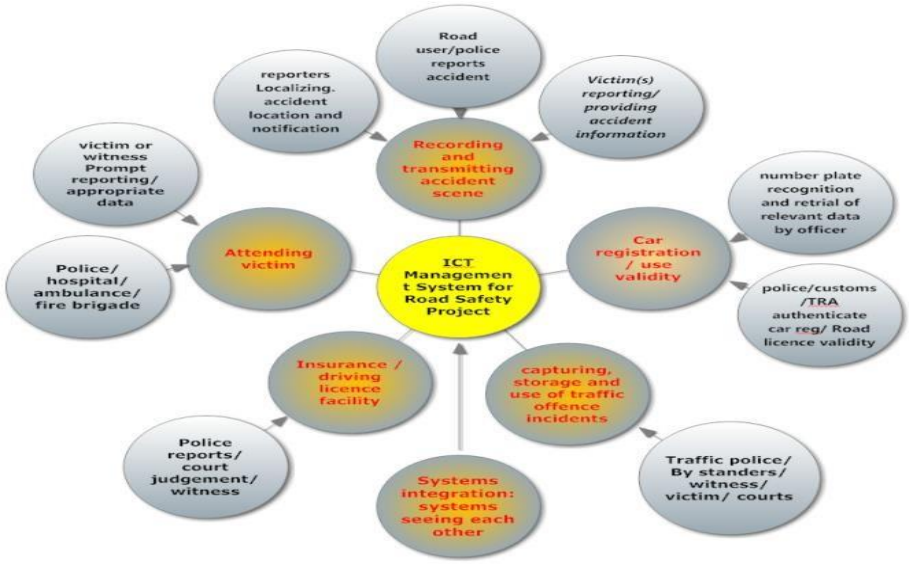


Figure 6: Integration Framework

Proposed Integrated Road Safety Information System

An integrated framework is needed that integrates road safety services of the different stakeholders and data systems across existing road traffic reporting systems and inclusion of new sub systems, namely silent policing using camera and mobile phones, community policing through mobile phones, and accident management system and mobile phone applications to capture, manage, transmit and retrieve data. The integration framework supports the services of those actors enabling them to share the information in an integrated fashion. Integration of information systems can enhance coordination, optimize utilization of resources, and link offences to offenders, and increase revenue collection.

This integration framework is implemented as an integrated platform (called **Road2**) to capture different scenarios and data such as (i) Recording and transmitting of accident scene (ii) Car registration and user validity (iii) Driving license facility (registration and validation) (iv) Reporting and recording of traffic offence (v) Vehicle and driver offence tracking (vi) Reports and statistics (vii) Insurance Capture. The integrated platform can be accessible to all road safety stakeholders involved.

Road2 facilitates capturing traffic offences using a web application and mobile phones, and it allows information sharing to enable penalizing of all offenders and drivers for changing behavior and thus reducing accidents. The police can report a violation automatically using their mobile phones. Also, once an accident has occurred it should be reported immediately by citizens using

their mobile phones and appropriate post-accident management of victims instituted by all stakeholders involved in a coordinated manner to save lives. Road2 has made it possible for the citizens to report violation/accident information instead of the offenders themselves, thereby widening the enforcement scope to reduce the accidents and traffic violations.

CONCLUSION

Tanzania has been investing in ICT infrastructure by putting in place a metropolitan optical fiber network, national optical backbone, and extensive mobile telephone network offering all kinds of applications therefore setting a good environment for operalization of e-governance. The political will is very strong, so a holistic national prescribed solution that addresses local context backed by created local expertise is bound to be successful.

The existing countrywide connectivity through a wireless mobile telephone network has set up a good environment for implementation of an integrated electronic system. The use of mobile phones is becoming more and more an integral part of the Tanzanian society, such that even some remote rural areas can now access online services and mobile money systems using low-cost mobile phones. There is also the rapid adoption of e-services in government, albeit in a fragmented manner. Since there is a strong political will and an ICT network infrastructure, it is possible to implement the integrated framework for road safety management to address the challenges of existing fragmentation.

Such integration, however, cannot be achieved without a policy direction from the government since currently road safety issues are partly managed by four government ministries (of works, health, transport, and home affairs) in an uncoordinated manner. Based on experiences from other countries that have attempted to integrate road safety matters (Bax *et al.*, 2014; Hughes *et al.*, 2015), the process of having all stakeholders embrace the use of an integrated information system needs adequate effort, resources, and a policy direction from the government.

ACKNOWLEDGEMENT

We wish to acknowledge the generous provide financial support given by the Tanzania Communication Regulatory Authority (TCRA) and other stakeholders who participated in different stages and meetings of this project which made this research possible. We take this opportunity to urge other institutions in the country to follow this good example for the betterment of our services and citizens.

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Non Conventional Livestock for Better Livelihood: Prospects of Domestic Cavy in Mixed Production Systems of Tanzania

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Abstract: *Similar to majority of Sub-Saharan African countries, Tanzania depends largely on small and large ruminants, poultry and seafood to meet its animal protein needs. While most of the non-conventional protein sources are hunted, domestication of some of the species is equally promoted because hunting harvests cannot provide sustainable and affordable meats. Meanwhile, there have been growing demands for white meats, especially among the middle and high income population classes, exacerbated by changes in eating and living habits. Recent reports have identified domestic cavy (*Cavia porcellus L.*) as a right delicacy. This small pseudo ruminant that is also referred to as guinea pig or as Pimbi or Simbilisi in Kiswahili, is adopted in rural and urban households in Tanzania. This paper highlights on prospects of production of cavies focusing on the mixed production systems of Central Tanzania, where identified farmers keep a few cavy families either in own pens in a compound or within living houses of owners. Results indicated that farmers have such major reasons as keeping cavies for food (37%) or cash income (33%). Inadequate knowledge on improved husbandry practices was the most limiting constraint (38%) in the study sites where cavy keeping hinges on local knowledge and locally available feed resources. Therefore, innovative approaches and more attention from research and extension services are called for to improve production, consumption and marketing of cavies and other non-conventional meat sources as stipulated in the national livestock policy.*

Key words: cavies, protein, meat, extension, forages.

INTRODUCTION

Tanzania is among the few countries with countless sources of food whereby people depend largely on small and large ruminants, table birds, seafood and several insects for protein intake. The current National Livestock Policy (URT,

2006), recognizes the abundance of non-conventional meat sources and advocates the need for inventorization, characterization and evaluation of these sources for increased livestock productivity and improved livelihood. At the same time, the National Livestock Policy guarantees government support and commitment to strengthen technical services for production and encouraging utilization, processing and marketing of non-conventional meats. It has been shown in a wide context that non-conventional livestock species could provide enough meat, if not more than what is needed (NRC, 1991). Meanwhile, there are increasing needs for food and nutritional security due to growing human population and the consequent pressure on the depleting natural resources (Nielsen, 2004). However, health concerns for middle and high income social classes are pushing for demand of low fat animal protein sources. Cavies, rabbits and several insects are listed among non-conventional delicacies that would provide more convenient alternatives to this end (NRC, 1991; URT, 2006; Matojo and Yarro, 2013).

The domestic cavy (*Cavia porcellus* L) is a member of the rodents in the family Caviidae and subfamily Caviinae (Chauca de Zaldivar, 1995). Domestic cavies (or guinea pigs) are native to the Andean highland areas of South America and Philippines (Blench, 2000; Grégoire *et al.,* 2012) and are also raised in western, central and eastern African countries (Adu *et al.,* 2005). Records show that Peru is the country with the highest population of cavies worldwide where 22 million cavies are raised under family production systems producing 16,500 tons of meat annually (Grégoire *et al.,* 2012). Lammers *et al.* (2009) demonstrated the potentials of cavies to enable developing countries meet their animal proteins fast growing demands.

The cavies (also known as *Pimbi* or *Simbilisi* in Swahili) are kept in rural and peri-urban areas of Tanzania especially in southern highlands and in neighbouring regions (Nielsen, 2004; Mwalukasa, 2009). Despite variations in socio-cultural norms in cavy management, it is reported (Metre, 2011) that cavies are mostly cared for by women and youths and are sources of food, cash income and organic manure in eastern Africa countries. These animals are also kept as pets and are used in biological and medical training as well as in biological researches particularly in diagnosing diseases (Grégoire *et al.,* 2012; Daoud *et al.,* 2013; Dildeep *et al.,* 2013). In 1980s, several cavy families were also kept at the Livestock Production Research Institute (LPRI, now TALIRI Mpwapwa) for veterinary research purposes.

This paper highlights the management and production of cavies among agro-pastoral communities in Dodoma, central Tanzania. Broadly, the reported study aimed at investigating and promoting sustainable utilization of non-conventional meats in Tanzania. Specifically, it intended to (i) investigate

production and management patterns of cavies in mixed production systems of central Tanzania (ii) determine the constraints and challenges in management of cavies in study areas (iii) and proposing sustainable steps and pathways for improving management and productivity of cavies.

MATERIALS AND METHODS

Cross-sectional and longitudinal surveys as well as participant observations were conducted between April and May 2015 in Kongwa (6°12′00″S 36°25′01″E6.200°S 36.417°E) and Mpwapwa (06°21′0″S 36°29′0″E) districts of Dodoma region, Central Tanzania. In Kongwa district, crop and livestock farmers from Mlali Iyegu, Mlali Bondeni, Kiwanja cha Ndege, Ibwaga, Sagara and Tubugwe villages were involved. Similarly, farmers from peri urban sub-villages (streets) of Kiboriani, Ng'hambo, Kota, Hazina and Vigh'awe in Mpwapwa district were involved. A snowball sampling technique (Laerd Dissertation, 2015) was employed to identify current and former cavy keepers where the sampling unit was the individual cavy keeper. Thirty one (31) respondents were contacted from where both quantitative and qualitative information were solicited using a checklist.

Participant observations and discussions were employed to notice cavy housing, number and size of cavy families, types of feeds and general attitudes towards cavy keeping and the accrued benefits. Descriptive statistics of data obtained and content analyses of information were done thematically to highlight reasons for cavies keeping and general husbandry practices. These included cavy housing and feeding, reasons for not keeping cavies at the moment of surveys, roles played by various members of household in cavies production, acquired benefits, production constraints faced, methods used to control/overcome production constraints and suggestions about the future of cavies at large including sustainability of cavy production, consumption and marketing strategies.

RESULTS

Out of 31 respondents involved in the study, 70% of them were males and 30% were females (Table 1).

During the interview it was revealed that most of cavy keepers had an initial stock of between one (1) and six (6) cavies. In addition, it was found that more than a half (53.3%) of the interviewed cavy keepers started with one (1) male and one (1) female; 20% had one (1) male and more than two (2) females; 13.3% had started with one (1) male and two (2) females (Table 1). The survey indicated that 51.6% (n = 31) were still keeping cavy while 48.4 % had stopped keeping these animals.

Table 1: Respondents on cavy keeping and number and sex initial cavy stock

Sex		Frequency	Percentage
Male		22	70.0
Female		9	30.0
	Total	**31**	**100.0**
Sex of cavy started with			
1 M and 1 F		16	53.3
1 M and 2 F		4	13.3
1 F only		2	6.7
1 M and not more than 2 F		6	20.0
2 M and more than 3 F		3	6.7
	Total	**31**	**100.0**
Still keeping		16	51.6
Stopped keeping		15	48.4
	Total	**31**	**100.0**

Characteristics of Cavy Keepers and Keeping Status

The minimum, and the mean age for the interviewed respondents were 12 years, 78 years and 38.95 respectively (Table 2). The highest number of cavies reached among the interviewed respondents was 70 with mean and standard deviation of 25.26 and 20.30 respectively. Likewise, the current number of cavies possessed ranges from 1- 30 with average of 5.4 (Table 2).

Table 2: Age of Cavy Keepers and Keeping Status

Item	Minimum	Maximum	Mean	Std Deviation
Age of respondent	12.00	78.00	38.95	17.64
Number of cavies started with	1.00	6.00	2.77	1.22
The highest number of cavies reached	5.00	70.00	25.26	20.30
Current number possessed	1	30	5.40	8.18

Reasons for Keeping Cavy

Discussion with farmers revealed that they had different reasons for keeping cavy (Figure 1). Majority of respondents (70%) were keeping cavies as source of food and income while the rest had other social reasons including maintaining them for their children who were not at home but had initiated the activities. Others admitted that they had kept cavies for so long and did not want to lose the animals. Discussion with respondents revealed that the price of a cavy in the village ranged from Tshs. 2,000 – 3,000 which was almost

the price of about half a kilogram of beef in some village markets in Dodoma region.

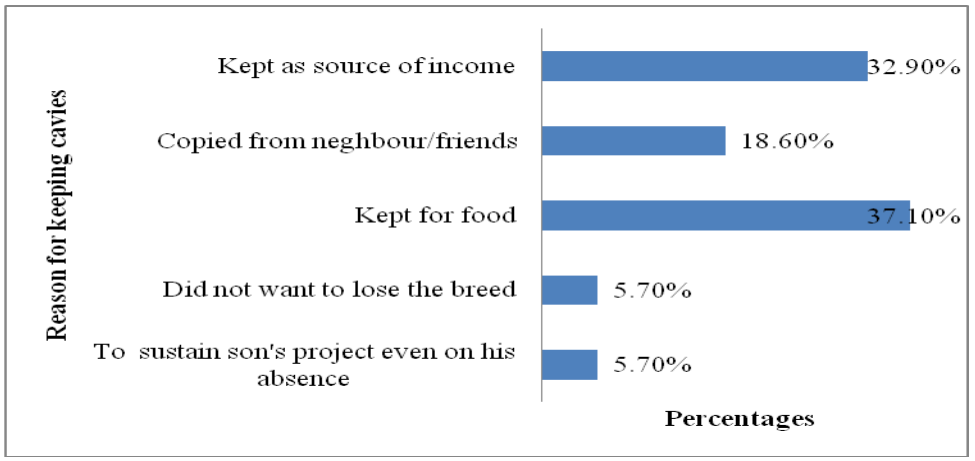


Figure 1: Reasons for Keeping Cavy

Reasons for not Keeping Cavies

The reasons for not keeping cavies included difficulties in obtaining feeds during dry season (5.7%), disturbances caused if kept in the same house with human other than their own sheds (11.4%) and presence of predators (17.1%) (Table 3).

Table 3: Reasons for not Keeping Cavies

Constraints faced	Count	Response
Difficult to get feeds during dry season	2	5.7
Disturbance if kept in the same house with human other than their own sheds	4	11.4
Predators	6	17.1
Grown up and decided to deal with other income generating activities	2	5.7
Busy with farm activities	8	22.9
No reliable/attractive markets	4	11.4
Went to school/moved from home to urban centres	1	2.9
Decided to slaughter all for meals at home	7	20.0
Husband died and no one was interested on cavy keeping	1	2.9
Total	**35***	**100.0**

*Multiple responsesTable 4 indicate source of cavies kept by farmers in the study area. Majority of respondent (66.7%) of the interviewed farmers bought cavies from friends and neighbours whereas 6.7% of the respondents got their initial stock through traditional batter system where they agreed to exchange cavy with other social items including chicken, dogs, firewood and sugarcane.

Table 4: Sources of Initial Cavy Stock

Source of initial stock	Frequency	Percentage
Bought from friends	12	40.0
Bought from neighbours	8	26.7
Given as a gift from grand parents	4	13.3
Bought from relatives in the village	4	13.3
Exchanged with other social items (chicken, firewood, dogs, sugar cane etc)	3	6.7
Total	**31**	**100.0**

Table 5 indicate significantly strong associations between the size of the current possessed stock (χ^2 =60.179, p ≤ 0. 021) and the means used to obtain the initial stock (χ^2 = 47.356, p ≤ 0. 039) implying that those who bought the initial stock were also affectionate of maintaining the animals.

Table 5: Association between size of current possessed stock and some independent variables

	Size of current possessed stock	
	χ^2	P-value
Number of cavies that a respondent started with	60.179	0. 021*
Means used to obtain the initial stock	47.356	0. 039*
Sex of initial parent stock	49.075	0. 027*

Note: * Significant at 5% level (P ≤ 0.05)

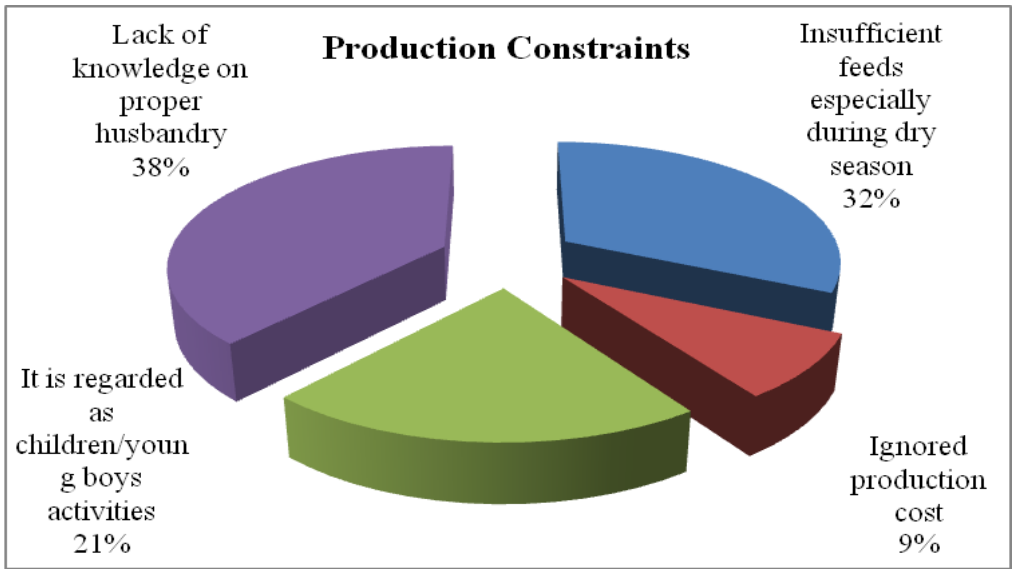


Figure 2: Production Constraints

Farmers Suggestion Regarding the Future of Cavies

Production Constraints

The study revealed some production constraints regarding the keeping of cavies in the study area including inadequate knowledge on proper cavy husbandry (38%); insufficient feed especially during dry season (32%); cavy keeping regarded as children activity so little attention has been paid by adult people (21%) and ignored production cost (9%) (Figure 2).

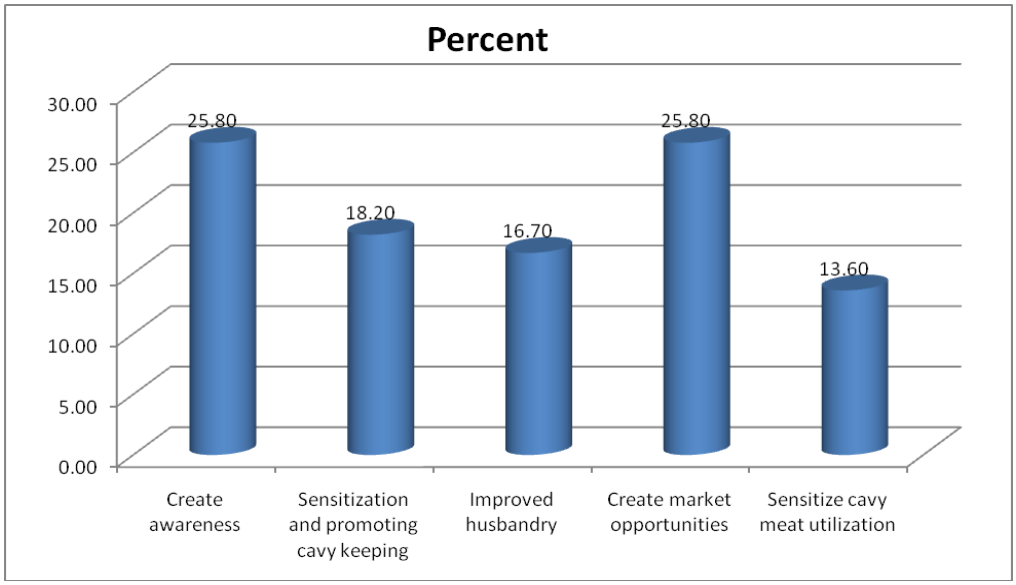


Figure 3: Farmer's Suggestions about the Future of Cavies

The interviewed farmers came up with valuable opinions regarding the future of cavies in respective areas whereby 25.8% respectively emphasized a need for awareness creation and the need for market creating and increasing marketing opportunities for cavies and cavy meat (Figure 3).

DISCUSSION

The population of domestic cavies in Tanzania is not known and this fact that calls for more studies and documentation. However, the number of cavies per household found in the study area was within ranges reported to be in Njombe region where 10-25 cavies are raised per household (Mwalukasa, 2009). Farmers in Central Tanzania indicated that many do not easily opt to slaughter a female cavy because they can conceive shortly after parturition. Provided they normally keep males and females together it is difficult for them to identify non pregnant females for slaughter especially in the early pregnancies. However, it is reported that at the age of two months a cavy can breed and it takes the mother 60 to 70 days to farrow where piglets suckle for three to four weeks (Nalugwa, 1999). There are other studies (Mwalukasa, 2009; Grégoire *et al*., 2012; Dildeep *et al*., 2013) that have established the

gestation period of 68 days and have noted of existence of promising protocols for estrus synchronization

The financial gains reported from keeping cavies of Tshs. 2,000 – 3,000 per cavy indicates that a household that could raise 50 - 75 cavies per year would fetch Tshs 100,000 – 225,000 per year (or US $ 100 – 150, assuming 1 US $ = Ths. 2000). Similar findings (Nalugwa, 1999) indicated that in Kilifi district of the coastal region of Kenya, each cavy could worth 60 – 120 Kenya Shillings (or US $ 0.6 – 1.2, assuming 1 US $ = KES100), enabling youngsters to be able to pay school fees. Generally, this is a substantial amount and qualifies farmers' needs for more sensitization and practice for improved husbandry of cavies, meat consumption and general marketing channels for cavies and other non conventional animal sources. Farmer sensitization on financial and nutritional benefits of cavies could alleviate problems and challenges encountered in cavy keeping in the study areas. Therefore, public and private institutions promoting agricultural investment and productivity need to equally support initiatives towards improving household incomes from a small stock.

The Tanzania's National Livestock Policy (2006) recognizes the need for emphasis in non conventional livestock including small stock (rabbits, cavies) and poultry (ducks, guinea fowl) as they significantly contribute livelihood of many rural and urban communities. Related finding conducted in West Africa (Nuwanyakpa *et al.,* 1997) that analysed prospects of guinea pig production under smallholder conditions.

The basal diet for cavies in the study sites were green forages including *Commelina africana* and C. *benghalensis* and *Launea* spp that are normally sourced in fields and rangelands. Green leaves of crops such as maize (*Zea mays*), sweet potatoes (*Ipomoea batatas*) and other vegetables are also collected and fed. These findings are similar to that of Adu *et al*. (2005) who reported that cultivated pastures such as Lucerne (*Medicago sativa*) and *Pueraria phaseoloides* are suitable forages to eat for protein.

However, it was reported that there are difficulties in obtaining feeds for cavies that is compounded by a long dry spell of up to eight months. In order to have a more sustainable feed resource base for cavies and other livestock farmers in the study areas are advised to establish feed gardens with recommended pastures and forages types.

Meanwhile, local knowledge of farmers in keeping cavies indicated their understanding that there are no major diseases affecting cavies provided that cleanliness and proper feeding are adhered to. However, infectious diseases

such as *salmonellosis* and pneumonia, bacterial conjunctivitis and dermatitis due to fungal attack can erupt where proper housing and hygiene are compromised. There are also likelihoods of ecto- and endo-parasite infections in cavy management. Generally, proper and adequate feeding and attention to improved husbandry can strongly decrease cavy susceptibility to diseases and parasites.

It was earlier observed that the numbers and sex of initial stock that the farmers own have influence on ultimate cavy numbers owned and disposed. This means that stakeholders who want to support communities in cavy keeping have to bear such factors in mind. Where necessary, farmers should also have a hand in these ventures where they could partially or wholly contribute in obtaining the animals or putting up proper housing structures. Similarly, at least few cavies comprising of both family couple have to be there in order to sustain several cavy families in a long run.

CONCLUSION AND RECOMMENDATIONS

In mixed production systems of Tanzania, keeping of livestock such as domestic cavies depend heavily on local knowledge in feeding and general husbandry practices. Cavies are sources of food and household incomes and are potential capital for other household investments. However, there are avenues for improved cavy productivity if the current local knowledge and systems are explored and conventional scientific approaches are utilized.

Therefore, more attention from research and extension services are called for in order to improve production, processing techniques, consumption and marketing of cavies products and other non-conventional meat sources as already stipulated in the National Livestock Policy (URT,2006). Likewise, financial and intellectual investments in cavy breeding, sustainable production systems, product promotion and marketing are also inevitable.

Acknowledgement

Authors acknowledge active participation of all farmers visited during field studies and logistical support from the Director General, Tanzania Livestock Research Institute (TALIRI).

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Innovative Strategies for Control of Coffee Insect Pests in Tanzania: A Review

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Abstract: *Coffee insect pests are one of the major factors which affect coffee production and quality. globally, coffee insect pests are estimated to cause losses of about 13%. However in Africa, yield losses can be much higher, particularly where Arabica and Robusta coffee are grown for a long time. In Tanzania the major insect pests are white coffee stem borer (Monochamus leuconatus), coffee berry borer (Hypothenemus hampei), Antestia bugs (Antestiopsis spp), leaf miner (Leucoptera spp), green scale (Coccus spp) and mealy bugs (Planococcus kenyae). Minor important pests including yellow headed borer (Dirphya nigricornis), thrips (Diarthrothrips coffeae) and berry moth (Prophants smaragdina) are reported to vary in crop losses caused. For decades industrial chemicals have been used to control the prevailing coffee insect-pests. But uses of industrial chemicals have been reported to have negative implications to the environment, animals and human health. In the recent years worldwide, efforts have been focused to researching on the sustainable control measures for coffee insect pests. For a period of over ten years Tanzania Coffee Research Institute (TaCRI) has been developing ecologically and environmentally sustainable coffee insect-pests control measures which include; use of bio pesticides, traps, parasites, attractants and biological agents. These technologies are progressively adopted by coffee farmers in the country. The potential of these innovative insect pests control measures and their impacts on management of coffee insect pests are discussed in this review paper.*

Key words: Coffee insect pests, Arabica, Robusta, IPM strategies

INTRODUCTION

Coffee is one of the five most important commodities in the world market (Ibrahim and Zailani, 2010). Nestle (2004) and DaMatta, (2004) describe coffee as the second most valuable legally traded commodity in the world after petroleum, representing a significant source of income to several tropical and sub-tropical countries. It is the primary export of many developing countries, and as many as 25 million farmers depend on coffee for their livelihood. It also provides significant foreign exchange earnings of many developing countries (Waller *et al*., 2007; Kaplinsky, 2004). In Tanzania coffee accounted for 25% of the crops exports value in the year ending June 2013 (BOT, 2013). Coffee

subsector employs more than 400,000 smallholder farmers in Tanzania who produce 90 – 95% of coffee while the remaining 5 -10% is produced by 110 coffee estates. It is estimated that 2,000,000 other people depend on coffee indirectly (TaCRI, 2011).

PESTS OF ECONOMIC IMPORTANCE IN TANZANIA AND THEIR IMPACTS TO COFFEE PRODUCTION

Insect pest problem is one of the major factors which affect coffee production and quality (Hella *et al.*, 2005). Over 900 insect species are known to infest coffee in the world (CABI, 2007; Kimani *et al.,* 2002; Hillocks, 2001). Globally, coffee insect pests are estimated to cause losses of about 13% (Bardner, 2006). However in Africa, yield losses can be much higher, particularly where Arabica and Robusta coffee is grown for a long time. About 36 insect pests have been recorded in East Africa including Tanzania (Mbungua, 1995; Mugo, 1994).

In Tanzania the major insect pests include the following; the African white coffee stem borer, *Monochamus leuconatus*, Pascoe is a serious pest in Africa coffee growing countries, including Tanzania, causing production losses, severe damage to trees and in some cases, substantial tree mortality if not controlled (Le Pelley, 1968). The pest causes a yield loss as high as 25% in South Africa (Oduor and Simons, 2003; Schoeman, 1998). Antestia bug is a major coffee pest with a density of 2 to 3 per tree considered as the economic threshold level and caused a crop loss of 45 % (Le Pelley, 1968).

The coffee berry borer, *Hypothenemus hampei* is serious coffee pest worldwide and major pest for Robusta and low altitude Arabica coffee (Rutherford and Phiri, 2006). Crop losses caused by this pest can be severe, ranging from 50-100% of berries attacked if no control measures are applied (Le Pelley, 1968). Waterhouse and Norris (1989) reported a yield losses as high as 96% due to attack by this pest in Africa. The leaf miners (*Leafminer spp*) is another pest of economic importance which attacks more Arabica than Robusta. Density of 4 mines per leaf make a maximum number of a leaf to fall and causes losses that may reach 50% of the total production (Motte, 1976). The green scale, *Coccus alpinus* De Lotto and *Coccus viridis* Green are common but minor insect pest of mature Arabica coffee. Damage caused by the pest will in turn lead to decreased yield and low quality coffee beans (Minai, 2009; CABI, 2007). The coffee mealy bugs, *Planococcus kenyae* Le Pelley are important sucking pests of Arabica and Robusta coffee. Serious infestations of the pest are often found where there has been use of insecticide sprays, especially highly toxic Organophosphate sprays (CABI, 2007; Wrigley, 1988). Other coffee pests of minor but importance include; yellow headed borer, *Dirphya nigricornis*

(Olivier) berry moth, *Prophantis smaragdina* (Butler) and Thrips, *Diarthrothrips coffee* (Williams) (Magina, 2011; Minai, 2009; Le Pelley, 1968).

MANAGEMENT OF COFFEE INSECT PESTS

For decades industrial synthetic chemicals have been used to control coffee insect-pests. However industrial chemicals have several negative implications to the environment, animals and consumers of coffee (Horrigan *et al.,* 2003). Also use of pesticides results losing market of our coffee to some countries with niche markets that have set Maximum Residue Levels (MRL) (e.g. Japan). In the recent years worldwide, efforts have been focused on identifying alternative strategies which are cost effective and sustainable control measures for coffee insect pests. Integrated pest management (IPM), as one component of Integrated Crop Management, uses a combination of available and compatible pest control methods to minimize pest damage by most economical means, and with the least possible hazard to people, property, and the environment. Consideration of management practices is given to acceptability, ecological stability, environmental safety, and human resource development (CABI, 2007). For over ten years Tanzania Coffee Research Institute (TaCRI) has developed a number of IPM strategies and improved some technologies which are ecologically and environmentally friendly in controlling coffee insect pests.

IPM TECHNOLOGIES DEVELOPED

The technologies developed by TaCRI include the following: use of bio-pesticides (botanicals), sticky traps, entopathogenic fungus, attractants (locally made brews) and biological agents. The technologies developed are progressively disseminated to farmers through participating agricultural shows, open days, demonstration plots, backstopping programme and publications to coffee farmers

Technologies developed by TaCRI

(a) Management of Antestia bugs by use of bio pesticides

Botanical bio-pesticides are naturally occurring chemicals which are extracted from plants (Isman, 2006; Silva, 2004). Botanicals have shown to have short residual effect and are at best, moderately effective in killing insect pests and they are biodegradable, breaking down quickly as compared to synthetic industrial chemicals. Currently Antestia bug is controlled by application of Chlorpyrifos which are synthetic industrial chemicals (Magina, 2011). Some botanicals with insecticidal properties has been used to control insect pests as industrial chemicals on several crops including coffee in Tanzania (Mwatawala, 2005; Paul *et al.,* 2001), however appropriate dosages and their active ingredient (AI) have not been established (Magina; 2011; Paul, 2001). TaCRI has collected about 11 plants believed to have insecticidal properties

and established them in the botanical garden at TaCRI-Lyamungu for the purpose of evaluation of their effectiveness for coffee pest management.

Among the botanicals, Fish bean (*Tephrosia vogelii*) has been evaluated against management of Antestia bugs. Fresh extracts of *T. vogelii* at a rate of 1.2 kg per 1 litre of water have been evaluated and observed to be effective as Chlorpyrifos and has been recommended to be used as an alternative for management of Antestia bugs in the field (Magina *et al.,* 2012). Research to evaluate the active ingredient (AI) of *T. vogelii* has been initiated in collaboration with Tropical Pesticide Research Institute (TPRI) based in Arusha region.

(b) Alcohol traps for management of coffee berry borer (CBB)

Mass trapping technique by use of attractant is currently being considered worldwide as one of the best ways to control CBB in the field (Durfour and Frerot, 2008). Various authors have reported to establish the control of adult CBB by use of traps baited with lures such as methanol and ethanol in the ratio of 1:1 (Prakasan *et al*., 2001), methylated spirit and water in the ratio of 1:1 (Magina, *et al.,* 2006); and local brews ("mbege", "dengelua" and "rubisi") and banana juice (Magina *et al.,* 2014) respectively. TaCRI, in collaboration with IPM Collaborative Research Supportive Project (IPM/CRSP) in East Africa, has evaluated different attractants, which include; banana juice, local brews ("mbege", "rubisi" and "dengelua"). Results showed these lures and observed to be effective in management of the pest (Magina *et al.,* 2014). The attractants perform better when used in the red painted bottle traps locally made by use of discarded plastic bottle (used for packing drinking water). The trap reduces the infestation of the pest damage in the field by 80 – 85% per year, when entrapped with methylated spirit. The trap is an improvement of BROCAP™ trap developed by CIRAD which is still an inaccessible by resource poor farmers in the developing countries in the world. Also the trap has the capacity to capture 300 to 500 adult coffee berry borer in the field per week. The trap made by TaCRI is inexpensive, environmentally friendly and can be easily used by small holder farmers for management of CBB in the field (Figure 1). The technology has been recommended to be used by coffee farmers in Tanzania. Due to its cheapness and simplicity to make, some coffee estates and small holder farmers in the country where CBB is a problem has started adopting the technology.

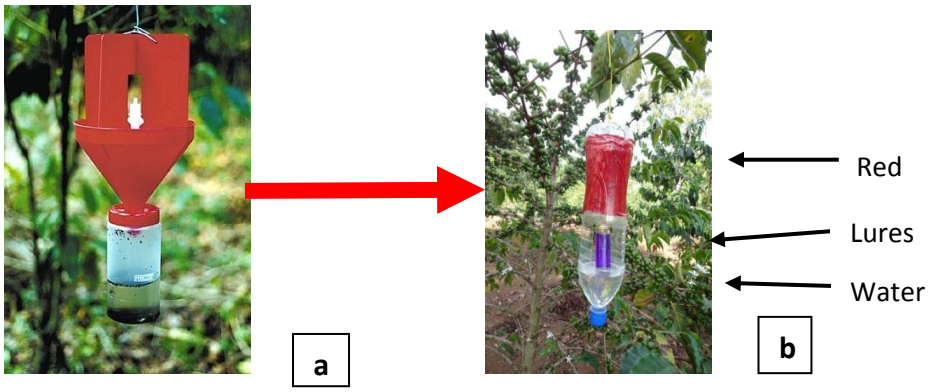


Figure 1: Brocap trap type ("a") from CIRAD and TaCRI trap type ("b") for coffee berry borer in the field

(c) Management of African white stem borers by the use of cooking oil/animal fats

In the past the African white coffee stem borer was effectively managed through use of Aldrin and Dieldrin 18 % EC chemicals. However, these chemicals are no longer used due to their hazardous effects on the environment and non-target organisms and also risk to the user (Rutherford and Phiri, 2006; Magina, 2011). There has therefore not been any effective control measure for the pest to date. Among other cultural management used for management of the pest, TaCRI has evaluated cooking oils and animal fats as an attractants of ants which minimizes the infestation of the pest. Smearing oils or animal fats on the holes made by larvae of the coffee stem borer attracts ants to feed on oils and fats and eventually enter and kill stem borer larvae in the tunnels (Magina, 2011). The technology has been evaluated and recommended to coffee farmers in Tanzania.

Management of mealy bugs and green scales by the use of predators (ladybird beetles)

Predators are mainly free-living species that directly consume a large number of preys during their whole lifetime. Ladybird beetles are typical predators that feed on a wide range of insect prey, and have been used extensively in the bio-control of insect pests (Dixon, 2005). Most lady bird beetles are beneficial as both adults and larvae, feeding primarily on aphids, mites, scale insects, small insects, and insect eggs (Shelton, 2005). According to Leppla and Johnson II (2010) in Florida (USA) they have managed to multiply the predator and they are selling them commercially to other countries for uses in orchards and field crops for management of insect pests. TaCRI has collected and evaluated the feeding habits of about six different types of ladybird beetles naturally occurring at Lyamungo (Hai district) in Kilimanjaro region.

These were identified as the black lady beetle, *Exochomus aethiops*, striped lady beetle, *Cheilomenes propinqua,* black spotted lady bird beetle, *Cheilomenes lunata,* red chilocorus, *Chilocorus circumdata,* Indian wave striped ladybug, *Cheilomenes seximaculata* and spotted potato ladybird beetle, *Henosepilachna vigintioctopuntata.* Among the six species four of them namely as *C. propinqua, C. lunata, C. circumdata* and *E. aethiops* were observed to feed on coffee mealy bugs, scale insects and aphids. The other two species feed on foliage of Cucurbitaceae (e.g. cucumber, pumpkins, water melon and common beans). TaCRI has initiated the process of mass multiplication in the insectary and the progress is encouraging, although a small number of the pests still reach the adult stage. TaCRI is also in process to collaborate with ICIPE for capacity building for rearing protocols of the predators.

Technologies adopted from other countries

(a) Management of thrips and leaf miners by the use of coloured sticky traps

Insect traps are used to monitor or directly reduce populations of insects or other arthropods. Traps warn of pest presence, hot spots, and migration. They also provide a relative measure of insect density through comparisons of the number of adults caught (Weinzierl, *et al.,* 2005; Kronkright, 1991). Edelson *et al.* (2003) indicated that yellow, blue and white sticky traps attracts a range of flying pests, including, thrips, whitefly, moths, aphids, whitefly, fruit fly and leaf miner. TaCRI has modified instead of using the yellow sticky traps made of special paper they modified and use of plywood (30 cm x 30 cm) painted yellow and spread with petroleum jelly or used motor oil on yellow painted plywood.

The trap has indicated non-significant difference ($P>0.05$) as compared with the yellow special papers recommended to attract and capture the moths of coffee leaf miner and thrips which are not easily accessible to our coffee farmers and not available in Tanzania. For example mean thrips trapped per week for special yellow sticky paper and ply wooden made are 489.1 and 475.2 respectively. The locally made yellow sticky traps made of plywood by TaCRI are recommended to be used together with other management practices to minimize the infestation of thrips and leaf miners in the field. TaCRI is in the process to evaluate the efficacy of the same trap for the control of other flying coffee pests such as whiteflies, aphids (winged forms) and moths of leaf skeletonizer, berry moth and fruit fly.

(b) Management of coffee berry borer (CBB) by the use of entomopathogenic fungi (*Metarhizium anisopliae*)

Metarhizium anisopliae (Metschnikoff), *Beauveria bassiana* (Balsamo) and *Vertillium lecanii* (Zimmerman) are entomopathogenic fungi that occur

naturally in the environment. The fungi are potential as biological control agents against many insect pests (Prasad and Pal, 2014). They are the most prevalent fungi attacking CBB populations in African countries where this insect originated, as well as in those countries where the borer has spread, including Brazil (Bustillo *et al.,* 1998). Several attempts have been made throughout the world to use mass-produced bio-pesticides based on entomopathogenic fungi for management of CBB and other pests. In Brazil, the role of *B. bassiana* and *M. anisopliae* was evaluated for regulation of CBB populations that emerged from the fallen berries, and persistence of fungi in the soil (Bustillo *et al.,* 1999). Effectiveness of *M. anisopliae* for management of CBB in the laboratory at TaCRI-Lyamungu was evaluated and it was considered to perform well. Mass multiplication of the fungus (fungus sporulation) has been evaluated in several countries by the use of locally available agricultural and industrial waste for a cheap and substrate for the low cost of production (Latifin *et al.,* 2014; Prasad and Pal, 2014). TaCRI has adopted and succeeded in mass multiplication of the fungus by use of rice grain in the laboratory. The way forward with TaCRI is to evaluate the effectiveness of the same fungus in management of the pest in the field.

(c) Management of coffee berry borer by the use of parasitoids

A parasitoid is an organism that lives on or in a host organism and ultimately kills the host. These beneficial species are common in most natural communities and, although their presence is often unnoticed, they help maintain the "balance of nature" by regulating the density of their host or prey population (Smith and Capinera, 2015). Several parasitoids of coffee berry borer have been investigated in various coffee growing countries in the world including; Africa, America, the Caribbean, Oceania and Asia (Vega *et al.,* 2009).

In Colombia three species of bethylid wasps, *Prorops nasuta* Waterston, *Cephalonomia stephanoderis* Betrem, and *C. hyalinipennis* Ashmead, attack the coffee berry borer, *Hypothenemus hampei* (Ferrari) (Coleoptera: Scolytidae), by both predation and parasitism (Vegas *et al.,* 2009). Recent survey by TaCRI in collaboration with IPM Collaborative Research Supportive Project (IPM/CRSP) in East Africa, has identified the presence of *P. nasuta*, *C. stephanoderis* as potential parasitoids naturally occurring in the coffee farms in Kilimanjaro region (Magina *et al.,* 2012). The way forward with TaCRI is mass multiplication and later release in coffee farms infested with the pest. Capacity building on mass rearing techniques of the parasitoids has been initiated between International Centre of Insect Physiology and Ecology (ICIPE) and TaCRI, Lyamungu.

CONCLUSION

This paper has discussed the achievements made by TaCRI in the past twelve years in the area of Integrated Pest Management (IPM). Some IPM techniques have been adapted, with some modifications from other countries while others, like the coffee berry borer trapping have undergone such heavy modifications as to become our own innovations. It is the authors' opinions that the achievements for twelve years are substantial. TaCRI is committed to continue in its meticulous research in IPM so as to have in place an appropriate IPM package which is ecologically and environmentally friendly for coffee farmers in Tanzania. In so doing we will have helped the coffee industry in the country to penetrate the lucrative, but restrictive, niche coffee markets in some countries which have set the maximum residue levels (MRL).

ACKNOWLEDGEMENT

The authors are very grateful to European Commission (EC, Tanzania), IPM/CRSP in East Africa and Tanzania coffee growers for their financial support for these studies. We also extend our appreciations to Mr. Elisante David, Ms. Esta Kasapano, Mr. Mashaka Lutema, Mr. Martine Munishi and Mr. Aden Mbuba for their assistance in the insectary, laboratory and field data collection. We are also thankful to *ICIPE,* Kenya, for the kind cooperation in the identification of parasitoids and predators and the anonymous reviewers of this paper for their useful corrections and suggestions.

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Production Performance of Indigenous Chicken under Semi Intensive Management Conditions in Central Tanzania

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Abstract: *A study to evaluate four indigenous chicken – namely: Horasi, Kuchi, Naked neck and Frizzled in order to obtain grand-parent and parent stocks was carried out at Tanzania Livestock Research Institute, Mpwapwa district of Dodoma, Tanzania. The perfomance of the ecotypes were compared so as to come out with the best indigenous chicken among the four. A total of 548 indigenous chicken including Horasi (162), Kuchi (253), Naked neck (81) and Frizzled (52) were used in the study. All chicken were treated equally in terms of management under semi intensive system. Data were collected on body weight, external egg characteristics, day old chick weight, body weight gain, weight at 4, 8, 12, 16, 20, 24 weeks of age for each ecotype. Age at first egg and egg number were also determined. The collected data was analysed using General Linear Model of SAS (2006). The results showed that there were significant differences in mature body and egg weight between the ecotypes. The mature body weight and egg weight respectively were 2075g, 2070g, 1792g , 1622g and 44.73g, 45.94g, 38.28g, 38.08g for Horasi, Kuchi, Naked neck and Frizzled respectively. Day old chick weight were 34.26g, 36.26g, 31.99g and 29.02g for Horasi, Kuchi, Naked neck and Frizzled respectively. Average growth rate per day in grams for Horasi and Kuchi was 3.67g and 3.96g per day from day old chick to week 4 and 6.83g and 8.25g per day from week 5 to week 8, respectively. Average egg numbers per clutch for Horasi and Naked neck were 16 and 18 eggs respectively. Average body weight at week 24 for naked neck and Horasi (F1) were 1427g and 1572.8g respectively. Average ages at first egg for Horasi and Naked neck (F1) were found to be 15 weeks and 16 weeks, respectively. The study reveals that, Horasi and Naked neck ecotypes under semi intensive system perform better than Frizzed. It was conclude that, Horasi and Naked neck can be used at farm level for egg production and Kuchi could be used to improve meat production on other indigenous chicken hence increase income of smallholder farmers.*

Keywords: Indigenous chicken, productivity, semi-intensive management

INTRODUCTION

Tanzania has about 54 million chicken where 35 millions are indigenous chicken which provide almost all the poultry meat in the rural areas and also contribute almost 100% and 20% eggs consumed in rural and urban areas respectively (MLFD, 2011; Guni *et al.,* 2013). Nearly 90 percent of the

indigenous chicken are raised by smallholder farmers in the rural areas under traditional free-range system. The flock sizes mostly ranges from 5-15 chicken with an average of 10 chicken per household making it difficult to have a viable commercialized indigenous chicken enterprise. On the other hand, the demand for indigenous chicken meat and eggs has been increasing and yet the supply side has continued to depend largely on these smallholder famers. In general, poultry products (egg and meat) constitute 30 percent of all animal protein consumed worldwide, while consumption of meat and eggs in Tanzania are reported to be 12 kg and 75 eggs per annum respectively which is very low compared to the world average which is 50 kg of meat and 300 eggs (MLDF, 2010).

Indigenous chicken production in rural areas plays a significant role in contributing to nutritional status of human being and source of income. This is due to advantages over other species of livestock which include short generation interval, prolificacy, low initial cost and maintanance cost compared to other livestock (Mengesha, 2012). Another advantage is their fast reproductive rates, ability to be raised even under limited land spacing per household, however their production are still fairly poor due to inadequate skills on management.

Previous effort in improving indigenous chicken production over years were through crossbreeding with exotic breeds especially the Rhode Island Red (RIR). Studies show that crossbreds could not perform well due to lack of management skills that were needed for the crossbreds and the management changes that should be adopted by the rural people (Goromela, 2009). As a result most of these crossbreds died due to diseases and nutritional- disorders despite their higher egg-laying and faster growth (Theerachai, 2006).

Another initiative through private sector was to commercialize indigenous chicken; however there has been a shortage of quality day old chicks because there are no grand-parent and parent-stock farms in the country (Vera, 2010). Currently, there is no farm or institution raising indigenous chicken grandparent or parent stocks. Also, management system at farm level is free range which promote random mating hence become difficult to identify a pure line and their performance. This study was therefore conducted to evaluate the performance of four indigenous chicken kept under semi intensive management. It was expected that the results from this study would come out with recommended ecotype which perfom better and could be promoted for production of day old chick at large scale for commercialization.

MATERIAL AND METHODS

The study was carried out at Tanzania Livestock Research Institute (TALIRI) Mpwapwa, which is central part of Tanzania. The area lies between 900 and 1,000 metres above sea level. The mean temperature is about 26.5°C, but at certain times temperature can go down to as low as 11°C. The coolest dry weather occurs from January to June when temperature reads between 20°C - 33°C. The main rainy season is from November to April with an annual average rainfall of 500 to 800 mm.

A total of 548 indigenous chicken of four (4) ecotypes namely Horasi, Kuchi, Naked neck and Frizzled were collected from Shinyanga, Tabora, Singida and Dodoma and were kept at the station. Each ecotype was kept separately in a well ventilated open sided house. Perches and nests placed in the the chicken houses and a fence separating chicken houses by ecotypes and biosecurity was put in place. Chicken were vaccinated against Gumboro and Newcastle and normal managerial practices were followed. These included deworming after every three months and provision of compounded rations according to body requirements. Adult chicken were given 100 - 120gm per day, with clean water throughout the day.

Data collection

Body weight of chicken collected from farmers were taken. The weight, length and circumference of collected eggs at the institute were measured and recorded daily. The weighed eggs were stored in a cold room for seven days before transfering to the incubator machine to avoid development of the embryo. Stored eggs were against different deformities, and then fumigated using 0.5ml 40% formalin and 0.2g potassium permanganate. Chicks hatched were weighed and tagged followed by periodic measurements after every four (4) weeks. Chicks were monitored from day one up to 24 weeks in body weight, gain, age at first egg and egg number. The difference in body weight values between two consecutive measurements was divided by the number of days in the interval to obtain daily body weight gain.

Data analysis

Data on mature body weight, egg weight, egg length, circumference, day old chicks weight, 4, 8, 12, 16, 20, 24 weeks, age at first egg and egg number were analysed using GLM procedure of SAS (2006) software package and where significance were observed, Duncan's multiple range option of the same software was used to separate the means.

RESULTS AND DISCUSSION

Mean body weight of four indigenous chicken are presented in Table 1. Horasi ecotype had significantly (P<0.05) higher body weight than Kuchi, Naked neck and Frizzled. Kuchi ecotype had significantly (P<0.05) higher body weight than Naked neck and Frizzled. The results are in agreement with Guni *et al.* (2013) who reported higher body weight for Horasi ecotype in Southern Highlands of Tanzania. The result from this study could also be attributed to differences in genetic make up.

Table 1: Least square means of mature body weight of four indigenous chicken collected from farmers

Ecotype	N	Lsmeans ± se
Horasi (gm)	253	2075 ± 0.04[a]
Kuchi (gm)	162	2070 ± 0.03[a]
Naked neck(gm)	81	1792 ± 0.05[b]
Frizzled (gm)	52	1622 ± 0.06[c]

Least square means with no superscript letters in common within a column are significantly different (p <0.05) and se means standard error

The effect of sex on body weight on four ecotypes are presented in Table 2. The body weight for males birds were significantly (P<0.05) greater than those of the female birds. When each sex was compared separately between ecotypes, Horasi was significantly (P<0.05) superior for body weight in male birds. Kuchi ecotypes was higher in body weight for female birds than Naked neck and Frizzled ecotypes. The difference could be attributed to difference in their genetic make up.

Table 2: Least square means of mature body weight on sex

Ecotype	n	Sex	Ls ± se
Horasi	14	M	2753±0.11[a]
	148	F	1675 ±0.03[b]
Kuchi	50	M	2379 ± 0.07[a]
	203	F	1716±0.03[b]
Naked neck	14	M	2147 ± 0.08[a]
	67	F	1422±0.04[b]
Frizzled	42	M	1779±0.08[a]
	10	F	1247± 0.04[b]

Least square means with no superscript letters in common within a column are significantly different (p <0.05) and s.e means standard error

Egg characterists, day old chicks weight and chick percentage of egg weight
The egg weight, egg width, egg length and weight of chicks ecotypes of four indigenous chicken are presented in Table 3. Kuchi had the highest egg weight (45.9gm) followed by Horasi (44.7gm), naked neck (38.3gm) and frizzled (38.1gm). Egg width and length was highest for Horasi ecotype compared to other ecotypes, the trend was the same for eggs collected from indigenous chicken brought from farmers and those hatched at the institute (F1). The egg weight in this study is in agreement with Lwelamila et *al.* (2008) who reported 45g of Kuchi egg weight.

Table 3: Least square mean (±SE) for on-station egg weight, width and length, day old chick and chick % of egg weight of ecotype of chicken

Ecotype	EW(gm)	ED (cm)	EL (cm)	DOC	Chick % of egg wt
Horasi	44.73±0.352[a]	12.67 ± 0.058[a]	8.20 ± 0.392[a]	34.26[a]	78.9
Kuchi	45.94± 0.376[a]	12.58 ± 0.062[a]	7.43±0.419[a]	36.26[a]	76.5
Naked neck	38.28 ± 0.405 [b]	11.86 ± 0.067 [b]	6.77±0.452[a]	31.99[b]	83.0
Frizzled	38.08 ± 0.608[b]	11.81 ± 0.101[b]	6.74±0.678[a]	29.02[b]	76.2

Least square means with different superscript letters in column within a column are significantly different ($p < 0.05$), EW = egg weight, ED = egg width, EL= egg length, DOC = day old chick and SE =Standard error

The egg weight of Kuchi are slightly higher than egg weight (44.7g, 44.3g and 42.7g) reported by Guni *et al*. (2013) in three districts of Southern Highlands. The average mean weight of Kuchi egg was 45.94g and produced chicks with an average weight of 36.26g which was 78.9% of egg weight. The results in Table 3 show that chick weight in all for ecotypes were found between 76 to 83% of egg weight. Egg weight has implication on the weight of chick at day one and consecutively week one weight as shown in Table 3 and survival of chick. This implies that heavier eggs hatch to heavier chicks.

Body weight and growth performance of four indigenous chicken's ecotype
Table 4 shows mean weekly weight measurements and average daily gain of four ecotypes from day one to 24 weeks. The average body weight of Kuchi ecotype at day old chick was higher than other ecotypes. At the age of 24 weeks the Kuchi chicken ecotype scored the highest mean body weight (1738.70), Horasi ecotype ranked the second (1572.8g), Naked neck ecotype ranked the third (1427.58g) and lastly Frizzled ecotype (1100.47g). Differences in mean weights for day old chick and other stages of growth among the ecotypes could be attributed to differences in genotypes.

Table 4: Least square mean on growth performance of four indigenous chicken's ecotype

Parameter	Ecotypes			
	Kuchi	**Horasi**	**Naked neck**	**Frizzled**
Day old chick weight in gm	36.26[a]	34.26[a]	31.99[b]	29.02[b]
Average weight of chicks at 4weeks	154.91 [a]	144.49 [a]	140.30 [a]	117.14 [b]
Weight gain in gm per day (0-4weeks)	3.96	3.67	3.61	2.94
Average weight of chicks at 8 weeks	402.29 [a]	349.26 [b]	326.72 [b]	239.51 [c]
Weight gain in gm per day (4-8 weeks)	8.25	6.83	6.21	4.08
Average weight of chicks at 12 weeks	568.34 [a]	551.44 [a]	507.52 [a]	376.44 [b]
Weight gain in gm per day (8-12weeks)	13.20	11.6	12.70	8.94
Average weight of chicks at 16weeks	964.35 [a]	899.51 [a]	888.52 [a]	644.62 [b]
Weight gain in gm per day (12-16weeks)	15.46	13.63	9.60	7.26
Average weight of chicks at 20weeks	1428.03[a]	1308.46[ab]	1176.59[b]	862.41[c]
Weight gain in gm per day (16-20weeks)	10.36	8.81	8.37	7.93
Average weight of chicks at 24weeks	1738.70[a]	1572.80[b]	1427.58[b]	1100.47 [c]

Least square means with different superscript letters in row within a row are significantly different ($p < 0.05$). The average growth for Kuchi, Horasi, Naked neck and Frizzled of 3.96g, 3.67g, 3.61g and 2.94g per day from day old chick to week 4 and 10.36g, 8.81g, 8.37g and 7.93gm at week 20 respectively. The weight gains for Horasi at week 4 in the study are higher (2.8g) than those reported by Guni *et al*. (2013) on the same ecotypes. This implies that body weight gain can be influenced to some extent by management. Average body weight (1572.80g) at week 24 for Horasi (F1) obtained from this study was lower (1806gm) than reported by Guni *et al*. 2013 for Horasi of the same age in Southern Highlands of Tanzania probably due to differences in agro ecological zone and management practices.

Average weight of Kuchi at week 20 from this study was higher (1428.03g) than (1240.3g) reported by Lweramila *et al*. (2008) in Morogoro Tanzania under extensive system. The difference might be due to management systems. This shows that under good management particularly semi intensive system Kuchi gain more weight than in free range system. Average ages at first egg for Horasi and Naked neck (F1) were found to be 15 weeks and 16 weeks, respectively. The age at first egg for Horasi in this study are lower than (18.4 weeks) those reported by Grobbelaar *et al*. (2010), on the same ecotypes under intensive system. The difference might be due to different management

system. Average egg numbers per clutch for Horasi and Naked neck (F1) were 16 and 18 eggs respectively.

CONCLUSION AND RECOMMENDATION

Based on the findings from the present study, among the four indigenous chicken Horasi ecotype was leading in terms of body weight for chicken collected from farmers though not significant. On station study showed that Kuchi ecotype was superior in growth, weight gain and egg weight where possible the ecotype can be used to improve body weight of other indigenous chicken for meat production. However the study showed age at first egg and egg number were better for Horasi and Naked neck and therefore they could be good candidates for egg production. Nonetheless further studies to be done on molecular level.

ACKNOWLEDGEMENTS

The authors acknowledge the Commission of Science and Technology (COSTECH), for funding, the Director of Tanzania Livestock Research Institute (TALIRI) for facilitation and other workers especially staff of Department of Non Ruminant for their support.

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Agricultural Productivity, Co-Operatives and Organisational Innovations: A Case of Selected Coffee Production Communities in Mbinga District Tanzania

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Abstract: *Agriculture is the backbone of the majority of developing countries accounting between 30 and 60 percent of their Gross Domestic Product. Studies indicate that presence of cooperative societies, institutional support and other organisational linkages can enhance productivity and increase farmers' income by bringing financial services closer. The study objectives aimed at establishing coffee production level in the last farming season; examining the contribution of cooperative societies in the production of coffee; and determine organisation innovations existing in coffee production. Methodologically, the study made use of cross section research design and data were collected from five villages namely Utiri, Mtama, Mahumba, Mahande and Iringa located in Mbinga District. Key respondents were the coffee smallholder farmers located in the aforementioned villages who were also members of Kimuli Agricultural Marketing Co-operative Society (AMCOS) and Muungano Savings and Credit Co-operative Society - a SACCOS. Multistage sampling procedure was used to select five villages and smallholder farmers were obtained through systematic random sampling. Results indicate that smallholder farmers own small land sizes which limit their productivity where the average land size per household is 7 acres and average yield was 1145.14kg per household. The cooperatives had a great contribution to the production of coffee as they enabled members (smallholder farmers) to get inputs at reasonable prices, provide extension services, provide credits at reasonable interest rates, provide coffee processing as well as finding markets on behalf of farmers at regional, national and international levels. Also, coffee farmers were able to innovate a new structure for harmonising the institutional linkages between their cooperative societies (AMCOS and SACCOS) which is called "integrated co-operative model". The model proves to be one among the key organizational tools for revamping and sustaining agricultural productivity while improving rural smallholder farmer's livelihoods.*

Key Words: Production, coffee, cooperative societies, integration.

INTRODUCTION

Cooperatives have a long history in Tanzania as they flourished after independence, but then became part of state structures in a top-down approach and were used as a tool for government policy. Marketing cooperatives expanded their business tremendously in the early 1960s. One

source indicates that in 1966 there were 1,616 registered cooperatives and out of these 1,339 were engaged in the marketing of agricultural products. In 1960 cooperatives handled 145,000 tons of produce, in 1965 they handled 496,000 tons, and in 1966 the handled 628,833 tons of produce, which was worth TZS 605,200,500. By 1967 the cooperative movement had 3,000,000 members in rural areas (Kimario, 1992: 27). The data quantify that the cooperatives sector was making huge business and members benefited out of it.

Furthermore, radical changes in government policy on cooperatives occurred after the government's introduction of socialism to all macroeconomic and social programmes. On 14 May 1976 all primary cooperatives were abolished by the government. Their crop marketing functions were taken over by ujamaa villages (communual villages). At the same time, cooperative unions were also abolished and their functions were taken over by parastatal crop authorities (government owned), which had to buy crops directly from the villages. The abolished unions never bought crops directly from the peasants, but through primaries cooperatives. The other services which were rendered by the abolished cooperatives, such as wholesale and retail trade, were taken over by state owned companies, such as the Regional Trading Companies and District Development Corporations (Maghimbi, 1992:224-225). This reveals that government policy lead to significance impact of market power of the primary cooperatives.

The primaries positively started taking full business responsibilities on behalf of their members. Such a scenario of shifting to the primary societies is considered a positive outcome of liberalization and conducive to the implementation of the co-operative integration as we shall see in the analysis section, because it opened new possibilities for the members of primary societies to operate differently, in a more self reliant way (Sizya, 2001). Traditionally, the co-operative movement was based on a four tier structure with primaries, secondary unions, apex co-operatives and the federation. As the process of liberalization continued, the apex and unions were challenged by economic viability. Most apex bodies disintegrated in the past fifteen years. As a result the primaries had to come up with functional innovations in order to sustain their operations and fulfil members' expectations.

Globally, innovation at the cooperative level has emerge in a natural way between agricultural marketing and saving and credits cooperative, innovation in value chain financing whereby two institutions depend on each other. Access to sufficient and well-timed financial services for all actors in the value chain is a key element for business success. This financing may come in many forms – through other businesses involved in the chain, through banks,

micro-finance organizations, or financial co-operatives (credit unions). The inter-dependent linkages of a value chain and the security of a market-driven demand for final products can provide those throughout the chain (suppliers, producers, processors and marketing companies) with more secure channels for access to and sale of products. Financial instruments developed or adapted for use in financing value chains include warehouse receipts, forward contracts, and guarantees (FAO, 2012).

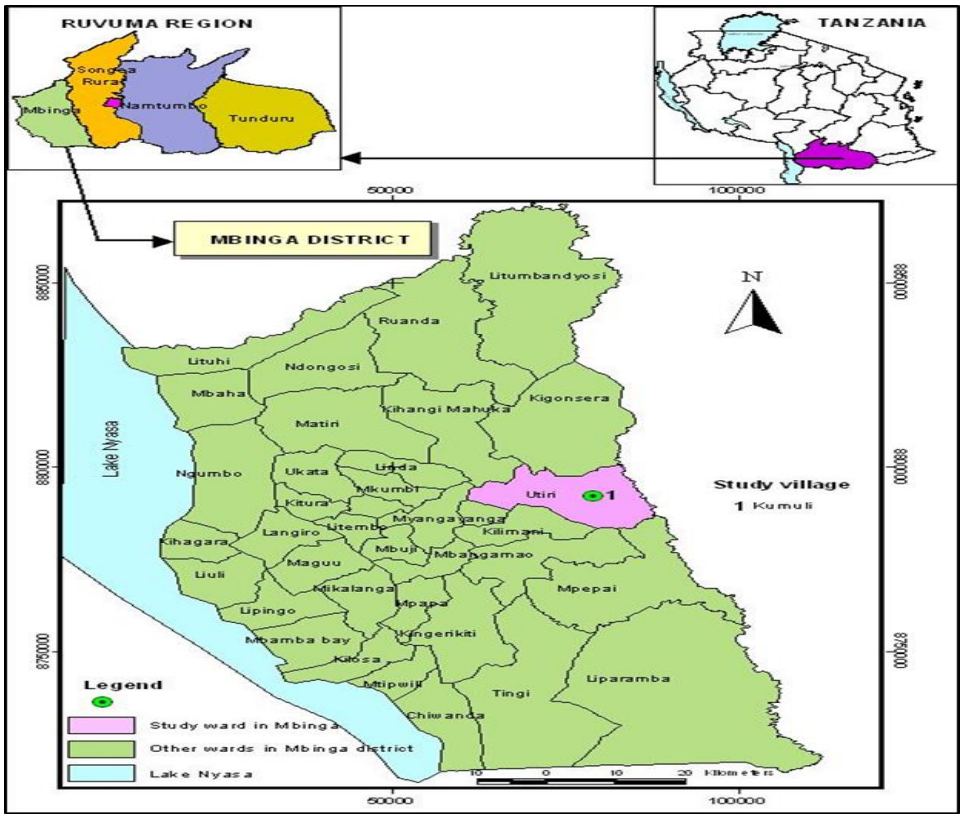
The questions which emerge after long cooperative movements are such as : What exists in Tanzania in terms of innovations in the cooperative sector? How can cooperative innovations in Tanzania be characterized? And, how such innovations would benefit members? These questions are paramount towards assessing means of development support to cooperatives and their members with a focus on improving productivity and achieving rural development goals aiming at improvement of smallholder farmer's livelihood.

METHODOLOGY

The study was conducted in Mbinga District in Ruvuma Region which is among the areas with high coffee production and marketing in the country. The study focused on coffee smallholder farmers who were members of Kimuli Agricultural Marketing Co-operatives (AMCOS) and Muungano SACCOS in five villages namely Utiri, Mtama, Mahumba, Mahande and Iringa.

The approached smallholder farmers were either both members of both AMCOS and SACCOS or only members of AMCOS or SACCOS. The areas was selected because it has both active coffee producers and dynamic primary co-operatives with long history of agriculture and co-operative business development dealing with coffee marketing

The study employed a cross sectional design where data regarding coffee production, organisation innovations and cooperatives were collected over a given period. A survey strategy was used to guide data collection by using the agreed tools. Data were collected by using a household survey questionnaire, focus group discussions and documentary reviews. The household questionnaire was pre-tested and edited before the commencement of actual data collection and it contained both open and close-ended questions.



Source: Mbinga District Profile

The researchers managed to conduct four focus group discussions with farmers (members of co-operative societies) and leaders of the cooperative societies to collect more information and validate data collected from other sources. Documentary review was used to collect secondary data from both AMCOS and SACCOS about coffee production levels, market prices, payment modalities and the credits borrowed and payback trends. A multistage sampling procedure was adopted in the selection of villages and the cooperative societies (Kimuli AMCOS and Muungano SACCOS). Systematic random sampling technique was used to select smallholder farmers from the member lists that were made available at the cooperative societies. A random number between 1 and 5 was selected by using a lottery technique to pick up the unit to start with (x) and the remaining units were selected basing on a fixed interval (k) as recommended by Daniel (2009).

The sample constituted a total of 101 smallholder farmers who were the members of AMCOS and SACCOS. Quantitative data was analysed by using mean, standard deviation, cross tabulation and frequency by using the Predictive Analytics Software (PASW) for quantitative data analysis.

Qualitative data analysis was done by using thematic approach (classic content analysis) which is the most commonly used method of qualitative analysis in research. This involved analysis beyond counting explicit words or phrases and focused on identifying and describing both implicit and explicit ideas within the data, that is, themes.

RESULTS AND DISCUSSIONS

Respondents Profile

The approached coffee farmers who had different background in terms of farming experience, membership in cooperative societies, sex, age and education background. This allowed the study to have data coming from respondents with different perspectives regarding coffee production, processing and marketing in Mbinga District. The profiles are presented in Table 1 below and discussed thereafter:

Table 1: Respondents Profile

Attributes		Frequency (n=101)	Percentage
Sex	Female	45	44.6
	Male	56	55.4
Age	21-30	15	14.9
	31-40	31	30.7
	41-50	21	20.8
	51-60	26	25.7
	61-70	3	2.9
	71-80	4	3.9
	81-90	1	0.9
Education	None	3	2.9
	Primary	85	84.2
	Secondary	12	11.9
	Tertiary	1	0.9
Cooperative Membership	Single Member	54	53.5
	Double Member	27	26.7
	Non Member	20	19.8

Coffee production has been like a traditional activity in Mbinga District where both males and females do participate in the farming activities together. This is evidenced by the statistics in Table 1 which shows that 44.6%

of approached farmers were females while the remaining 55.4% were males which demonstrate trivial difference in terms of gender participation. Furthermore, most of the farmers fall within the age group of 21 to 50 years which is the most active group - as most of them are youth and energetic to deal with coffee production activities. Most of the farmers (84.2%) were primary school leavers whereas only few of them (11%) had managed to attend secondary schools. Hence, coffee farming seems to be the highest priority for gaining income and sustaining family expenditures.

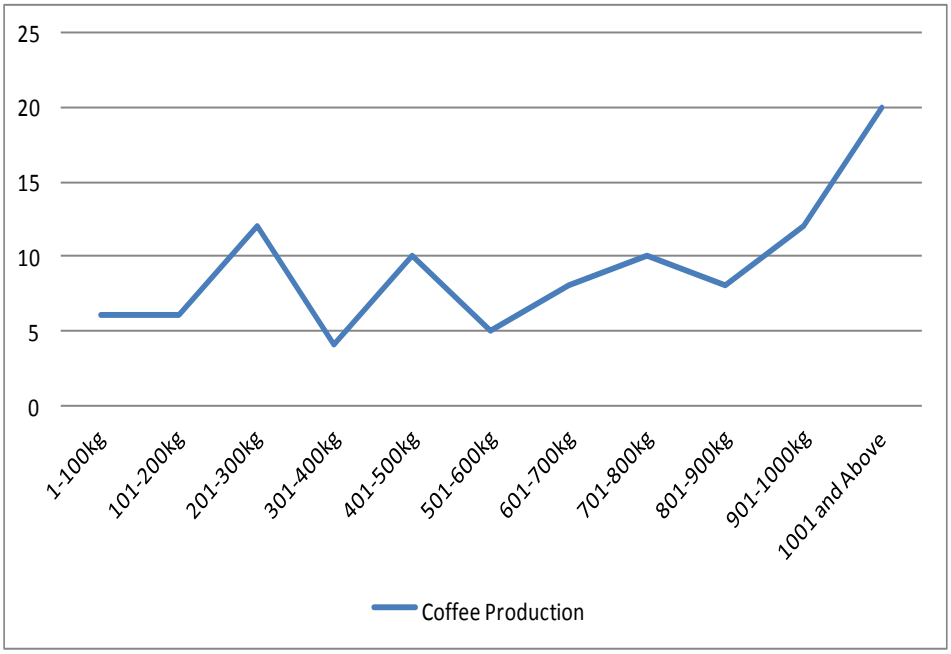
Majority of farmers were active members of cooperative societies as single members or double members. Of the single members (53.5%) were members of Kimuli AMCOS or Muungano SACCOS alone while the double members (26.7%) were members in both AMCOS and SACCOS at the same time. Some of the farmers (19.8%) who were the emerging farmers had chosen not to be members of any of the cooperative societies, either due to lack of interest or unawareness of the cooperative societies. Farmers who chose to be members of cooperative societies were able to access farm inputs or credit for buying the inputs as well as extension services. Also, they had the opportunity to access processing services, storage services and marketing services.

Coffee production levels in the last farming season

Agricultural production is the key activity in Mbinga District and particularly in rural areas, villages such as Utiri, Mtama, Mahumba, Mahande and Iringa, coffee production is the main commercial crop in every household. The land size - particularly for coffee production, is not large enough to guarantee more produce where the minimum land size is 2 acres and maximum is 12 acres while the average land size per household is 7 acres. Farmers use a variety of inputs to support coffee production which were either coming from AMCOS, SACCOS or own stock from last season. The inputs included local seeds, manure and pesticides for dealing with pests that attack coffee plants. The production units in the last farming season ranges according to the land size, inputs used and implementation of the extension advice provided by the extension officers.

The majority of farmers (19.80%) harvested about 1001kilograms and above, followed by those in the category of 901-1000 kilograms (12.87%) and 701-800 kilograms (10.89%). Statistics show that the minimum yield was 25kg, maximum yield 10,000kg and the average was 1145.14kg per household. According to the farmers who participated in the focus group discussion the trend of coffee production has been dwindling over the past 3 years as a result of having same old trees and diseases.

Figure 1: The production levels are presented in the figure below as per identified categories



Also, farmers mentioned other production challenges limiting high yield to include harsh weather conditions, pests, lack of improved seed varieties and small land holdings that do not allow expansion. Nonetheless, through being members of cooperative societies they have been able to get trainings and extension services on how to deal with pest or coffee diseases and to use new seeds from the Coffee Research Institute though the results were yet to mature to the expected levels.

Contribution of cooperative societies to coffee production

The study wanted to measure the contribution of cooperative societies to coffee production. In five villages where the study was conducted, there were two cooperative societies namely, Kimuli AMCOS and Muungano SACCOS. All these were owned by farmers, cooperative societies were established by farmers to cater for their interests. Kimuli AMCOS - was the oldest, was pointed out by farmers to having a great contribution in the coffee production and marketing. The statistics are presented in Table 2.

Table 2: Contribution of Kimuli AMCOS

Sn	Contribution	Percentage from Multiple Responses
1.	Source of Farm Inputs	48.0%
2.	Provide Extension Services	37.3%
3.	Source of Market Information	67.1%
4.	Provide Temporary Storage and Processing Services	70.0%
5.	Provide Marketing Services	59.4%

Kimuli AMCOS has a small store for selling coffee farm inputs at reasonable prices compared to other shops in the village or town centre. The inputs sold included improved seeds, farm tools and pesticides. Hence, farmers who were members of AMCOS could access the inputs conveniently and even by credit when they do not have cash. This allowed them to start production at the right time. Also, the AMCOS always made some arrangement with public or private extension officers and other coffee experts to train farmers in the field or at the AMCOS premises on how to prepare their coffee farms, the use of improved seeds, application of pesticides, harvesting, storage and processing. The services provided farmers with an opportunity to improve their production practices and adopt the best practices to increase productivity.

Information asymmetry is one among the challenges facing coffee farmers in the rural setting. However, in the study area, famers who were members of AMCOS had the advantage of getting reliable market information from the AMCOS offices. The leaders normally collect information from the District Council, extension officers, NGOs, and research institutes then share the information with farmers through notice boards and mobile phone messages which helps them to know the coffee market trend and prices in the private market or auctions. More importantly, the AMCOS had a storage area and offered temporary storage services to member farmers but also, it had two CPUs (Coffee Processing Units) with modern machine and tools that process and grade coffee according to their quality. The machines contributed greatly to the value adding process that enabled coffee farmers to get good prices for their produce in the market. Moreover, AMCOS look for coffee buyers with good price offers on behalf of the member farmers in Mbinga as well as throughout the country rather than allowing farmers to be exploited by private buyers. In most cases the coffee is sold through the coffee auction at Tanzania Coffee Board premises in Moshi Municipality. The auction enables farmers to get good prices depending on the coffee quality. This has enabled

farmers who were members in the AMCOS not to struggle in finding buyers or being exploited.

On the other hand, Muungano SACCOS has also made a big contribution to the production of coffee in Utiri related villages. The SACCOS offered saving and borrowing services which were highly needed by farmers to support coffee production activities. Only farmers who were members of SACCOS had access to the identified services when needed. Most of the farmers (78.1%) have used SACCOS as their main place for savings after selling coffee and on receiving payments. Since there were no banks or financial institutions in the village, SACCOS has remained a safe place for farmers to keep their money for future use thus reducing the risks of keeping cash at home. It has been found that 89.2% of the farmers had borrowed money from SACCOS and the majority of them used the money to buy farm inputs, pay school fee or invest into small businesses. Therefore, SACCOS is the main source of credit to farmers in Utiri, Mtama, Mahumba, Mahande and Iringa villages to support purchasing of inputs from the AMCOS or other traders in the town center.

It can be argued therefore that the contribution of cooperative societies is significant and cannot be ignored in the coffee production particularly in the rural setting where most of the services are not available or available but not timely. However, Cooperative networks share common characteristics with complex organizations (Cillier, 2005). Both are based on relationships and interactions among the members and they are open systems that interact with other organizations and with their environment, and therefore shape and get shaped by them. Co-operative networks abide by the principle of open membership, leaving the boundaries of the organization open to external influence and re-examination of its purpose and functioning.

The existing organisational innovations

The innovation done by the smallholder farmers was to integrate the operations of AMCOS and SACCOS by considering the 6th principle of cooperatives which is *cooperation among cooperatives.* The principle calls for cooperatives to strengthen each other by working together through local, national, regional and international networks. Innovations in the value chain financing have been predominantly practices between Kimuli AMCOS and Muungano SACCOS. Access to sufficient and well-timed financial services for all actors in the value chain is a key element for business success and growth for both institutions. This financing can come in many forms – through other businesses involved in the chain, through banks, micro-finance organizations, or financial co-operatives (credit unions). The inter-dependent linkages of a value chain and the security of a market-driven demand for

green coffee beans provide interested stakeholder throughout the network market chain (suppliers, producers, processors and marketing companies) with more secure channels for access to and sale of products. Financial instruments developed or adapted for used in financing value chains include warehouse receipts, forward contracts, and guarantees between agricultural marketing cooperatives and saving and credits cooperatives.

Through the innovation in the value chain financing between AMCOS and SACCOS brought significance impact to smallholder farmers who are members in both cooperative societies at the same time (double members). It is through the double member farmers where some smallholder farmers are allowed to borrow from SACCOS to buy farm inputs from AMCOS and continue with production until the harvest season where the coffee will be brought to the AMCOS for processing and selling. After selling, smallholder farmers get paid and on payday, AMCOS the SACCOS officials - on behalf of the farmers, will take the money and save them to the farmers accounts in SACCOS. If a farmer has a debt to settle then it will be settled automatically at the SACCOS and the remaining cash will go to farmer's savings for future use. Hence, this creativity by the smallholder farmers allows them to access inputs on credit, produce quality output and build saving habit among coffee farmers in order to sustain future expenses.

CONCLUSION

Coffee production has been declining over the years and initiatives should be done in order to assist the farmers to change their production techniques and address the associated challenges. Research institutions as well as cooperative societies remain to be the best alternative institutions for reaching the rural majority who are the smallholder farmers., Research institutions will be able to provide extension services and distribute new improved seeds with high yield as well as pesticides to deal with pests and diseases through cooperative societies.

Most of the rural smallholder farmers are organised into cooperatives, hence through their societies it becomes easier to reach them and work with them collectively to address the common needs. The integrated cooperative model is a key organizational tool for revamping and sustaining coffee agricultural productivity and improvement of farmer's livelihoods in rural Tanzania. Hence, there is a need to formalize and popularise it into other areas of the country so that coffee farmers and other crop farmers can benefit from the model and sustain their production activities while improving their livelihoods as well as the community at large.

However, most of the smallholder farmers in rural areas have only primary level education. This has an implication on capacity building approaches, technological advancement and the conceptualization of policy and legal documents disseminated by the government. There is a need to use appropriate capacity building and mobilization approaches that take into account the level of education.

Therefore, there is a need to enhance the existing integrated model by involving the members and anticipated members who will take into account their business environment, entrepreneurial capabilities, agro-ecological factors and social aspects. Double members often choose to diversify their income sources as a successful livelihood strategy. Others are barely participating in rural primary co-operative societies at all. Co-operatives have very few women members due to the traditional land ownership system, and youth are not participating in co-operatives and agriculture. There is a need to diversify the traditional cash crop marketing agricultural co-operatives to deal with food crops, livestock and value addition activities that will increase the participation of women and youth in rural primary co-operative societies.

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In vitro activity of *Allium sativum* and *Aloe vera* extract against *Salmonella enterica* subspecies *enterica* serovar Gallinarum

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Abstract: *The rapid increase of antibiotic resistance needs to be taken as a threat to both animals and human being. In this study the arbitrary concentration of 25%, 50% and 75% of individual and combined Allium sativum and Aloe vera were tested against Salmonella Gallinarum. The antimicrobials were extracted using aqueous solution where 25g, 50g and 75g of Allium sativum were dissolved in 100ml of sterile distilled water and left for 24hrs and filtered to obtain the concentration of 25%, 50% and 75% respectively and 1ml, 2ml and 3ml of Aloe vera exudates were homogenized in 4ml of distilled water separately by centrifugation to obtain concentration of 25%, 50% and 75% respectively. Aqueous extract of Allium sativum and Aloe vera exudates of 25%, 50%, 75% concentration and 25ml, 50ml, 75ml respectively were homogenized together to obtain a mixture. The different concentration of single and mixtures were tested against Salmonella Gallinarum for growth inhibition through pour plate method. The concentration of 50% and 75% illustrated strong antimicrobial activities but Allium sativum was more effective than Aloe vera. Combined concentration of 25% was less effective but those of 50% and 75% were highly effective than corresponding concentration of single. The combined concentration at 50% and 75% could be used to treat or to control clinical cases in poultry production caused by Salmonella Gallinarum with low cost compared to the synthetic drugs which have become less effective and have high cost. Aloe vera and Allium sativum can be refined and processed in the pharmaceutical industries at required concentrations and sold to the farmers at low cost for inhibition and control of Salmonella Gallinarum in poultry production.*

Keywords: Antibiotic resistance, Allium sativum, Aloe vera, Salmonella Gallinarum

INTRODUCTION

Microbial pathogenicity and other diseases have been controlled by the use of commercially available antimicrobial drugs for many years. Development of drug resistance in pathogens and increasing interest of consumers for safe food forced to explore new antimicrobial agents (Erdogrul et *al*., 2002; Belguith *et al*., 2010). Natural products are major good source of new natural drugs and their uses as alternative medicine for treatment of various diseases have increased in the last few decades (Vuorela*et al*., 2004; Arunkumar *et al*., 2009). In comparison to the synthetic drugs, the herbs and spices have fewer side effects and less expensive, show better tolerance by patient and are readily available at low cost (Adeshina *et al*., 2011).

The antimicrobial activities of spices and herbs are due to specific phytochemicals present in them such as organic sulfur compounds in garlic (Mikail, 2010) and the main factors that determine the antimicrobial activities are the types and composition of spices and herbs, amount used, type of microorganisms, *pH* value and temperature of the environment (Sagdic, 2003;Yabaya *et al*., 2010). Garlic (*Allium sativum*) is one of the most popular spices in the world and it has been reported to contain a powerful natural antibiotic stronger than penicillin and tetracycline (Adetumbi and Lau, 1993). *Aloe vera* consists over 75 biological active compounds, and these compounds known to have a broad range of pharmacological activities including wound healing, anti-inflammatory, anti-arthritic, ant-oxidative and anti-tumor effect (Reynold and Dweck, 1999; Boudreau and Beland, 2006). Garlic (*Allium sativum*) and *Aloe vera* reported to have anti-mutagenic and ant-carcinogenic effect against Escherichia coli (Ogunjobi *et al*., 2007) and, oral supplementation of single garlic (*Allium sativum*), *Aloe vera* or combination reduced oocyst shedding, lesion score and mortality rate of broilers challenged with mixed infection of Eimera spp. (Banna *et al*., 2013). Also *Aloe Secundiflora* reported to reduce clinical signs and mortality rate in chickens after salmonella infection (Waihenya *et al*., 2002). *Salmonella enteric* subspecies *enterica* serovar Gallinarum (*Salmonella* Gallinarum) is a *Salmonella enterica* biotype that exhibit most specificity for poultry and aquatic birds. In this study, *in vitro* antimicrobial activity of single and combined *Allium sativum* and *Aloe vera* were investigated against *Salmonella* Gallinarum which is a veterinary important bacterial pathogen.

MATERIALS AND METHODS

Study location and Sample collection

The study was conducted at the Faculty of Veterinary Medicine, Sokoine University of Agriculture, Morogoro. Fresh garlic (*Allium sativum*) used in this study was purchased from a local market at Morogoro, Tanzania and *Aloe vera*

was obtained from the garden at the Department of Animal Science and Production, Sokoine University of Agriculture, Morogoro.

Bacteria strain

Salmonella Gallinarum isolate was generously received from the Microbiology laboratory (Sokoine University of Agriculture). The isolate was maintained in nutrient agar slants at room temperature until testing.

Preparation of aqueous *Allium sativum* extracts

The aqueous *Allium sativum* extract was prepared according to Iwalokun *et al.* (2004) method. The cloves were separated and peeled to obtain the edible portion. Fifty grams of the edible portion was chopped and homogenized in 100 ml of sterile distilled water in a warming blender. The homogenate were filtered through 25µm filter paper (Iwalokun *et al*., 2004). The procedure was repeated for 25g, 50g and 75g to obtain the concentration of 25%, 50% and 75% of singles.

Preparation of *Aloe vera* extracts

A fresh *Aloe vera* peels were obtained from Department of Animal Science and Production (Sokoine University of Agriculture) at lower farm and its exudates were collected in vials. One milliliter, 2ml and 3ml of *Aloe vera* exudates were homogenized in 4ml of sterile distilled water separately by centrifugation to obtain concentration of 25%, 50% and 75%. Aqueous extract of *Allium sativum* and *Aloe vera* exudates of 25%, 50%, 75% concentration and 25ml, 50ml, 75ml respectively were homogenized together to obtain a mixture. The different concentration of single and mixture were tested against *Salmonella* Gallinarum for growth inhibition through pour plate method.

Bacterial culture by pour plate method

Briefly, 100ml of Mueller Hinton agar was autoclaved and cooled to 60-70^{0}C in a water bath. About 25ml of MH agar was aseptically dispensed to each of Petri dishes sized 60 x 15 mm and allowed to solidify. Bacterial suspensions were prepared at 0.5 McFarland (equivalent to 1-2 x10^{8}CFU/ml) with thelatex equivalence turbidity standards (Fisher Scientific, Waltham, Massachusetts, USA) in 2 ml of sterile 0.85% NaCl solutions. Approximately 1ml of bacterial inoculum was uniformly spread over the plates using a sterile cotton swabs. Pores of 7mm diameter were prepared and known volumes of extracts were placed into Mueller Hinton agar based pores seeded with *Salmonella* Gallinarum. The plates were incubated in upright position at 37°C for 24 hours. The diameters of zone of inhibition were measured in millimeter and the results were recorded. The zone of inhibition with diameter less than 12mm was considered as having no antibacterial activity. Diameter between

12 and 16 mm were considered moderately active and those with > 16mm were considered highly active.

DATA ANALYSIS

Data collected were analyzed in tables and figures. Descriptive statistics was used using excel programme.

RESULTS AND DISCUSSION

Inhibitory activity of *Aloe vera* and *Allium sativum* extracts more obviously depicted by decreasing the growth of *Salmonella* Gallinarum that was subjected to different arbitrary concentration of these extracts. At low concentration and high concentration both *Aloe vera* and *Allium sativum* were effective. But *Allium sativum* was highly and more effective than *Aloe vera* at the same concentration (Table 1).

Table 1: Inhibition effect of different concentration of *Aloe vera* and *Allium sativumagainst Salmonella*Gallinarum through pour plate method

Concentration (%)	Average zone of inhibition (mm)		
	Aloe vera	***Allium sativum***	***Aloe vera* + *Allium sativum***
25	18	20	10
50	20	25	26
75	24	30	33

At high concentration the combination of *Aloe vera* and *Allium sativum* concentration seemed to have higher inhibitory activity compared to individual concentration of *Aloe vera* and *Allium sativum* at the same concentration level (Figure 1). At low concentration level the combined concentration illustrated to be less effective than single concentration of *Aloe vera* and *Allium sativum* at the same concentration level. There was variation in zone of inhibition between different concentrations of the same extract whereby increase in concentration led to increase in zone of inhibition (Figure 1).

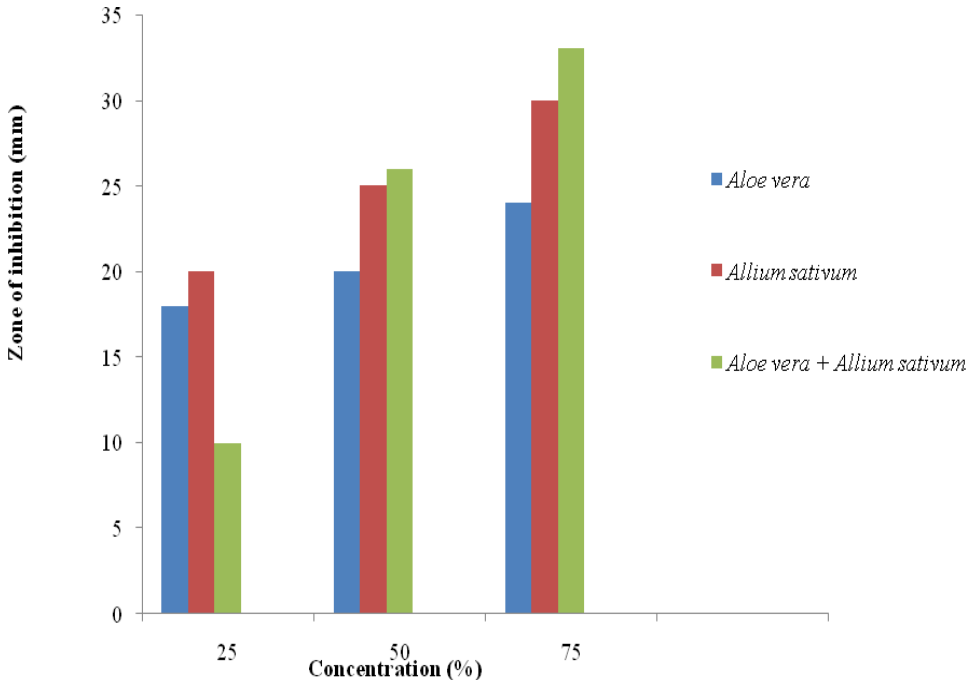


Figure 1: Inhibition effect of *Aloe vera* and *Allium sativum* on the growth of *Salmonella* Gallinarum

Allium sativum showed to be highly effective than *Aloe vera* at both low and high concentration. This proves that *Allium sativum* has stronger inhibitory effect than *Aloe vera*. In other words *Salmonella* Gallinarum is highly sensitive to *Allium sativum* than *Aloe vera*. Several studies including that of Kwon *et al*. (2011) have shown that *Aloe vera* aqueous extract demonstrated excellent antimicrobial activity against *Escherichia coli* and *Vibrio* spp after being tested against *Staphylococcus aureus*, *Bacillus* spp, *Enterococcus* spp, *Escherichia coli*, *Salmonella* typhimurium, *Pseudomonas aeruginosa* and *Vibrio spp*.

Also previous studies have shown that antimicrobial activities of aqueous garlic extracts against 133 multidrug resistance bacteria including *Staphylococcus aureus*, *Staphylococcus epidermids*, *Staphylococcus pneumoniae*, *Staphylococcus pyogenes*, *Haemophilus influenzae*, *Salmonella* typhi, *Pseudomonas aeruginosa*, *Escherichia coli*, *Shigella* spp. and *Proteus* spp. whose diameters of zone of inhibition were studied and characterized to range from 20.2-23.7 mm for gram positive and 19.8-24.5 for gram negative (Iwalokun *et al*., 2004; Durairaj *et al*., 2009). The variation in zone of inhibition amongst researchers could be due to variation in climate, soil type, pH, plant subspecies or varieties, arbitrary concentration used, and extraction methods. Other literatures have shown that antimicrobials extracted from the ethanol are highly effective than those extracted from aqueous solution.

CONCLUSION

The combined concentration level of *Aloe vera* and *Allium sativum* showed high inhibition effect at concentration level of 50% and 75% than the corresponding concentration level of the individual. Inhibition activity of combined concentration level of *Aloe vera* and *Allium sativ*um aqueous extract at 50% could be used to treat veterinary cases in poultry caused by *Salmonella* Gallinarum which is resistant to the common prescribed antibiotic at low cost. However further research is required to be conducted to determine minimum inhibitory concentration (MIC) of the combined concentration and to determine whether there is toxicity at the concentration level of 50% and 75% of combined level of *Aloe vera* and *Allium sativum* (which exemplified to be more effective) in animal body especially poultry. The use of these natural medicinal plants in poultry production could reduce the cost margin and increase the profit margin. *Allium sativum* and *Aloe vera* can be processed and refined in the pharmaceutical industries at required concentration and sold to the farmers at low cost for inhibition and control of *Salmonella* Gallinarum in poultry production.

ACKNOWLEDGEMENTS

This work was funded by the High Education Student Loan Board. We are thankful to Mr. Mgusi the laboratory technician for the technical assistance. Much gratitude goes to Prof. P.N. Wambura for permission to conduct the experiment in the Microbiology Laboratory at the Faculty of Veterinary Medicine.

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Comparative Economic Analysis of Beekeeping Using Traditional and Improved Beehives in the Miombo Woodlands of Tabora and Katavi Regions, Tanzania

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Abstract: *The study was carried out in Tabora and Katavi regions in the miombo woodlands of Tanzania. The overall objective of the study was to undertake a comparative economic analysis of beekeeping using improved or traditional beehives. Data were collected from 198 beekeepers that were randomly selected from a sampling frame of 237 beekeepers using a structured questionnaire. Data were analyzed using descriptive statistics, analysis of variance (ANOVA) along with budgetary analysis and profitability ratios. The findings revealed that improved beehives were more productive than traditional beehives, although both beekeeping systems were profitable ventures. However, beekeepers who used traditional beehives realized higher net farm incomes than those who used improved beehives. Return on investment was estimated to be 3.7% per shilling for beekeepers using traditional beehives against 1.3, 0.3 and 0.8% for those using Tanzania Top Bar, Box and Longstroth (improved beehives), respectively. The lower gains associated with improved beehives that are more productive than traditional ones, are most likely to be a result of failures within the market system to value and reward quality. Earnings for adopters of these productivity enhancing beehives could increase if new mechanisms that allow fair pricing of high-quality honey extracted from such beehives are instituted in local markets. These endeavours could be pioneered by relevant institution including local government and non-governmental organizations in respective areas.*

Key words: beekeeping, beehives, budgetary analysis, profitability ratio analysis.

INTRODUCTION

There has been a growing world-wide emphasis to accelerate the adoption of improved technologies in agriculture and related value chains owing to potential gains, especially with respect to resource use efficiency (Fan *et al.,* 2012; Godfray *et al.,* 2010; Pretty *et al.,* 2006). While there have been several sector-specific endeavours of this nature, many of such endeavours have been futile as the adoption rate has been disappointingly low (Langyintuo and Mekuria, 2005; Moser and Barrett, 2003). Literature identifies several factors underlying this low adoption rate including uncertainty among potential adopters with respect to potential gains vis-à-vis the cost of adoption (Pannell *et al.,* 2006; Koundouri *et al.,* 2006); inability to afford the cost of adoption/use of a technology (Fisher and Kandiwa, 2014; Kurkalova and Zhao, 2006) and lack of/ inadequate knowledge on how to use it. Despite all these challenges, efforts to develop and upscale modern technologies for enhancing productivity as well as profit gains among small scale farmers are still in the wheel.

According to this presumption, the introduction of modern beekeeping technologies including the use of improved beehives has been considered as a hallmark of the sector to enhance resource use efficiency along with beekeepers' earnings and welfare in Tanzania (MNRT, 1998). Many of the small scale beekeepers in Tanzania - about 99%, rely on a beekeeping system that entails the use of traditional beehives made of material such as logs, barks and guards and fires to protect beekeepers from bee sting. This practice is associated with low productivity, poor product quality and has been declared as environmentally unfriendly and a major threat to sustainability of bee colonies. Meanwhile, the demand for bees' products is expanding in both local and international markets (MMA, 2007; Hausser and Mpuya, 2004; MNRT, 1998). For instance, the driving force for the honey industry in Tanzania has been the existence of big companies which are involved in buying bee products. A good example is Fidahussein's companies which buy honey for a conventional export market. Other exporters in the country include Mohamed Enterprises (T) Limited, Shamshudin Honey Care Africa (Tanzania) Limited and Dabaga Limited. In addition, there are small and medium enterprises (SMEs) which access local and sub region markets for honey.

Several studies have been undertaken by national and international development agencies to address the challenges in the bee keeping sector. For instance, TAWIRI (1997, 1998, 2002, 2004 and 2006), Mlingwa and Mwakatobe (2004) and Swai and Oduol (2003) conducted studies which addressed challenges related to value addition, design of bee beehives, economic value of bee products, marketing of bee products and beekeeping husbandry. Other

studies were conducted to assess factors underlying women's and youth's participation in beekeeping and value chain activities (MMA, 2007; Mkamba, 2006; TAWIRI, 2004). All these studies had an overall objective of improving the sector's productivity as well as reducing poverty among beekeepers. Several interventions have been developed and implemented based on recommendations of these studies.

One of such interventions has been the introduction of modern beekeeping technologies including the use of improved beehives (transitional and commercial), protective gears and smokers. The system has been proved to be more effective in conserving the environment and bee colonies. Thus, promotion efforts for the use of such technologies have centred more on apiculture as a means of conserving forestry and biodiversity. Despite the technical advantage of these technologies, studies have revealed that the adoption rate of such technologies by small scale beekeepers is still low (Nkojera, 2010). It is estimated that over 95% of the small scale beekeepers continue to use log beehives (Laila and Machangu, 2008) mainly because of the abundance of logs in Miombo woodlands that are perceived to be cheaper owing to the public nature of forests that are not conserved. There are only a few farmers who have been sensitized to adopt improved beehives following the national-wide promotion efforts by government, non-governmental organizations (NGOs) and donor-supported development projects. However, many of these farmers tend to maintain both traditional and improved beehives. It is unclear whether the perception about high investment cost is valid for all types of beehives that are likely to have different levels of productivity. Thus, there is a need to empirically test whether: i) there are differences in productivities of traditional and improved beehives and; ii) such differences translate into additional gains for beekeepers to outweigh investment costs. There is no empirical study which has examined these differences in Tanzania. The current study used household survey data from Tabora and Katavi regions to compare economic performance of improved vis-à-vis traditional beehives and gains among small scale beekeepers.

METHODOLOGY

Study Area

This study was conducted in four districts - three in Tabora region (Urambo, Kaliua and Sikonge) and one district in Katavi region (Mlele) (Figure 1). All the four districts fall within the miombo ecosystem.

The miombo ecosystem describes African woodlands that are dominated by tree species such as *Brachystegia spp, Julbernardia spp* and *Isoberlinia spp*. These woodlands cover approximately 2.7 million km^2, stretching across Angola,

Democratic Republic of Congo, Malawi, Mozambique, Tanzania, Zambia and Zimbabwe. These woodlands are particularly suitable for beekeeping because they provide excellent bee forage along with several tree species that are good resources for making traditional bark and log beehives. In most areas, beekeepers are able to harvest twice a year, depending on the dominant tree species and their flowering patterns (Mickels-Kokwe, 2006). Tabora and Katavi regions form the potential habitant for bees in Tanzania. However, beekeeping is spreading quickly to other areas of Tanzania as people are convinced by its contribution to poverty reduction among rural communities.

Since 1999, government agencies, non-governmental organizations and development projects have intervened the beekeeping industry in various ways to improve the production of bee products including the introduction of improved technologies. In Sikonge district, for example, improved beekeeping technologies were introduced and promoted by the District Council, Tabora regional office, Honey King Ltd and the Korea International Cooperation Agency (KOICA) (Sikonge District Council, 2012). In Urambo and Mpanda districts, improved beehives were introduced by the Tanzania Social Action Fund (TASAF) and the Association for Development of Protected Areas Project (ADAP) (Urambo District Council, 2012; Mpanda District Council, 2012). The majority of the rural population in these districts depend on agricultural production for their livelihood. Tobacco is the main cash crop for farmers in the area, although a significant number of farmers is also involved in beekeeping to generate extra income.

Four (4) districts were purposively selected from Tabora and Katavi regions, where beekeeping is one of predominant economic activities among farmers. One hundred and ninety eight (198) beekeepers were randomly selected from the sampling frame of 237 beekeepers that were using improved beehives. Data were obtained from both primary and secondary sources. Primary data were collected using a structured questionnaire, focus group discussions and in-depth interviews with key informants, targeting village and ward leaders, extension officers (especially beekeeping officers) at the district level. Sources of secondary data included District Council reports, journals, project reports and the Internet. Attempts were made to solicit all relevant information on socioeconomic variables of beekeepers including sex, experience in beekeeping, age, education status and household size. Other variables were number of beehives owned (both traditional and improved), size of improved beehives, production level and market prices of various inputs. Additional data on costs incurred in- and revenue realized from beekeeping were also collected during the survey.

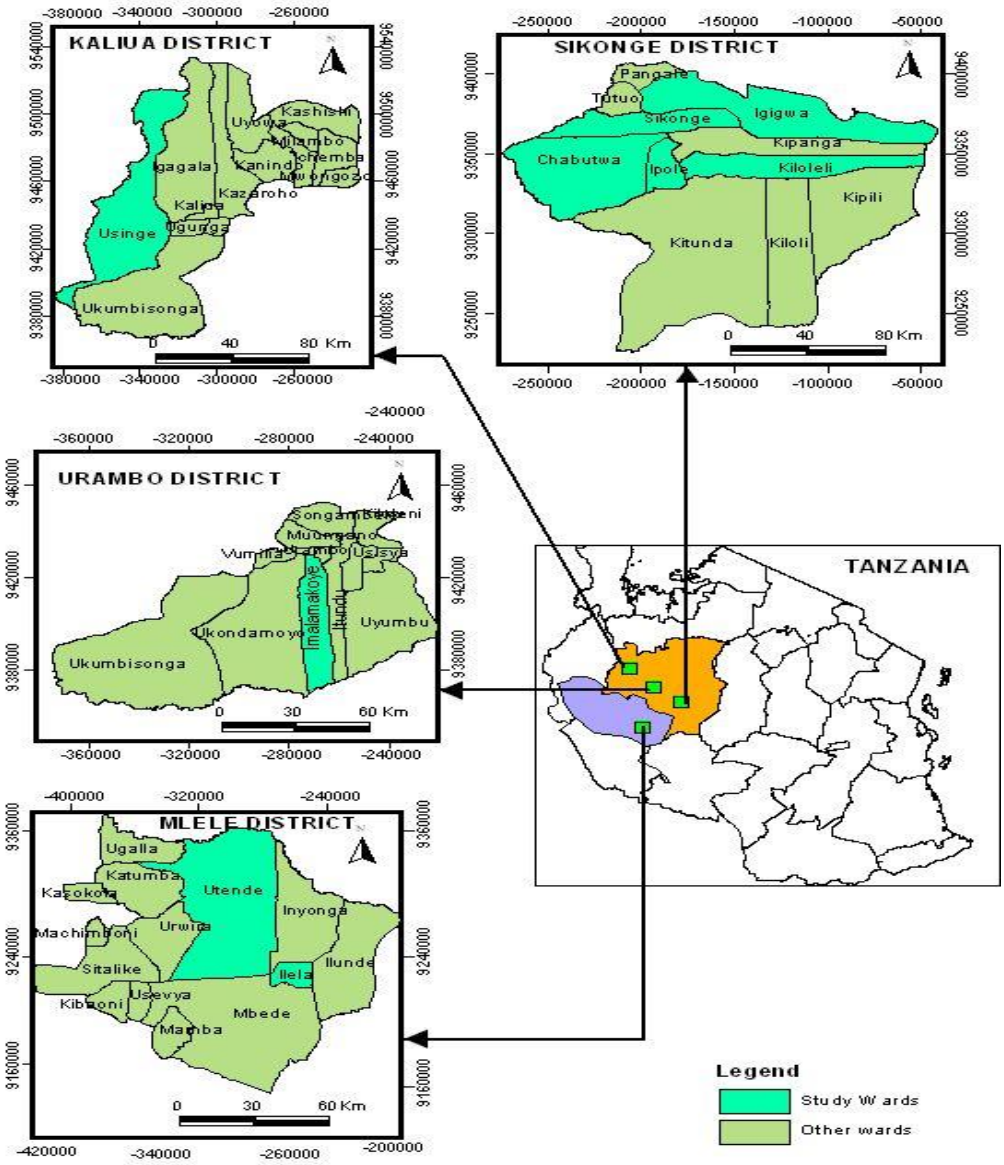


Figure 1: Map of the study area

Sampling Techniques and Data Collection

Analytical Tools

The analytical tools employed in this study included descriptive statistics, analysis of variance (ANOVA), followed by budgetary analysis and profitability ratios. Descriptive statistics such as percentages and frequencies were used to analyze socio-economic variables of beekeepers while means were computed and compared as preliminary analysis of differences in productivity levels between traditional and improved beehives. This

comparison was extended to ANOVA to allow multiple comparisons of such differences using Dunnett *t*-test. The thrust was to capture individual-specific differences for beekeepers using similar (within comparisons) and different (between comparisons) beehives. Budgetary technique, specifically the gross margin analysis, was used to estimate the cost and revenue associated with traditional and improved beekeeping systems. In the context of this study, improved beehives included transitional and commercial beehives. Transitional beehives comprised the Tanzania Top Bar and Box hives.

Comparing productivity of beehives

Dunnett's method was adopted to compare all the other beehives' means to the mean of a control group that was selected from the domain of beehives considered. To perform multiple comparisons for each of the possible pairs of beehives, the method requires the use of a special table to find hypothesis test critical value (t_{cr}) for each pair of beehives being compared. This critical value is needed to calculate significant difference (d_s), which is mathematically given as shown in equation (1.0).

$$d_s = t_{cr} S_{\bar{d}} \quad \text{.......................................} \quad (1.0)$$

Where $S_{\bar{d}}$ is standard error of difference between means of productivity for a pair of beehives considered and is calculated as per details in equitation (2.0).

$$S_{\bar{d}} = \sqrt{\frac{2S^2}{n}} \quad \text{.......................................} \quad (2.0)$$

Note that S^2 represents mean square error from ANOVA.

Comparing gains from beehives

In computing the cost and return, the budgetary analysis method was used. The model was specified as shown in equation (3.0).

$$NFI = TR - TVC - TFC \quad \text{.......................................} \quad (3.0)$$

Where NFI is net farm income (TZS), TR is total revenue from bee products (TZS), TVC is total variable costs and TFC is total fixed costs. Equation (3.0) can be expanded to describe how each of the right-hand side variables is calculated (equation (4.0)).

$$NFI = \sum_{j=1}^{m} P_{ij} Q_{ij} - \sum_{g=1}^{n} p_{ig} X_{ig} - \sum_{k=1}^{r} p_{ik} q_{ik} \quad \text{……..……. (4.0)}$$

Where; Q_{ij} is quantity of j^{th} output ($j = 1,2,..,m$), P_{ij} is unit price of j^{th} outputs in relation to i^{th} respondent, X_{ig} is quantity of i^{th} variable input ($i = 1,2,3,...,n$), P_{ig} is unit price of i^{th} variable input in relation to i^{th} respondent, p_{ik} is unit price of k^{th} fixed input in relation to i^{th} respondent, q_{ik} is quantity of k^{th} fixed input for $k = 1,2$ and $\sum$ is summation sign.

To determine economic performance of beekeeping using improved or traditional beehives, the profitability index for returns on sales (*PI*) for each bee keeper/enterprise was computed using the formula shown in equation (5.0):

$$PI = \frac{NI}{TR} \quad \text{……..…… (5.0)}$$

Other ratios that were computed are rate of return on investment (RR_I), rate of return on total variable cost (RR_{TVC}), rate of return on total fixed cost (RR_{TFC}) and operating ratio (*OR*) that are presented in equations (6.0), (7.0), (8.0) and (9.0), respectively.

$$RR_I = \frac{NI}{TC} * 100 \quad \text{……..…… (6.0)}$$

$$RR_{TVC} = \frac{TR - TFC}{TVC} * 100 \quad \text{…….…… (7.0)}$$

$$RR_{TFC} = \frac{TR - TVC}{TFC} * 100 \quad \text{… ……..…….. (8.0)}$$

$$OR = \frac{TVC}{TR} \quad \text{……..……..… (9.0)}$$

RESULTS AND DISCUSSION

Respondents' Socio-Economic Characteristics

The socio-economic characteristics of the respondents consisted of age, sex, beekeeping experience, education level, major occupation, number of colonies as well as the number of improved and traditional beehives owned (Tables 1 and 2). The findings in Table 1 show that the majority (58.1%) of beekeepers were within the age group of 35 - 64 years; followed by 21.2% of beekeepers who were in the age group of 15 – 34 years. In the context of Tanzania, age

groups between 35 – 64 years and 15 – 34 years are referred to as the working age group of the population, representing older and youth members, respectively. The rest of the beekeepers are in the dependant category (above 64 years) who accounted for 20.7% of the population. These findings imply that most of the beekeepers were in the productive age group.

This finding conforms to that of Mbah (2012) who found that many (93.3%) beekeepers in Nigeria were within the productive age ranging from 20 to 50 years. Similar findings were also reported by Abdullahi *et al.* (2014) and Onwumere *et al.* (2012) who found a large proportion of beekeepers in Nigeria being within the productive working age category. This might be due to the fact that the age of a farmer determines the type of agricultural activities undertaken. In Nigeria, for instance, younger farmers spend more time on farm and tend to engage in labour intensive activities than older farmers (Tijani *et al.*, 2010). Furthermore, the finding suggests that beekeeping is a viable enterprise which can also be used as a source of income for the elders hence reducing their dependence.

Out of 198 respondents who were interviewed, only 9 were females, representing only 4.5% while the remaining 189 (95.5%) were males. This is due to the fact that beekeeping is mostly done in forest reserves which are far from the homesteads; females find it difficult to travel long distances; hence only few women venture in this activity. Also females were less involved in beekeeping probably because the activity involves tree climbing when hanging beehives and harvesting honey, which, according to African culture, is not suitable for females.

Similar findings are reported by Abdullahi *et al.* (2014) who found the dominance of men in beekeeping enterprise in Kaduna state, Nigeria. However, they noted indirect involvement of women in field operations for honey production whereby women had to hire men to hang beehives and harvest honey. The findings of this study indicate further that 72.7% of the respondents had primary education, while 12.1% had no formal education. The proportion of beekeepers that had secondary and tertiary, college or university education levels was 7.6% for each category.

Table 1: Socio-economic characteristics of the respondents

Variable Name	*Frequency*	*Percent*
Experiences in beekeeping (years)		
0 – 5 years	78	39.4
Above 5 years	120	60.6
Total	198	100.0
Age groups		
15 – 34 [Youth]	42	21.2
35 – 64 [Elder]	115	58.1
Above 64 years [Dependants]	41	20.7
Total	198	100.0
Gender of the household head		
Male	189	95.5
Female	9	4.5
Total	198	100.0
Education levels		
Non formal education	24	12.1
Primary education	144	72.7
Secondary education	15	7.6
Tertiary/college/or university	15	7.6
Total	198	100.0
Main Occupation		
Beekeeping	42	21.2
Farming (crop production)	141	71.2
Petty trade	6	3
Government employment	9	4.5
Total	**198**	**100.0**

The findings also revealed that 60.6% of the respondents had more than 5 years of experience in beekeeping, while 39.4% had less than 5 years of experience in beekeeping (Table 1). This implies that most of the beekeepers in the study areas had adequate beekeeping knowledge.

Ownership of Assets and use of Improved Beekeeping Practices among Beekeepers

About a half (48.5%) of the beekeepers owned 10 – 50 bee colonies. Those who owned 0 – 9 and 51 – 150 bee colonies were 22.7% and 25.8%, respectively. The findings also revealed that only 3% of the beekeepers owned more than 150 bee colonies (Table 2). A large proportion of beekeepers who owned both improved and traditional beehives were found in the group category of 10 – 50 beehives. Data revealed that 46.5% and 34.3% of the respondents owned improved and traditional beehives, respectively (Table 2). This reveals the small scale nature of the majority of the beekeepers in the study area.

Only 5.04% of 198 respondents had press for extraction of honey, and only 23% of these respondents had protective gears. These gears included smokers, overalls and gloves. Further analysis was conducted to assess the use of improved beekeeping practices among beekeepers. The findings revealed that 37.9% used honey press for extracting honey whereas the rest (62.1%) used their own traditional methods such as dripping and squeezing honey using hands. It was also noted that despite the low rate of ownership of protective gears, 84.8% of the respondents used protective gears that were borrowed from fellow beekeepers. The remaining (15.2%) used other means including using smoke, fire or wire mesh to cover their heads during harvesting of honey.

Table 2: Number of colonies, improved and traditional beehives owned by respondents

Variable Name	*Frequency*	*Percent*
Number of bee colonies		
0 – 9	45	22.7
10 – 50	96	48.5
51 – 150	51	25.8
Above 150	6	3
Total	198	100
Number of improved bee hives		
0 – 9	73	36.9
10 – 50	92	46.5
51 – 150	27	13.6
151 – 300	3	1.5
Above 300	3	1.5
Total	198	100.0

Variable Name	*Frequency*	*Percent*
Number of bee colonies		
0 – 9	45	22.7
10 – 50	96	48.5
51 – 150	51	25.8
Above 150	6	3
Total	198	100
Number of improved bee hives		
0 – 9	73	36.9
10 – 50	92	46.5
51 – 150	27	13.6
151 – 300	3	1.5
Above 300	3	1.5
Number of traditional bee hives		
0 – 9	48	24.2
10 – 50	68	34.3
51 – 150	55	27.8
151 – 300	15	7.6
Above 300	12	6.1
Total	**198**	**100.0**

Comparative Analysis of Beekeeping using Improved or Traditional Beehives

Data show that 90.91% of the respondents were using transitional beehives and only 9.09% were using commercial beehives. Transitional beehives comprised the Tanzanian Top Bar beehives (56.1%) and box beehives (40.9%). In the study area most beekeepers used log traditional beehives while 56% of the respondents owned Top Bar beehives while 40.9% owned box beehives. It was noted that almost all the respondents used log traditional beehives. Log and bark beehives are considered to be more convenient owing to the availability of trees.

Productivity of improved and traditional beehives

Productivity estimates of improved and traditional beehives are given in Table 3. The results show that productivity is generally higher for improved than for traditional hives—being highest for Box followed by Tanzania Top Bar and Longstroth beehives.

Table 3: Annual productivity of improved and traditional beehives

Annual productivity of hive (litres of honey/hive)	*Mean*	*N*	*Std. Deviation*	*Std. Error Mean*
Boxes beehives	13.24	81	5.63480	.62609
Tanzania Top Bar beehives	11.98	111	5.59000	.53058
Longstroth beehives	10.37	6	5.75036	2.34758
Log beehives (traditional)	7.90	120	4.01021	0.36608

A *Post hoc test* was performed in SPSS programme to compare all groups of beehive types with each other. The findings in Table 4 revealed significant differences between log traditional hives and Tanzania Top Bar as well as box beehives ($p < 0.01$). The findings also revealed a non-significant difference between log traditional and Longstroth beehives ($p > 0.1$).

Table 4: Multiple comparison of annual honey productivity improved beehive types

Dependent Variable: Productivity							
			Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
Test	(I) Beehive	(J) Beehive				Lower Bound	Upper Bound
Games-Howell	Box	Tanzania Top Bar	1.25936	.89485	.496	-1.0618	3.5805
		Longstroth	2.88004	2.44397	.661	-5.6476	11.4077
		Traditional	5.36474*	.76811	.000	3.3652	7.3643
	Tanzania Top Bar	Box	-1.25936	.89485	.496	-3.5805	1.0618
		Longstroth	1.62068	2.42206	.905	-6.9312	10.1726
		Traditional	4.10538*	.69525	.000	2.3031	5.9077
	Longstroth	Box	-2.88004	2.44397	.661	-11.4077	5.6476
		Tanzania Top Bar	-1.62068	2.42206	.905	-10.1726	6.9312
		Traditional	2.48470	2.37815	.733	-6.1307	11.1001
	Traditional	Box	-5.36474*	.76811	.000	-7.3643	-3.3652
		Tanzania Top Bar	-4.10538*	.69525	.000	-5.9077	-2.3031
		Longstroth	-2.48470	2.37815	.733	-11.1001	6.1307
Dunnett *t* (2-	Box	Traditional	5.36474*	.78217	.000	3.4969	7.2326

sided)[a]	Tanzania Top Bar	Traditional	4.10538*	.71629	.000	2.3949	5.8159
	Longstroth	Traditional	2.48470	2.27538	.599	-2.9489	7.9183

*. The mean difference is significant at the 0.05 level.
a. Dunnett t-tests treat one group as a control, and compare all other groups against it.

However, though productivity of improved beehives was higher than that of traditional beehives, its productivity was below its potential of approximately 20 litres of honey per beehive per annual (Mpanda District Council Annual report, 2012). Also this productivity was below the global recommendation, which is about an average of 40 litres of honey annually per beehive for commercial beekeepers using modern technologies (Muhammad and Abdulrahman, 2004). The observed differences in terms of annual productivity motivated the analysis of cost and benefit.

Cost and benefit

Analysis of cost and benefit associated with each of the two beekeeping systems revealed that beekeeping using improved and traditional beehives is a profitable business (Table 5). Beekeepers using improved beehives realized an average gross farm income ranging from TZS 286,708.10 to 656,599.60; with a total cost ranging from TZS 155,550.30 to 326,572.00 per annum. Thus, net annual farm income of TZS 376,733.50, TZS 131,157.80 and TZS 88,423.70 was realized from using Tanzania Top Bar, Longstroth and Box beehives; respectively. The findings reveal benefit-cost-ratios of 2.3, 1.3 and 1.8 for Tanzania Top Bar, Box and Longstroth beehives, respectively.

These findings imply that, for every Tanzanian shilling invested in beekeeping using Tanzania Top Bar, Box and Longstroth beehives in the study area, the profit realized is about TZS 1.3, 0.3 and 0.8; respectively. Meanwhile, the findings reveal that beekeepers using traditional beehives, on average, realized a gross farm income of TZS 1,138,151.60 while incurring a total cost of TZS 242,444.90 per annum. Thus, the net annual farm income was about TZS 895,706.80 with a benefit-cost ratio of 4.7. Therefore, for every one Tanzanian shilling invested in beekeeping using traditional beehives there is a profit of TZS 3.7.

Table 5: Comparative economic performance of beekeeping using traditional and improved beehives in Tabora and Katavi regions

Variables	Types of beehives used			
	Traditional	Improved		
	Log	Box	Tanzania Top Bar	Longstroth
Annual Average Gross Farm Income (GFI)	1,138,151.6	414,995.7	656,599.6	286,708.1
Total Cost (TC)	242,444.9	326,572.0	279,866.1	155,550.3
Net Annual Farm Income (NFI)	895,706.8	88,423.7	376,733.5	131,157.8
Benefit-Cost Ratio (B/C Ratio)	4.7	1.3	2.3	1.8
Return on Investment/TZS	3.7	0.3	1.3	0.8
Profitability Index (PI)	0.8	0.2	0.6	0.5
Rate of Return on Variable Costs (%)	469.5	127.4	236.6	186.6
Rate of Return on Investment (RRI) (%)	369.5	27.1	134.6	84.3
Operating Ratio (OR)	21.3	77.7	42.0	52.8

Source: Household survey data, 2013.

When compared, the net benefit from traditional beehives outweighed those from improved beehives as the investment in traditional beehives yields more profit than similar investment in improved beehives. These findings are in line with Attri *et al*. (2010) who found that traditional beekeeping with *Apis Cerana* was more profitable than modern beekeeping with *Apis Mellifera*. However, other studies conducted in Cameroon never revealed any significant differences in terms of total income, net profit or annual profit (Matsop *et al.* 2011 in Cristina and Anca, 2012).

However, contrasting findings were reported by Abdullahi *et al.* (2014) and Onwumere *et al.* (2012) in Nigeria where modern beekeeping generated more income than traditional beekeeping despite the high production costs of the former. The difference in profit level between beekeepers using either traditional or improved beehives can also be explained by the fact that buyers in the study area do not differentiate products from improved and traditional systems, although handling practices and possibly quality differ. It is important to note that respondents felt that honey from improved beehives had better quality than honey from traditional beehives but buyers of honey were not willing to offer a premium for the better quality honey. This

discouraged beekeepers from using improved beehives that were perceived to be capital intensive than the traditional ones.

Profitability ratio analysis

The findings in Table 5 reveal that the profitability indices (PIs) associated with the use of Tanzania Top Bar, Box, Longstroth and log hives were 0.6, 0.2, 0.5 and 0.8, respectively. The indices indicate that every one Tanzanian shilling (TZS) invested on Tanzania Top Bar, Box, Longstroth beehives yields TZS 0.6, 0.2 and 0.5 respectively as net income for beekeepers. The corresponding net return from traditional beehives is TZS 0.8 per Tanzanian shilling. The operating ratio ranged from 42.0% to 77.7% for beekeeping enterprises using improved beehives while it was estimated to be 21.3% for those using traditional beehives. This implies that a range of 42.0% to 77.7% of the sales revenue would be used to cover operating expenses of beekeeping enterprise using improved beehives compared to only 21.3% of the traditional beehives. Note that a low operating ratio means high net profit ratio. Since the operating ratio for traditional beehives is less than that of improved beehives, then traditional beehives were more profitable than improved ones. Furthermore, the rate of return on variable costs was estimated to be 236.6% for Tanzania Top Bar, 127.4% for Box and 186.6% for Longstroth beehives against 469.5% for traditional beehives (Table 6). This signifies that for every shilling incurred on inputs generates more return when traditional bee hives are used instead of improved beehives.

CONCLUSION AND RECOMMENDATIONS

Conclusion

Many beekeepers in the study area were males with primary education level. Many of the beekeepers were still using traditional technologies, especially log beehives as well as local methods to extract honey as there is little incentive to upgrade their production practices. Improved beehives are more productive than traditional beehives. Beekeeping has proven to be a profitable venture in the study as all farmers are able to break-even. However, profitability for beekeepers using traditional beehives outweighs the profitability for those using improved beehives.

Recommendations

The adoption of beekeeping facilities among beekeepers such as honey press, protective gears and smokers could be accelerated if beekeepers had access to means that allow honey from improved beehives to be fairly valued and priced in the market. Where feasible, small holder beekeepers could be organized and supported to undertake collective action to participate and compete fairly in the market place. Other means to make their products unique and/ more appealing to buyers are worth pursuing. These means

could be pioneered by relevant institutions including Local Government Authorities (LGAs) and NGOs in respective areas.

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Determinants of the Use of Cell phones in Access to Beef Cattle Market Information for Smallholders in Mpwapwa District, Tanzania

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Abstract: *Cell phone is said to be an innovative communication device which allows consumers, traders and farmers to search market appropriate information for timely decision-making to save time and travelling costs. However, determinants of using this technology in beef cattle market information seeking for smallholders in Tanzania - particularly in Mpwapwa District, are not well established. Thus, this study analysed the determinants of the use of cellphones in accessing beef cattle market information in Mpwapwa District. Data were collected from 120 respondents using a structured questionnaire and focus group discussion guide. The questionnaire-based data were analysed using the Statistical Package for Social Sciences in which the main analytical model was binary logistic regression. In the model, the dependent variable was access to beef cattle market information via cell phones with two options; did not access (0) and accessed (1). Research findings revealed that the nature of using cell phones in access to beef cattle market information was mostly determined by distance from home to the nearest cattle market; the variety of information demands; income earned per year; level of local network coverage and access to mobile financial services (M-Pesa). On the basis of these findings it is concluded that the smallholder beef cattle producers can use cell phone technology in market information sharing to enhance their marketing participation. Therefore, the study recommends that cell phones service providers should extend their services more in the rural areas of Mpwapwa District.*

Key words: Determinants, cellphones, market information, smallholders

INTRODUCTION

Information needs is growing rapidly due to up-and-coming of modern Information and Communication Technologies (ICTs). According to Mittal and Mehar (2012) access to insufficient agricultural market information has paved a way towards the use of modern ICTs including cell phones to share crop and livestock market information for involved stakeholders. Literature

has shown that the rapid expansion of cell phones ownership has increased participation of smallholders' access to market information for their produce (Marini and Wiedemann, 2006). Similarly, a study by Muto and Yamano (2009) found that the growth of cell phones local coverage in Uganda has increased concomitantly with an increase in sales of banana outside the producers' district centres. Henceforth, with appropriate communication technology smallholder beef cattle producers would have been informed about the prevailing cattle market prices and demands for reduced market search costs, increased bargaining power and beef marketing participation.

A study by Aker (2008) has shown that although traditional agricultural market information systems provide information to farmers, buyers and consumers via radios and message boards, market actors have not been active participants in sharing the information gathered to enhance timely decision-making. Mnenwa and Maliti (2009) explain the absence of an information system in Tanzania as a cause of high level of information asymmetries, causing inefficiencies in the marketing system in terms of pricing and condition set for increased efficiency in marketing.

Likewise, Shepherd *et al.* (1997) explained market information dissemination as a regular public dissemination of prevailing market prices, commodity volumes, market conditions and available price trends. A study by Kristjanson *et al.* (2004) which put an emphasis on improved cattle husbandry for enhancement of cattle performance, also suggests more research on determinants of smallholder livestock keepers' access to appropriate information regarding marketing of cattle. According to Aker (2008), cell phone is an innovative communication device which allows consumers, traders and farmers to search market information appropriate for timely decision-making to save time and travelling costs. However, the determinants of using this technology in beef cattle market information sharing among smallholders in Tanzania particularly in Mpwapwa district are not well established. Thus, this study analysed the determinants of the use of cell phones in access to beef cattle market information for smallholder beef cattle producers in Mpwapwa district.

METHODOLOGY

Description of the Study Area

The study was conducted in Mpwapwa district located in Dodoma region, Tanzania. The district was selected for the research because it is connected to four mobile telephone service providers and it is one of the catchment areas for beef cattle marketing in the country. According to URT (2013) the traditional beef cattle population in the district is 262,076.

Research Design and Methods of Data Collection

A cross-sectional research design was used to collect data once from individual beef cattle smallholders, an individual being the sampling unit. The study collected both primary and secondary data and used both quantitative and qualitative data collection methods. The sampling frame consisted of all beef cattle smallholders in Rudi and Mpwapwa divisions, in four wards namely Rudi, Chipogoro, Gulwe and Godegode where by four villages distinctively Chilendu, Gulwe Chipogoro and Godegode were surveyed. The surveyed villages were selected purposively based on the availability of cattle population and cell phones local network coverage. In addition, the study used systematic sampling to select 30 respondents from each village to get a sample of 120 respondents. Information regarding the number of existing beef cattle farmers in the surveyed villages was obtained from the district, ward and village levels. Criteria for using systematic sampling to select 30 respondents from each village included ownership and marketing of cattle seasonally or annually. Hence systematic sampling was used to ensure that all members of population had equal chances of being selected. Quantitative data were mainly collected using a structured questionnaire. Qualitative data were collected from focus group discussions. A focus group discussion guide was used in discussion to gather information from 32 beef cattle smallholders who participated in four group discussions (eight participants in each of the four villages). The number of eight participants per session is the one recommended by Barbour (2011). Likewise, secondary data about primary and secondary cattle markets were obtained from the village and livestock district offices as well as the Ministry of Livestock and Fisheries Development reports.

Data Analysis

The questionnaire-based data were analysed using the Statistical Package for Social Sciences (SPSS) whereby descriptive statistics including means, percentages, frequencies and multiple responses were computed. In addition, binary logistic regression model was employed to analyze the odds of some covariates indicating determinants of the use of cell phones influencing chances of market information access among beef cattle smallholders. The theoretical basis of the model was to determine the likelihood of using cellphones and its influence towards access to rapid cattle market information. This hypothesis was tested using a binary logistic regression model since such a model is ideal for variables in which the dependent one is dichotomous. The dependent variable was a dummy of the determinants of using cell phones in access to beef cattle market information, whereby access to beef cattle market information was 0 if an individual beef cattle smallholder did not have access to any cattle market information via cell phones in the previous 12 months. Conversely, access to market information was 1 if an individual smallholder

had access to any type of cattle market information via cell phone in the previous 12 months. This dependent variable was regressed on the above seven covariates to determine the influence of each of them on the dependent variable.

The formula for binary logistic regression that was used is:
Log [Pi/1-Pi] = $\beta o + \beta_1 X_1 + \beta_2 X_2 + ... + \beta_n X_n$ (Agresti, 2002; Powers and Xie, 2000).....(1), where:

Log [Pi/1-Pi] = Natural logarithm of the odds of some covariates indicating determinants of the use of cell phones in access to market information.

Y = 0 if a beef cattle smallholder didn't access market information via cell phone in the previous 12 months.

Y = 1 if a beef cattle smallholder accessed market information via cell phone in the previous 12 months

β_0 = Constant of the equation

β_1 to β_n = Logistic regression coefficients of the covariates

n = Number of covariates

X_1 to X_n = Covariates entered in the model

X_1 = Number of cattle owned

X_2 = Age of respondent

X_3 = Estimated income earned per year

X_4 = Approximate distance from home to the nearest cattle market place

X_5 = Ownership of a cell phone

X_6 = Access to market information about cattle sales volumes

X_7 = Access to information about beef cattle grades applicable

Likewise, inferential analysis was done by using Chi-square test at $p \leq 0.05$ concomitantly with cross tabulations to test the associations between some categorical independent variables and factors determined access to cattle market information via cell phones. The Chi-square model used is:

$$X^2 = \sum \frac{(o - e)^2}{e} \quad \text{...(2)}$$

Where:

χ^2 = the value of Chi-Square statistics

o = Observed frequencies in the contingency table

e = expected frequencies in the contingency table

Qualitative Data Analysis

The qualitative data obtained were analysed thematically to highlight diversity among the individual experiences and results were reported concurrently with quantitative and secondary data.

RESULTS AND DISCUSSIONS

The Nature of Using Cell phones in Access to Market Information

The Chi-square test showed that there was a significant association between access to beef cattle market information and the use of cell phones ($\chi^2 = 10.085$; $p \leq 0.001$) indicating that rapid access to beef cattle market information is determined by the use of cell phones. Furthermore, findings in Table 1 emphasise that more than seven-eighths (90 percent) who usually sell their cattle at home places were using cell phones in access to cattle market information. Likewise the Chi-square test indicated that there was a significant association between access to market information via cell phones and selling of beef cattle at home places ($\chi^2 = 10.085$; $p \leq 0.001$). This implies that the use of cell phones enabled smallholders to share instant cattle market information about prices, volumes, and beef cattle grades applicable in the various market places hence increased bargaining power and reduced price-cheating customs when selling cattle at home places.

Similar observations were reported by Sife *et al.* (2010) as well as Nyamba and Mlozi (2012) who indicated that cell phones had enhanced the ability of smallholder's access to market information for better price thus reduced chance of being cheated by brokers. Additionally the Chi-square test confirmed the significant association between the use of cell phones in access to beef cattle market information and access to M-Pesa services (χ^2 8.386; $p \leq 0.004$). This indicates that access to market information via cell phones is associated by the use of mobile banking, which enables smallholder beef cattle producers to overcome problem of cash theft after cattle sales and encourage savings among cattle producers in the rural areas. Of 27 percent respondents who responded to multiple responses enquiry more than one-fifth (22.5 percent) indicated the use of cell phones had increased their abilities in sending and receiving cash for various financial transactions including school fees for their children. The findings imply that the use of cell phones, which facilitates mobile banking services, could reduce risk of travelling with bulk cash in rural areas where bank facilities are not available.

The Use of Cell phones in Access to Market Information and Network Coverage

The findings in Table 1 show that 45 percent of the interviewed respondents had access to moderate network connection whereas 39.2 percent had access to high network connection. The study revealed that there were telecommunication towers in Rudi and Chipogoro villages where most of the respondents indicated high network connections in contrast to Gulwe and Godegode villages where there were no telecommunication towers but residents were able to access network connection through the nearby village's telecommunication towers mainly Msagali and Mpwapwa headquarters thus moderate network connection.

However, the network connection was considered favourable because 97 percent of cell phone users were able to communicate via cell phones throughout day and night by using both short message service (SMS) and voice calling modes, the most reliable network being Airtel 54.2 percent and Tigo 23.3 percent. The Chi-square test showed the significant association between access to beef cattle market information via cell phones and level of network coverage ($\chi^2 = 4.587$; $p \leq 0.032$) indicating that access to beef cattle market information via cell phone is determined by the level of network coverage in the area of residence. Similarly, the Chi-square test indicated that there is significant association between access to market information via cell phones and location of respondents ($\chi^2 = 4.473$; $p \leq 0.034$) this entails that market information searching were determined by many factors including distance from home to the market places.

These findings concur with the findings reported by Aker (2008) and Abel-Ratovo *et al.* (2012) who explained the distance as an environmental determinant that increases the use of cell phones in access to market information for both sellers and buyers before travelling to distant market places. The distance from home to the nearest market place in the surveyed area ranged from 1-55km with average of 13.51km. Some of the most important cattle market places in the study area include Kibakwe; Chipogoro; Rudi; Fufu; Chogola; Malolo; and Mima. Other cattle market places are Ilolo; Msagali; Gulwe; Chisalu; and Chinyika. According to the Ministry of Livestock and Fisheries Development (2014) report, currently there are over 400 primary cattle markets in Tanzania. These markets are under the jurisdiction of Local Government Authorities and most of them are held once per week.

Table 1: The Use of Cell Phones and Access to Market Information (N = 120)

Access to beef cattle market information				
Number of variables	**Frequency**	**Percent**	**χ^2**	**P-value**
The use of cell phone	79	65.8	10.085***	0.001
Selling cattle at home place	108	90.0	10.337***	0.001
Access to M-Pesa Service	27	22.5	8.386***	0.004
Level of network coverage				
High network connection	47	39.2		
Moderate network connection	54	45.0	4.587*	0.032
Division of residence				
Rudi	60	50.00		
Mpwapwa	60	50.00	4.473*	0.034

Note: ***, **,* significant at 0.1, 1 and 5percent levels respectively ($P \leq 0.001$, $P \leq 0.01$ and $P \leq 0.05$)
Source: Survey data (2014).

The Impact of Using Cell phones in communicating Cattle Market Information

The findings revealed that cell phones had been useful for smallholders in many ways in terms of communication and dissemination of information related to beef cattle in the study area. Findings in Table 2 indicate that 22.1 percent were using the devices to share information with their fellow beef cattle producers on the existing prices in the various local market places. More than one-fifth (21.5 percent) reported that cell phone saves time and cost on the market searching process while about one-fifth (19.2 percent) said it enables beef cattle smallholders to secure better price. Similar findings from focus group discussions (FGDs) revealed that the price assurance increases bargaining power since information is power, thus smallholders may opt to sell their cattle whenever there is better price in the market. Furthermore, 18.9 percent said that the use of cell phones had simplified the dissemination of information in case of cattle theft hence it is easier to search stolen cattle now than it was in the previous time before the introduction of the technology and 18.3 percent reported that the interactions with many cattle buyers had increased because of cell phones using.

Several researchers including Jagun *et al.* (2008); Masuki *et al.* (2010); Rabayah and Qalalwi (2011) have indicated the same observations that the use of cell phones has increased cooperation within farmers, enables to reach important customers and facilitates linkage between famers and buyers in the rural areas.

This implies that the use of cell phones has shown a positive impact in communication and dissemination of information among various stakeholders in rural areas. Generally, access to the knowledge about prevailing cattle market prices, quality and quantity demands prior cattle selling are noticeable determinants of cell phones usage for beef cattle smallholders that enhances negotiation for better prices in a cost effective manner.

Table 2: Impact of Cell Phones for Cattle Market Information Sharing (N = 120)

Positive impacts	Count	Percent of responses	Percent of cases
Helps in communication with fellow beef cattle keepers on the existing price in the different local market places	77	22.1	100.0
Increases interaction with many cattle buyers	64	18.3	83.1
Searching stolen cattle becomes easier by disseminating theft information via cell phones	66	18.9	85.7
Saves time and cost on the market searching process	75	21.5	97.4
Enabled cattle keepers to secure better price	67	19.2	87.0
Total	**349***	**100.0**	**453.2***

NB: *Multiple responses
Source: Survey data (2014).

Cell phones and Access to Beef Cattle Market Information in the Past 12 Months

Findings showed that about two-third (65.8 percent) of respondents shared beef cattle market information from various localities via cell phones in the past 12 months; that is from September 2011 to September 2012. Similarly, five-eighth (62.5 percent) of respondents used their own cell phones in access to market information shared; while few respondents (3.3 percent) used friend's cell phones as follows, 2.5 percent used friends device without paying and 0.8 percent borrowed friend's/relative's phone and recharge airtime to access cattle market information. Similar study by Martin and Abbott (2011) also noted that 70 percent of farmers in Uganda rural areas used cell phones to access market information from fellow farmers and buyers from different distant markets.

Furthermore, the study revealed that four-fifth (84.2 percent) of respondents preferred voice calling while only 1.7 percent preferred both voice calling and short message services (SMS) modes of communication using cell phones. In discussion with respondents, various opinions were given out concerning the preference for voice calling to SMS first of all they said that voice calling

allows rapid interactions with many actors involved in the process such as extension agents; cattle buyers and fellow farmers. Other reasons mentioned were the high SMS prices; visual disabilities; unfamiliarity; illiteracy; and inadequate skills on the use of SMS in rural areas.

These findings confirm earlier findings by Okello *et al*. (2010), Furuholt and Matotay (2011) and Abel-Ratovo *et al*. (2012) which indicated that the use of voice calling outweighed the SMS mode in the rural areas due to significant factors including constraints on the use of SMS format as well as individual's two-way interaction preference. Implying that farmers prefer communication mode that provides two-way interaction for questions and clarification of information sought.

Table 4: Cell Phones and Access to Market Information in the Past 12 Months (N = 120)

Access to market information	Frequency	Percentage
Accessed	79	65.8
Own phone	75	62.5
Friend's phone	4	3.3
Mode of communication preferred		
Voice calling	101	84.2
Both voice calling and Short Message Services (SMS)	2	1.7

Source: Survey data (2014).

Cell phones and Access to Market Information Disseminated by Extension/Ward/Village Executive Officials

The study revealed that nearly three-fifth (57.5 percent) of respondents had access to beef cattle information disseminated by extension agents as well as ward and village executive officials on various aspects with time. Findings in Table 5 showed different types of information related to beef cattle disseminated by the government officials via cell phones for smallholders in the study area. More than two-fifth (41.1 percent) reported that they had received information concerning the outbreak of cattle diseases; about 39.9 percent said they had received quarantine information; while 15.5 percent said that they had received information concerning access to cattle movement permit documents. Other type of information disseminated via cell phones was beef cattle grades applicable in the market 2.4 percent and 1.2 percent information about the cause of un-conducive price based on the special requests.

Similarly, results from focus group discussions (FGDs) revealed that information related to dipping, vaccination dates, and livestock keepers meetings/seminars were disseminated by Village Executive Officials (VEOs) via cell phones. Furthermore, respondents reported that, one could call VEO to ask whether the cattle movement permits have already arrived in the village office from the district headquarters hence access to the service.

Additional findings from chi-square indicate a significant association (χ^2 = 19.228; p = 0.000) between the use of cell phones to access beef cattle market information and access to other information related to beef cattle disseminated by the local government officials via cell phones. This entails that those who were using cell phones to access market information were likely to have access to information disseminated by the government officials timely. These findings suggest that cell phones had enabled communication and dissemination of information related to beef cattle farming instantly for immediate act particularly during disease outbreaks thus a number of animal deaths could be prevented.

Table 5: Types of Information Disseminated by Extension/Ward Executive/Village Executive Officials (N = 120)

Information type	Count	Percent of responses	Percent of cases
Beef cattle grades applicable	4	2.4	5.7
Cause of un-conducive prices	2	1.2	2.9
Quarantine information	67	39.9	95.7
Disease out breaks information	69	41.1	98.6
Access to cattle movement permit documents	26	15.5	37.1
Total	**168***	**100.0**	**240.0***

NB: *Multiple responses: Chi-square = 19.228 P = 0.000 ($p \leq 0.001$)
Source: Survey data (2014).

Odds of Having Access to Beef Cattle Market Information via Cell phones
The odds of smallholders having access to beef cattle market information via cell phones were determined by using binary logistic regression for which the model and covariates presented in the data analysis section were used.

One of the vital outputs of the binary logistic regression model was the Omnibus test of the coefficients of the model. The Omnibus test is a test of the capability of all predictors (independent variables) in the model jointly to predict the response (dependent) variable. If significance is found, it means

that there is adequate fit of the data to the model and at least one of the predictors is significantly related to the response variable (Garson, 2008). Therefore, based on this description, and by looking at the results in Table 6, which indicate that there was significance at the 0.001 level (p = 0.000), the data entered in the model adequately fitted the model, and at least one of the predictors is significantly related to the response variable.

Table 6: Omnibus Test of Model Coefficients

		Chi-square	Df	Sig.
Step 1	Step	62.738	7	0.000
	Block	62.738	7	0.000
	Model	62.738	7	0.000

Likewise, the model summary, which is presented in Table 7 showing Cox & Snell R square and Nagelkerke R square, was chosen as an important output of the binary logistic regression model. The Cox-Snell R square and Nagelkerke R square are attempts to provide a logistic analogy to R square in Ordinary Least Square (OLS) regression; hence are called pseudo R square. Nagelkerke R square is a modification of Cox-Snell R square to assure that Cox-Snell R square varies from zero to one, as does R square in OLS regression. If Cox-Snell R square is not modified, its maximum value is usually less than one, making it difficult to interpret.

Table 7: Model Summary

Step	-2 Log likelihood	Cox & Snell R Square (R^2)	Nagelkerke R Square(R^2)
1	83.992[a]	0.418	0.582

Garson (2008) notes that Nagelkerke **(**R square**)** is normally higher than Cox-Snell R square and is the most reported of the pseudo R square estimates. Therefore, based on the results in Table 7, which show that Nagelkerke R square was 0.582, it means that the covariates entered in the model explained 58.2 percent of variance in the dependent variable.

Other vital outputs of the model were Wald statistics, which are presented in Table 8. The Wald test is an alternative test, which is commonly used to test the significance of individual logistic regression coefficients for each independent variable. The Wald statistic is the squared ratio of the un-standardized logistic coefficient to its standard error. Wald statistic corresponds to significant testing of β coefficients in Ordinary Least Square (OLS) regression. Wald coefficients associated with individual independent variables help us realise the relative importance of each independent variable.

In other words, a Wald coefficient is a measure of the unique contribution of each independent variable in the context of the other independent variables and holding constant other independent variables. A bigger Wald statistic implies that the independent variable associated with it has high contribution to the occurrence of the dependent variable, which in this case is access to beef cattle market information via cell phones for smallholders. The effect, which can be negative or positive, of an independent variable on the dependent variable is denoted by the sign (negative or positive) of individual logistic regression coefficients (β values) for the independent variable that is generated concomitantly with the Wald statistic. A negative sign associated with a β coefficient shows that, that particular variable decreases the logit of the dependent variable (i.e. it decreases the probability that that event (in this case access to beef cattle market information via cell phones) will be realised, and vice versa.

For example in Table 8, the age of respondents, and the number of cattle owned reduce chances of beef cattle smallholder's access to cattle market information via cell phones since their β values are associated with negative signs; their logistic regression coefficients (β values) were negative implying that they had negative effects on the dependant variable. The reason might be that elders were likely to cope with innovative technology slowly while smallholders with a little number of cattle were not influenced to use cell phones in cattle market information seeking since they had little to be sold.

The other variables increased chances of smallholder's access to beef cattle market information via cell phones since they had positive signs implying that they had positive effects on the dependent variable, but average income of individual smallholder per year had no effect on access to beef cattle market information via cell phones since its β value was 0.

Table 8: Variables in the Equation

Covariates	β	S.E.	Wald	Df	Sig.	Exp(β)
Age of respondent	-0.028	0.025	1.260	1	0.262	0.973
Number of cattle owned	-0.025	0.014	3.096	1	0.078	0.975
Approximate distance to the nearest cattle market	0.057	0.018	10.088	1	0.001	1.059
Income per year	0.000	0.000	5.291	1	0.021	1.000
Access to information about beef cattle grades	0.429	0.682	0.397	1	0.529	1.536
Cattle sales volumes	2.396	0.868	7.620	1	0.006	10.979

information						
Ownership of cell phones	1.088	0.788	1.907	1	0.167	2.968

Source: Survey data (2014).

From the results in Table 8, approximate distance from home to the nearest cattle market had a significant impact on the likelihood of smallholder's access to beef cattle market information via cell phones (p = 0.001). Moreover, it is the same variable that had the biggest impact (Wald statistics = 10.088) of all other variables that were entered in the binary logistic regression model, followed by access to information about cattle sales volumes (p = 0.006) with a Wald statistic of 7.620. Average income per year had no effect on the response variable but showed a significant impact on the likelihood of smallholder's access to beef cattle market information via cell phones (p = 0.021) with a Wald statistics of 5.291. The other Wald statistics and their level of significance are as presented in Table 8.

The Wald statistics shown in Table 8 are also presented in Fig. 1 to illustrate the extent to which each of determinants contributed to the probability of smallholders in various settings having access to cattle market information by using cell phones.

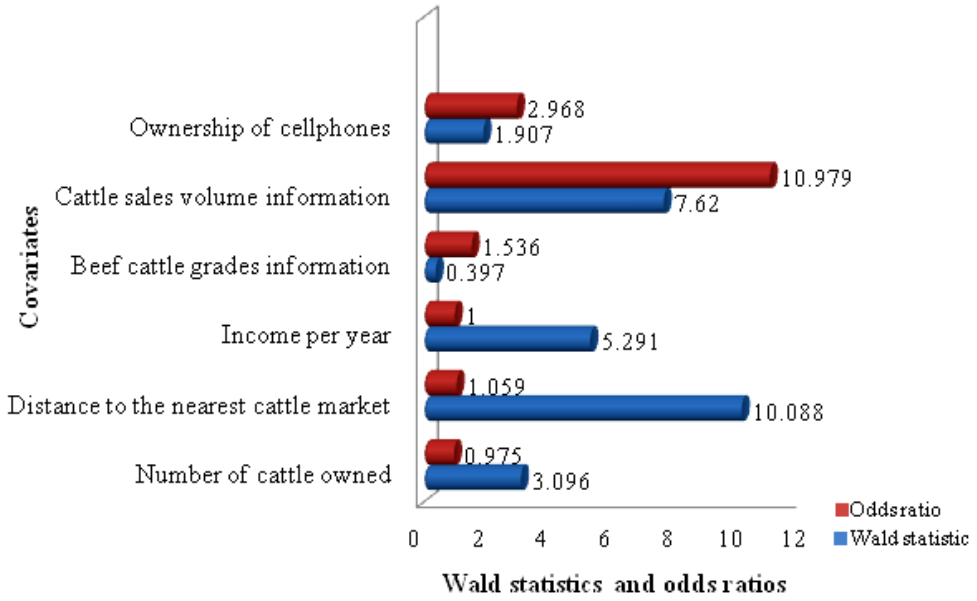


Figure 1: Contributions of independent variables to the odds of access to beef cattle market information via cell phones

Source: Survey data (2014)

According to the results presented in Table 8 and Figure 1, the most important variables that contributed highly to the use of cell phones increasing chances of getting access to cattle market information were approximate distance from home to the nearest cattle market, access to information about cattle sales volumes, and average income earned by the individual smallholder per year. The magnitudes of effects of other independent variables on the dependent variable (access to cattle market information via cell phones) are as presented in Table 8 and Figure 1.

In view of findings in Table 8, the chances of smallholders with different determinants of ages, income levels, distances, and different demands on the types of market information were not the same as indicated by the Exp (β), which measures the chances of access to beef cattle market information via cell phones among smallholders. The odds ratio is the natural log base, e, to the exponent, β, where β is the parameter estimate. The odds ratio is the predicted change in the odds for a unit increase in the corresponding independent variable. Odds ratios less than 1.0 correspond to decreases in the odds; odds ratios more than 1.0 correspond to increases in the odds.

In addition, an odds ratio equal to 1.0 means that the respective independent variable has no effect on the dependent variable; and an odds ratio close to 1.0 means that the respective independent variable almost has no effect on the dependent variable (Wuensch, 2008). Therefore, based on the results in Table 8, there is enough evidence to support that an increase in the information obtained about cattle sales volume demands from the different market places, increases chances of getting cattle market information via cell phone by a factor of about 10.979, controlling for other variables in the model.

CONCLUSIONS AND RECOMMENDATIONS

This study identified determinants of the use of cell phones to access beef cattle market information for smallholders in Mpwapwa District. The identified determinants include approximate distance from home to the nearest cattle market places, types of market information demanded (cattle sales volume and beef cattle grades applicable), income per year, and the ownership of the cell phones. This implies that smallholders who were located far from cattle market places could have been active participants in beef cattle market information sharing to enhance their bargaining power and decision-making using cell phone technology.

Other identified determinants were the level of network coverage, access to mobile banking (M-Pesa) services, and location of the smallholder beef cattle producer. Therefore, the study recommends that cell phones service providers should extend their services more in the rural areas of Mpwapwa District.

ACKNOWLEDGEMENT
Authors are grateful to the Enhancing Pro-poor Innovations in Natural Resources and Agricultural Value-chains (EPINAV) programme of Sokoine University of Agriculture for their financial support for this research. Authors are also indebted to beef cattle producers in the study area for their participation and cooperation during data collection.

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Domestic Cat (*Felis silvestris catus*) Urine Odour as a Potential Rodent Management Strategy

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Abstract: The aim of this study was to investigate the effects of cat urine *odour extract on rodent pest species to reduce crop losses. Cat urine from the captured cats was drawn using cat catcher. Urinary catheter was inserted into the urethra up to the urinary bladder and a syringe attached to the urinary catheter was used to draw urine which was stored in universal bottles at a temperature below -20°C. The stored cat urine was directly bound to the maize starch by slowly mixing the urine with the starch until dough was formed which was then granulated. The granules were dried at room temperature and packed in a tight closed jar. Mastomys natalensis of 25 – 40 g were used in this study. Wild captured individuals were acclimatized in a room for 7 days prior to experiment by providing them with food and water. The effect of cat urine odours on rodent pest species was studied in a single box. Camera traps were set at the top of each room in order to monitor rodents' activities. Our Findings suggests*

that cat urine odour has a potential to repel rodent pest species whereas female cat urine was more effective than male cat urine. However, more investigations are needed to evaluate its effectiveness under field conditions.

Keywords: rodents, rodenticides, crop losses, odours, repellants, cat urine, granules

INTRODUCTION

Rodent pest species are important agricultural pests causing severe crop losses. They have the potential to breed quickly and infest crops leading to serious economic damage (Mulungu, 2003). In Tanzania, damage to crops is largely attributed to *Mastomys natalensis* and the Nile rat, *Arvicanthis* sp, *Gerbilliscus* sp, *Lemniscomys* sp, and *Aethomys* sp. (Mulungu et al., 2006). The damage to maize crop can exceed 80% (Mulungu et al., 2003a) and 5 – 12% in rice crop, depending on season and location (Mulungu et al., 2014). The economic impact of rodent damage is high especially in small scale farms (Mdangi et al., 2013). The types of damage most often caused by rodents to crops in fields are: (i) destruction of seeds after sowing, and (ii) damage to stems of the mature crop (Mulungu et al. 2003b). Severe rodent damage to crops contributes to food shortage in rural communities of Tanzania, resulting in immediate financial loss.

The eruptive nature of rodent pest species raises serious concerns to farmers. Farmers control rodent pests using natural enemies, cultural techniques and killing by rodenticides. The most common method of reducing the size of rodent populations generally relies on lethal control methods, including the use of poisons (rodenticides) (Myllymäki, 1987; Mulungu et al., 2010). These methods, however, provide only a short-term solution. All too often removal of a rodent simply provides a space into which others from the surrounding areas may be drawn and the colony soon recovers and the problems posed by the rodents persist. Buildings rendered free of commensal rodent, for example, can be re-infested within a relatively short time (Kilonzo, 2006; Mulungu et al., 2010). The development of resistance to the most commonly used rodenticides has led to the introduction of more toxic variants. These variants currently pose a risk to non-target species and therefore, their use is strictly regulated. Thus the options for controlling rodent populations steadily decrease while conflict still remains.

The drawbacks of this method of rodent management suggest the need for an alternative approach. Humane, effective and environmentally acceptable approaches to rodent population control therefore, need to be developed, techniques that in the longer-term, will limit the growth and development of problem populations to levels where the problems posed are not economically

significant. Such techniques could either be used in isolation or be used to improve the efficacy and efficiency of current control techniques and thereby reduce the risks posed to non-target wildlife. Chemical repellents signals could produce an immediate avoidance response in rodent pests by restricting the growth of rodent populations in an area.

Potentiality for synthetic predator odors as repellents for different preys has been reported on the efficacy of various raw predator odors and extracts as feeding repellents for deer (Abbott et al., 1990; Swihart et al., 1991), elk (Andelt etal., 1992), and sheep (*Ovis aries*) (Arnould and Signoret, 1993). In addition, several studies support the hypothesis that predator odors also function as kairomones (interspecific chemical signals) for prey species that perceive the odors as "danger" signals and warn them that a predator is nearby. Perception of predator odors is thought to elicit a "fear-of-predation" response in prey animals which, in turn, causes the animal to seek out alternative, less threatening habitat (Abbott et al., 1990). Responses of rodents to predator's odor have been variable, including changes in habitat use, shifting of activity time and delaying maturation. Anti-predator behaviour therefore, can affect the fitness of individuals and the dynamics of population.

Therefore, if feasible using the cat urine odour will be an added tool to protect farmers' crops in fields and increase the economy. Little is known about whether predator-specific risk assessment and response could work as a rodent pest management strategies. This study aimed to investigating the effects of cat urine odour extract on rodent pest species activities to reduce crop loss.

MATERIALS AND METHODS

Trapping of cats

Urine from domestic cats (*Felis silvestris catus*) was used as a source of predator chemical cues. These cats normally hunt rodents and have rodents as part of their diet. Baited cages were set in evening and checked in the morning. Captured cats were brought at Sokoine University of Agriculture, Faculty of Veterinary in cages and kept in kennels where they were given adequate food and water. The cats in the kennels were caught using cat catcher and anesthetized by intramuscular injection of Xylazine and Ketamine hydrochloride. Urinary catheter was inserted into the urethra up to the urinary bladder. A syringe attached to the urinary catheter was used to withdraw urine into universal bottles. Therefore, freshly cat urine samples were frozen and stored in -20°C and transferred to Muhimbili University of Health and Allied Sciences, Institute of Traditional Medicine for cat urine extract production.

Cat urine extract
Stored cat urine was directly bound to the maize starch by slowly mixing the urine with starch until dough was formed. Granulation machine was used to form granules from the dough and were dried at room temperature and packed in a tight closed jar.

Rodent trapping
Wild rodent species of *Mastomys natalensis* 25 – 40 g was captured from field. This species was used as a model because is a major rodent pest species in sub Saharan African countries including Tanzania (Massawe et al., 2011; Mulungu et al., 2013). One Sherman LFA live trap (8×9×23 cm; H.B. Sherman Traps Inc., Tallahassee, FL) was placed at a distance of 10 m apart, for three consecutive nights. The traps were baited with peanut butter, mixed with maize bran/maize flour and were placed in the afternoon and inspected in the morning of the following day. The captured individuals were acclimatized in a room for 7 days prior to experiment by providing them food, which was maize grains and water.

Rodent activity study
The effects of cat urine odours upon *M. natalensis* were studied in a single box, which had two inner participations rooms similar to Y-maze set up. Rodents were released at the middle room and able to choose where to go either in room with or without cat urine. The camera traps were hanged at the top of each room with and without cat urine extract in order to monitor rodents' activities and visitations. Ten animals (5 females and 5 males) were released in the box's room. Maize grains, water and cat urine extract were available in the first room while the second room only maize grains and water were present. Both cat urine extract from females and males cats were tested to rodents' behavioural response separately. This built a comprehensive picture of the impact of cat urine odours on the physiology and behavioral of individual animals.

Data analysis
To determine whether *M. natalensis* in a room with or without cat urine extracts bias or equal, we counted the number of visits to each room and compared the two using percentages and graphs.

Results
Results show that the number of visits to rooms with or without cat urine extract and cat sexes were different. Results indicate that only 333 (6.8%) frequency visit activities were recorded in a room with female cat urine extract while 4564 (93.2%) were recorded in a room with no female cat urine extract. For male cat urine extract, 8283 (33.9%) frequency visits were recorded in a

room with cat urine extract while 16150 (66.1%) frequent visit was recorded in a room with no cat urine extract.

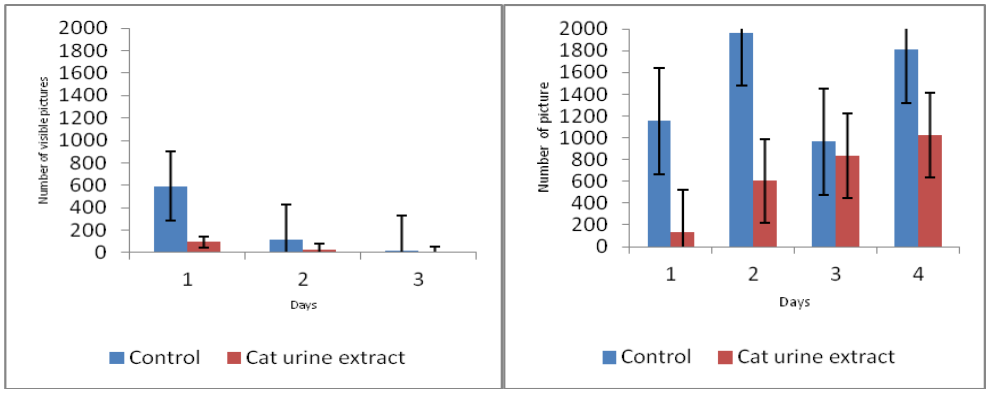


Fig. 1: Effectiveness of cat urine extract of (a) female cat urine extract, and (b) male cat urine extract

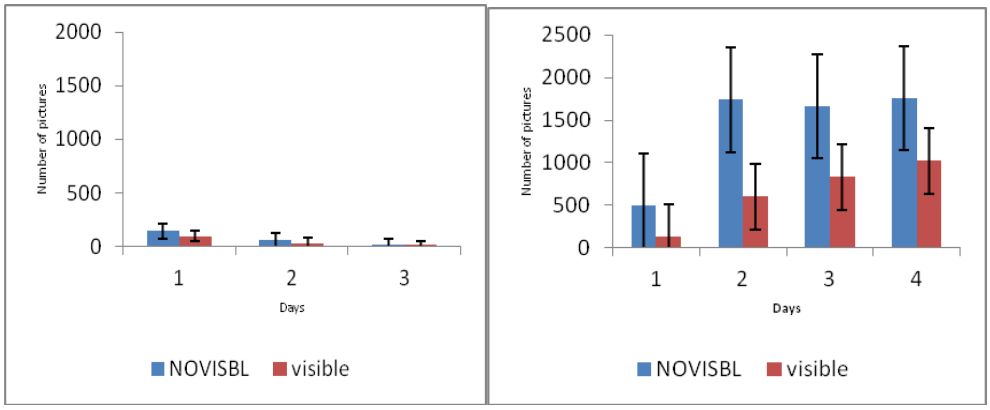


Fig. 2: Effectiveness of cat urine extract over the type of picture against (a) female cat urine extract, and (b) male cat urine extract.

Therefore, female cat urine extract was more effective in repelling rodents than male cat urine extract indicated by few pictures recorded in a room with female cat urine extract compared to more pictures observed in room with male cat urine extract (Fig. 1). Similarly, male cat urine extract produced higher number of both visible (pictures with complete individual rodent body) and invisible (pictures with incomplete individual rodent body) pictures as compared to female cat urine extract (Fig.2).

DISCUSSION

Our results indicate that cat urine is able to effectively repel *M. natalensis* which is a major crop pest in sub Saharan Africa. *M. natalensis* were able to detect the odour of their predator cats. Prey species show specific adaptations that allow recognition, avoidance and defense against predators. For many mammalian species this includes sensitivity towards predator-derived odors. The typical sources of such odors include predator skin and fur, urine, feces and anal gland secretions (Abbott et al., 1990; Arnould and Signoret, 1993). In the current study therefore, *M. natalensis* has shown to ovoid cat urine extract with evidence that the room with food and cat urine extract had significantly less activities than the room without cat urine extract. This indicates that *M. natalensis* were repelled by cat urine extract consequently their activities declined. Avoidance of predator odors has been observed in many mammalian prey species (Abbott et al., 1990; Swihart et al., 1991; Andelt etal., 1992, Arnould and Signoret, 1993).

It has been reported that predator odors have distinctive behavioral effects which include (i) inhibition of activity, (ii) suppression of non-defensive behaviors such as foraging, feeding and grooming, and (iii) shifts to habitats or secure locations where such odors are not present. This has also been shown in the current study where non-visible pictures were less in the room with cat urine extract. It seems that animals were looking space to escape in a room that is a reason where invisible pictures were observed. Most of animals were freezing in a corner of room without cat urine extract (Own observation), which is often used to measure fear (Fendt and Fanselow, 1999; Wiltgen and Fanselow, 2003; Sullivan et al., 2004), indicating avoidance behavior. Furthermore, flat back approaches (Own observation), a form of risk assessment (Blanchard et al., 1990), were observed only in the room with cat urine extract although this was not measured in the current study.

Similar observation has been reported for both raw and synthetic materials of urine from wolf, coyote, fox, bobcat, lynx, and wolverine, feces from lynx and bobcat, and weasel anal gland secretions were the most effective materials for suppressing snow shore hare feeding (Sullivan and Crump 1986). Generally, several predator odors as repellents have shown potentiality as feeding repellents for prey (Sullivan, 1985). Interesting, cat urine extract from female has been observed in the current study to be more effective to repel *M. natalensis*. This therefore needs to conduct further studies to determine the different in two urines. Female lions, for example, do the hunting for their prides being the main role of the males is to protect the pride and defend against foreign male lions who will often try to overthrow him in order to gain access to the females and resources. Therefore, it is likely that *M. natalensis* perceive more quickly the female cat urine odour due the effectiveness in hunting.

CONCLUSION

Our Findings suggests that cat urine odour has a potential to repel rodent pest species. Using rodent repellent in handling rodent problem might be considered scientifically sound, more humane and convenient as compared to using rodenticides and rodent traps. Nevertheless, results from the current study is inconclusive and therefore more investigations are needed to evaluate its effectiveness under field condition, application methods, states of the synthesis product (either in liquid, gel or powder), and under high population.

Acknowledgement

We wish to express our appreciation to the Pest Management Centre staff for their excellent laboratory assistance, especially from Khalid S. Kibwana, Shabani Lutea and Ramadhani Kigunguli. This work was supported by the Commission for Science and Technology (COSTECH).

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Commercial Seaweed Farming in Zanzibar Coastal Villages: Potential for Innovative and Competitive Economic Growth

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Abstract: *The study was on "Commercial Seaweed Farming in Zanzibar Coastal Villages: Potential for Innovative and Competitive Economic Growth". It aimed at assessing the competitive potential of Zanzibar seaweed farming for the purpose of improving the crop commercial aspect. The study assessed business management capacity; economic return; business model and level of value addition initiatives on seaweed farming. It applied both descriptive statistics and regression analysis in order to achieve results.*

This study was conducted in Unguja and Pemba Islands, Zanzibar, Tanzania. The study applied survey design using structured questionnaire. Questions and variables were tested by interviewing a small sample of farmers prior to commencement of enumerators' training. A minimum sample of 400 respondents were picked out of 23,000 farmers through the application of Slovan's formulas (n = N / (1 + Ne2). However, the study managed to interview 592 farmers from 48 seaweed producing villages. Systematic random sampling was used to pick villages and interviewed farmers were randomly selected.

The study found that farmers were significantly not realizing economic returns due to most of production being below breakeven point (1,439 kgs of dry seaweed per cycle). This is contributed by various constraints such as small farm size, lack of technology, and low innovation up scaling and low entrepreneurship skills. The industry is not linked to multi stakeholders (e.g. Financial Institutions, Research, Science and

Technology) and as a result it lacks support from other sectors due to farmers consistently dependence on exporters for seaweed market (Farmer-Exporter Model). Value addition activities in seaweed farming lack scaling up mechanisms compared to other seaweed producing countries such as the Philippines, Indonesia and Solomon Islands. Despite the challenges, there is still potential for commercializing Zanzibar Seaweed farming and that the sector is key for competitive economic growth if: development of seaweed policy and strategic plan are developed; entrepreneurship, research, technology and innovative up scaling system are promoted; mult-stakeholder business model is enhanced; youth and men are engaged in seaweed farming; and access to seaweed market information and financing are increased.

Key words: business model, seaweed, innovation, competitiveness

INTRODUCTION

Zanzibar began exporting seaweed as early as 1930s when the red seaweed, under the genus *Eucheuma*, was harvested from the wild and exported to Europe (Mshigeni, 1983, 1992; Msuya, 2012). However, commercial seaweed farming started in 1989, following initial experiments by Professor Keto Mshigeni of University of Dar-es-salaam (UDSM). In early 1990s the crop was exported to different parts of the world including France, USA and Denmark. According to Zanzibar Socio-Economic Survey (OCGS, 2013), until the year 2012 seaweed production for export arrived at the maximum of 15,087 tons per annum, but the industry experienced fluctuation in its productivity in 2004 and 2006 where productivity went down to 8,000 tons per annum due to climate change and diseases.

Until recently, the largest part of seaweed produced has been exported unprocessed. The crop also experienced low scale of value addition initiatives in terms of processing until early 2008's where value addition initiative began under Zanzibar Seaweed Cluster Initiative (Msuya 2011; Msuya et al, 2014;). Currently a small fraction of the produced seaweed is transformed into powder which assumes higher value compared to former unprocessed one. For instance 1kg of seaweed powder is sold at TZS 10,000/= (USD 6) compared to a TZS 500/= (USD 0.3) for 1kg of raw seaweed (Msuya, 2011a). However, the challenge is how to upscale value addition initiatives in order to accommodate both local and international market demands. Therefore, seaweed sector requires not only increased production for high export volume but also embracing value addition initiatives for increasing crop economic returns and farmers income.

Conversely, seaweed farming has been shown to be a substantial provider of socio-economic development to people of marginalized coastal communities in Philippine, Indonesia, India and Solomon Islands (Valderrama, 2013). The industry proves to be an alternative strategy for increasing enterprise revenue, personal income, country economic growth and poverty reduction in coastal villages and towns.

Comparatively, if well managed, Zanzibar seaweed sector can be an effective commercial activity for improving economic growth and poverty reduction for people living in coastal areas due to its simple farming process, short time farming cycle, requirement of low capital, use of inexpensive technology, provision of frequently- stable cash flows and can be used as gender empowering tool.

In addition, Zanzibar seaweed sector is estimated to employ over 23,000 farmers, 80 percent of whom are women. It also holds the first position among marine export produce, and a second position among the foreign currency earning crops (RGoZ, 2005; MACEMP, 2009; RGoZ, 2010; Msuya, 2011a; MANR, 2011; Msuya et al, 2014).

Despite its contribution, commercial seaweed farming in Zanzibar is largely untapped and has not brought the desired results on income to the level of poverty reduction to the people living in coastal villages. The sector is dominated by smallholder farmers, subsistence agriculture, and infancy agribusiness sector. In addition the dried seaweed produce has been experiencing low price compared to other seaweed producing countries. It also faces deficiency for input supply, poor diseases controlling techniques and poor enterprise management. However, based on these facts, need to commercialize the sector in order to enhance the crop contribution to economic growth and reduction of poverty for people living in coastal villages is paramount. This study therefore assesses competitive potential of seaweed farming for economic growth and poverty reduction for people living in Zanzibar coastal villages.

Material and Methods

Study covered all Regions of Zanzibar namely Unguja North, Unguja South, Urban West, Pemba South and Pemba North. It included four Districts of Unguja; North A, North B, South and Central, the three Districts of Pemba; Micheweni, Wete and Mkoani (See Map below), the study took a period of two years between September, 2013 to September, 2015.

Survey and data collecting instruments were designed and facilitated by collaborating institutions Zanzibar Institute of Financial Administration (ZIFA), Institute of Marine Science (IMS) and Zanzibar Business and Academic Consultancy (ZABACO). This stage involved extensive consultation with seaweed farmers and extension officers (experts) from Ministry of Fisheries and Livestock.



Figure 1: Map of Research Study Area

Structured questionnaires with mainly closed questions aligned with study objectives, research questions, concepts and constructs were tested by interviewing small sample of farmers' prior to commencement of enumerators' training. The rationale for testing the questionnaire was to ensure the logic and authenticity of questions to be asked. The sample frame was estimated from list of farmers amounting to 23,000 people. The

study, however, managed to interview 592 farmers from 48 seaweed producing villages with an average of 12 interviewees per location. Systematic random sampling was used to pick respondents from list of farmers in each village.

The completion of field work initiated data processing exercise which involved a set of tasks taken to ensure validity of information. The first task was designing CSpro 5.0 entry form which was used for data entry. In this case, raw data contained in the questionnaires were converted into electronic data and transferred to Statistical Package for Social Science (SPSS) version 20 for screening and analysis based on instruction provided in dummy table.

This study applied breakeven point and regression model analysis to find out economic returns of seaweed farming enterprises. The processes to find breakeven point and regression model were as shown in the following section:

A. Breakeven Point Analysis

a. Formula

[BEP = (TFC) / (SP - VC)]

Where;

BEP- Break Even Point

TFC- Total Fixed Cost – Short run

SP- Selling Price/Unit

VC- Variable Cost/Unit

Establishing Fixed Cost Figure

In order to calculate total fixed costs of all assets used by farmers, the following guidelines from the field and FAO have been considered as input (see Table 2.1 for details). Average farm size contains 756 ropes; One year contains seven cycles; Every farmer has one fibre boat costing $260 (TZS 436,800/=) at conversion rate of 1USD: TZS1,680 with five year economic life; A farmer can harvests 10 lines per trip and it is possible to harvest 10 lines of mature seaweed every day; Every farmer has 5 drying racks; Plastic cover for protecting seaweed during rainy season; 5 drying rack occupying total area of 60m2 (12m* 5m); One line utilizes two (2) pegs; and One farming cycle = 45 Days.

Table 2.1: Annual Estimated Fixed Assets Cost

Equipment	Counts	Unit Cost (TZS)	Total Cost (TZS)
Fibre Boat	1	436,800/5	87,360
Drying Rack	(5*1.5) =7.5m	5000	37,500
Plastic Cover	12m*5m	1000	12,000
Pegs	756*2=1512/50	3000	90,720
Rolls of ropes	((756*10) /82) m	4500/2	207,439
Total Fixed Costs			**435,019.00**

Establishing Unit Selling Price Figure
Selling Price per Unit Kilogram of dry seaweed: Spinosum TZS 500/=

NB:
This study used Spinosum species as principal variety for calculation and bases of discussion because the variety attract a majority of farming population in Zanzibar. Although cottonni" variety of seaweed commands a higher farm gate price than the "Spinosum" variety, Spinosum is more widely grown within the country at present than cottonni which faces the die-off problems (Crawford and Shalli, 2007) The authors believe that if innovative practices are engaged on this variety, significant economic impact will be realised.

Establishing Variable Cost Figure
One farm per cycle fixes 756 ropes
One rope (10m) contains 30 nodules, each nodule reach 1.5 kg to time of harvest.
Conversion of wet to dry seaweed is 10:1 that is (756*30*1.5) =34,020 kgs wet seaweed.

Note: 10kgs wet seaweed =1kg dry seaweed then 34,020 kgs is equal to?
(34,020*1)/10=3,402 kgs
Total Variable Cost per cycle = (Material Costs + Labour Costs)
(TZS 272,070/= + TZS 401,200/=) = TZS 673,270/=

Variable cost per unit Kilogram = (673,270/3,402) = TZS 197.90/=
Total variable cost per unit is TZS 197.90/=

b. Calculation;
BEP = (TFC) / (SP - VC)
(435,019)/ (500-197.90) = 1,439.98 kg of Dry seaweed

Not only Break Even Point but also Regression Analysis model was developed to approve the most contributing factors to quantity sold.

B. Regression Analysis
Linear regression was an approach for modelling the relationship between dependent variable Quantity sold and independent variables Farm size (Fs), Age (Ag) and Experience (Ex). The study tested the relationship between dependent variable Qs and the independent variables Fs, Ag and Ex for the purpose of determining the effect of independent variables on Quantity of seaweed at selling point. The study assumes that, independent variables explain dependent variables, however, the running of the regression analysis established the following model;

Regression Model: [Qs = 0.097 Fs + 8.1 Ag+ 1.25 Ex]

Where;

Qs = Quantity Sold = (Sales/Price)
Fs = Farm Size
Ag= Age
Ex= Experience

Quantity sold (Qs) represents the quantity of dry seaweed at the point of sale, Qs obtained by dividing Sales by Selling Price (Sales/Price). Farm size (Fs) represents the number of ropes which automatically determine the quantity of seaweed produced, while Age (Ag) represents the stage of human life in relation to family size, and Experience (Ex) represents the number of years a farmer engaged in seaweed farming. After running the regression analysis the following results were obtained.

RESULTS AND DISCUSSION

Key findings of the study include farmers profile, business management capacity, economic return, social economic benefit, business model and value addition initiatives.

Farmers' Profile

The study found that 77.5 percent of seaweed farmers are women. It revealed that 67.1 percent of farmers are aged between 36-60 years. Also it was revealed that, 42.6 percent of farmers had not attended formal education while more than half (54.6%) had 10 years' experience in the industry (Table 3.1). This implies that Zanzibar seaweed industry is female dominated and attracts less young generation. About half of the farming population have not attended formal education and conduct farming activities based on long term experience, Table 3.1 below shows the details.

Table 3.1: Respondent's Education Level

Education Level	Frequency	Percent
Degree	1	0.2
Diploma	3	0.5
Certificate	4	0.7
Secondary	196	33.1
Primary	136	23
None	252	42.6
Total	**592**	**100**

Business Management Capacity

On assessing the famer's capacity to carry out business activities, the study found that 44.49 percent of the farmers are good in traditional seaweed planting technics. Only 28.1 percent of farmers had sales and marketing skills, 25.1 percent of farmers had entrepreneurship skills, and 2.38 percent of them possessed financial management skills.

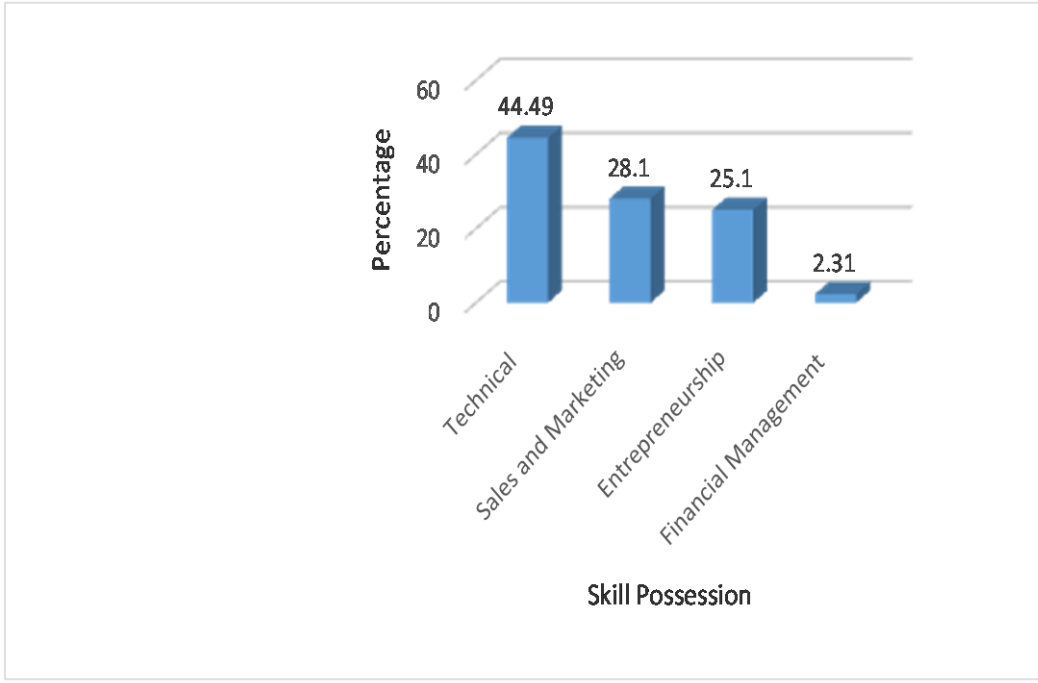


Figure 3.1 Farmers' Skills Profile

This situation indicates that the farmers had low ability to think entrepreneurially and are able to apply business techniques to improve the business of seaweed farming. Therefore, seaweed farming in Zanzibar is not commercially run as signified by presence of very low entrepreneurship and capacity to manage their enterprises commercially. See figure 3.1 for summary.

3.1 Economic Return

On the assessment of whether seaweed brings back returns on investments and whether which are the most influencing factors to higher profit as a result of high quantity sold, the study showed that 42.7 percent of the farmers make sales of dry seaweeds below TZS 100,000/= per farming cycle (45days) as shown in the table 3.2. This level of sales is not adequate for covering living and farming costs. There are many factors which have contributed to this low sale, among them include; various farming constraints for instance, lack both

sea and in-land transport facilities (81.9%), poor storage facilities (58.3%) and inadequate drying facilities (66.9%) resulting low return, productivity and price, Table 3.2 below illustrates. To further approve the extents of economic return on seaweed farming the study calculated the Breakeven Point to realise the actual cut-off point for one to realise returns and in addition to that it developed a Regression Model to realise the most influencing factors towards higher sales. The results are as shown in Table 3.2

Table 3.2: Range Of Sales Per Cycle

Range of Sales (TZS)	Percent
<100,000	42.7
100,000-249,0000	27.0
250,000-399,000	13.5
400,000-549,000	8.3
>550,000	8.4

Breakeven Point Analysis

The calculated breakeven point was 320 ropes per farmer equivalent to 1,439 kg of dry seaweed per cycle (45 Days) which is equal to a sale of TZS 719,500/= at price of TZS 500/= per kg. Moreover, varies conversions indicated the breakeven point in kilogram of wet seaweed is 1,439kgs *10 =14,390 kgs; and in sales is I, 439 kgs*TZS 500/= TZS 719, 500/=

The findings show that only 8.4 percent of farmers made above the breakeven point. In this case, large number of seaweed producers sale below breakeven point. For them or their enterprises to realise profit, they are forced to increase the size of their farms (ropes) or manage other deficiencies to get high quantity of sale. However, engagement into value addition is the most possible way for them increasing produce value in order to achieve higher prices.

Regression Analysis

The results of regression model analysis were categorised as follows:

Result 1: The Analysis of Model Strength

The result shows that the model was statistically adequate in approving the existence of relationship between dependant and independent variables. Referring to adjusted R^2 the model showed that independent variables explain dependent variable by 63.1 percent. Table 3.3 Summaries Model Strength.

Table 3.3: Model Summary

Model	R	R Square[b]	Adjusted R Square	Std. Error of the Estimate
1	.796[a]	.633	.631	377.36502

a. Predictors: Experience (Ex), Farm Size (Fs), Ages (Ag)
b. For regression through the origin (the no-intercept model), R Square measures the proportion of the variability in the dependent variable about the origin explained by regression. This cannot be compared to R Square for models which include an intercept.

Result 2: Significance of the Model

The interpretation of the analysis of variance (ANOVA) indicates that independent variables have implication on the dependent variable and that the model is significant. In table 3.5 the results of analysis imply that the model is significant because the value of significance is 0.000 and at least there is one independent variable explaining the dependent variable. Table 3.4 indicates the analysis of variance (ANOVA).

Table 3.4: Analysis of Variance (Anova A, B)

Model		Sum of Squares	Df	Mean Square	F	Sig.
Regression		138903820.421	3	46301273.474	325.139	.000[c]
1	Residual	80458460.579	565	142404.355		
	Total	219362281.000[d]	568			

(a) Dependent Variable: Quantity Sold (Qs)
(b) Linear Regression through the Origin
(c) Predictors: Experience (Ex), Farm size (Fs), Ages (Ag)
(d)This total sum of squares is not corrected for the constant because the constant is zero for regression through the origin.

Result 3: Effect of Coefficients on Dependent Variable

As it is indicated in the ANOVA table above, the regression model showed at least one independent variable that explain the dependent variable. In the case of analysing the coefficients the model goes further explaining the relationships between independent and dependent variables. The results in the regression model indicate that only Farm size (Fs) and Age (Ag) have effects on the dependent variable as they possess 0.000 significance values. On the other hand independent variable-Experience (Ex) does not have direct effect on dependent variable - Quantity sold (Qs) as its significance value is

greater than zero (1.25). Therefore, by suppressing (Ex) i.e. removing it from the regression equation the model is reduced to; [Qs = 0.097 Fs + 8.1 Ag].

Result 4: Interpretation of Coefficients

Farm Size: Results indicate that the effect of adding one unit of Farm size on Quantity sold is 0.097 kgs. Despite the famer's efforts to increase farm size, yet the Quantity sold is low. This little effect of farm size on Quantity sold is attributed to inefficiencies in the whole value chain of seaweed farming. Inefficiencies include high levels of die-off due to impact of climate change; drifting of seedlings due to sea waves; poor techniques in harvesting, transportation, drying and storage. These factors determine the amount of dry seaweed sold at the point of sale and therefore affecting farm economic return and the amount of seaweed the farmer's sales at the final market.

Age: Results indicate that effect of age on Quantity sold is 8.1. This means age contributes more than farm size. The main reason being that, 67.1 percent of seaweed farmers have middle to upper age between 36 to 60 years, hence, categorically, people of this age group have extra capacity in terms of increased number of family members critical for cheap labour supply.

Availability of cheap labourers encourages large farm size cultivation which then reveals high levels of quantity produced and sold to the market. This regression result concurs with the study finding that 75 percent of seaweed farmers use family labour for production which suggests low cost of production and automatically influence high quantity of seaweed produced and sold in the market. Table 3.5 shows details.

Table 3.5: Coefficients (A, B)

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	Farm size (Fs)	.097	.009	.320	11.062	.000
	Ages (Ag)	8.105	.900	.568	9.009	.000
	Experience (Ex)	1.298	2.863	.028	.453	.650

(a) Dependent Variable: Quantity Sold
(b) Linear Regression through the Origin

The results of regression analysis concur with the results of breakeven analysis on the fact that Zanzibar seaweed farmers realize low economic return compared to investment. Despite the fact that farmers can increase their farm size they will still realise low returns. Therefore, in order to increase quantity sold they need to invest in labour intensive mechanisms of which under normal circumstances is not realisable. Suggestions are, therefore, to encourage technology and Innovation up scaling systems to enhance high productivity levels for higher returns.

3.2 Social Economic Benefits

In evaluating the revenue impact of seaweed on social economic development, results on this study show that 68.2 percent of the farmers regard seaweed as dependable income generating activity. On expenditure basis, study revealed spending priorities on the income generated from seaweed as follows: Food received first priority among the five categories of expenditure (26.82%), Health occupied the second position (25.02), investment took third position (17.26%), the fourth was education which took (16.76%) and the fifth was investment on housing which took (14.14%). Figure 3.2 summarise the details.

Results also imply that, seaweed farmers spend their income mostly on food and health. Less priority is given to economic investment, education and housing. This situation signifies that income generated out of selling seaweed produce was much spent on social needs rather than economic development, which is an indication of poverty and that seaweed income is for fighting food security. In addition, the situation undermines sectorial growth and development as a result of low priority recapitalizing on the enterprise asset accumulation making the sector un-attractive to youth employment.

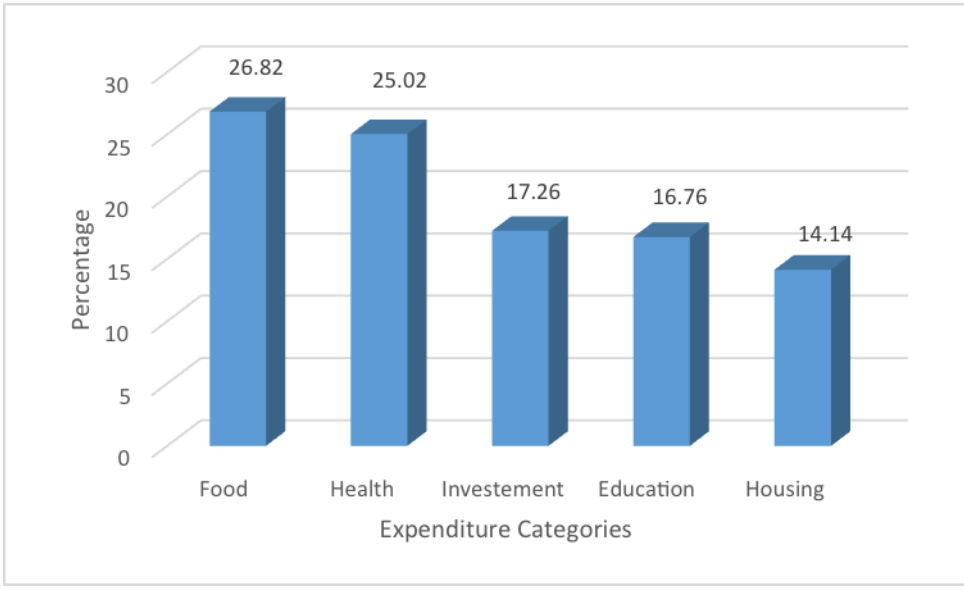


Figure 3.2: Priority on Income Expenditure

Moreover, in support to this idea, results indicate 92.6 percent of farmers had supplementary economic activities other than seaweed farming just to increase extra income and cope with life hardships. These economic activities include Agriculture (65.7%), Retail business (21.5%), Fishing (18.4%), Handcraft (14%), Livestock (12.5%), Tailoring (4.6%), Employees and Stone quarries (2.4%) and Carpentry (1%).

3.3 Business Model

In trying to assess how Zanzibar seaweed sector is supported and interlinked with technical know-how of the business, the study identified the influence of technical institutions and other sectors supporting services on growth and development seaweed farmers or their enterprise. The study found that 97.3 percent of farmers' depend on exporters for selling their produce while 71 percent of farmers' access market information through exporting companies. This situation shows that exporters are major buyers and have monopoly on market information and sector growth and development.

It was revealed that key partners in Zanzibar seaweed industry include; Ministry of Fisheries and Livestock, Cooperative Society, Exporting companies, Research Institutions (Institute of Marine Science), Local executive offices and Retail suppliers.

Each of these partners had role to play in promoting growth and development of Zanzibar seaweed industry. However, majority of these institutions had weak bonds with the sector except for exporters who have dominated the roles

of various stakeholders. Figure 3.3 portrays existing and ideal farmer entrepreneur business models.

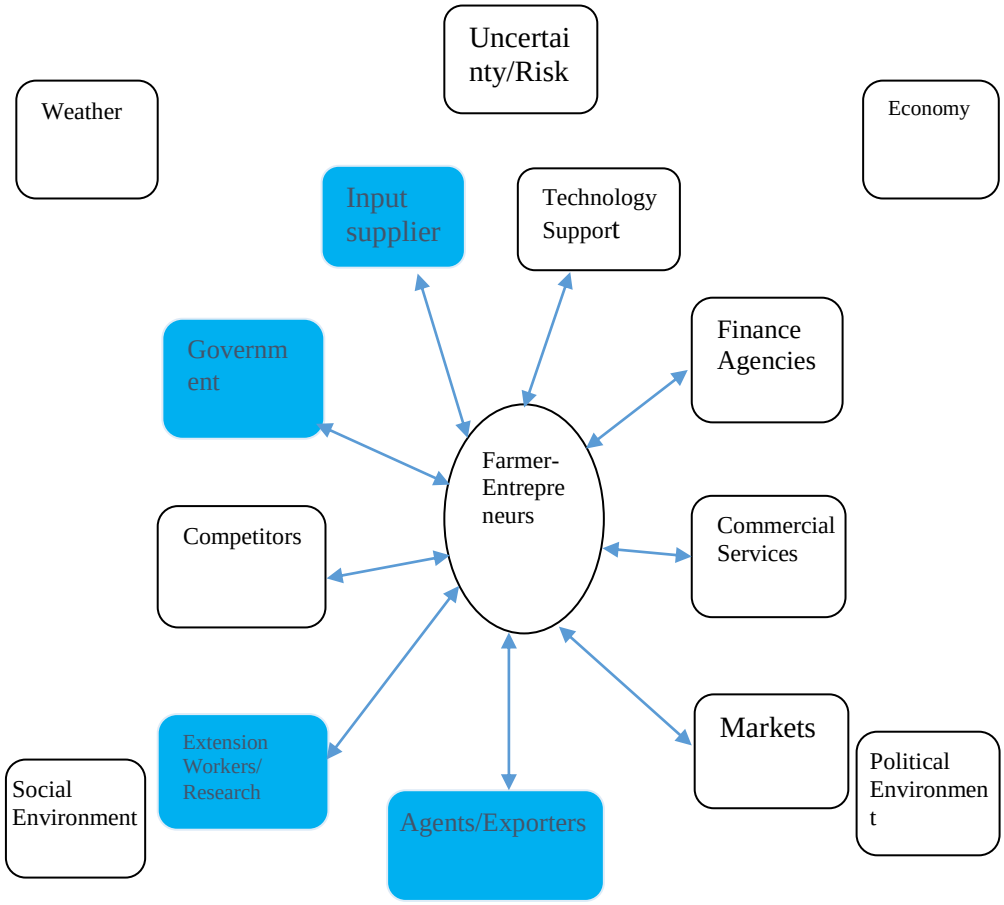


Figure 3.3: Farmer Entrepreneur Model
Source: Modified from Kahan (2013)

The highlighted boxes represent the existing Zanzibar seaweed farming business model while the whole figure represents an ideal farmer entrepreneur model, that is to say how a farming entrepreneurs should be linked with other actors in the sector. The highlighted boxes (Blue Coloured) connected with arrows to the farmer entrepreneur indicate the existing interlinks in Zanzibar Seaweed farming, while all boxes (Blue and White Coloured) indicate the required interlinkage. The peripheral boxes represent external factors influencing the sector and the rest players.

The only implication we get when comparing the two models, is that, Zanzibar seaweed business model involves few players as demonstrated by a short value chain (Farmer – Exporter), this type of model represents low linkage of the industry with technical know-how and other sectors of economy. The industry is dominated by exporters and facing daunting challenges for which solution can be obtained from other sector actors, such challenges include; shortage and unavailability of quality seedlings (90.4%) – Ministry of Agriculture and Fisheries, inadequate capital (90.2%) for expanding the enterprise- Microfinance Banks and high cost (80.9%) of inputs – Ministry of Trade. Inadequate extension services signified by (70%) of farmers not able to access the service- Ministry of Agriculture and Fisheries, otherwise, there are few farmers (36.7) who are members of cooperative societies- Ministry of Cooperatives and Economic Empowerment and others.

3.4 Level of Value Addition

Innovation and supply chain coordination are two approaches applied for defining value addition in agricultural value chain. In a nut shell, innovation is a process of translating an idea or invention into a good or service that creates value for which customers will pay for (Schumpeter, 1930). On the other hand, supply chains is a system that is composed of numerous activities spread over multiple functions and organizations (Khatib, 2000 and Arshinder and Deshmukh, 2008).

In assessing this aspect, study determined level of value addition by considering innovation and coordination processes occurring in the seaweed sector. It focuses on techniques and farming procedures, product processing, market opportunities, distribution channels and forms of business organisations within seaweed sector.

Results indicated that 70 percent of farmers did not apply value addition techniques in farming procedures and neither of product processing, new channels of distribution, and exploitation of new market opportunities was tried. Generally there is poor specialization as almost all farmers only concentrates on farming leaving other chain activities not attended. The following is specific explanation of each value addition (Innovation) component.

Farming Procedures

Adoption of new farming procedures is critical in attaining productivity and managing cost of farming. The study revealed 26 percent of farmers applied techniques for planting seaweed in different water levels and directing farms to avoid breaking and drifting of seaweed by sea waves. Others farmers located in stony geographical areas of the sea land tied ropes on rocks instead

of using pegs. Cost reduction was vital for increasing revenues and profit to seaweed producers. Observation showed that farmers did not apply cost reduction strategies due to limited basic knowledge in production economics and financial management. For instance, farmers drag 25-30 kgs of wet seaweed from plantation to off-shore while it could be less costly to carry 400 kgs of wet seaweed by plastic canoe (Kihori) at a time (See Photo Below).



Product Processing

Processing assists in transforming seaweed produces into various forms of products. In order to simplify transformation, adoption of simple technologies is required. Despite low development of small manufacturing industries in Zanzibar, there is little linkage between the manufacturing sector and seaweed farming. This situation brings low impact into seaweed processing as evidenced by only 2.7 percent of farmers engaged in processing, meaning that large volume of seaweed is exported in raw form resulting to farmers earning lower prices. For instance 1Kg of raw dry seaweed is sold at TZS (300-500)/= while the same weight of seaweed powder is sold TZS 10,000/- (Msuya, 2011a).

Market Opportunities

Identifying markets for seaweed products is an aspect of consideration for assessing farmer's ability in applying value addition techniques. Spotting market opportunities assist seaweed farmers to create demands for the produce. The results of study indicate only 0.3 percent of farmers had ability to spot additional market openings within and outside Tanzania. It is fact that, in Tanzania farmers failed to spot local markets and demand for seaweed materials for food processors, manufacturers and individual citizens. Instead, farmer's sale dry seaweed to exporting agents as solely market for their

produce. This situation weakens farmers' bargaining power as they continue to rely on local exporters for sale and inputs supply. This is different from Indonesia where the market system extends from farmers to middlemen to district trader to whole seller to/or manufacturing companies (Zamroni, et al ,2011)

Distribution Channels

Distribution channels are key for ensuring movement of seaweed from farm to final consumers, therefore an effective distribution channel requires not only enough number of players but also well-coordinated value chain system. The current trade relationship of Zanzibar seaweed sector is largely limited to farmer – exporter model, which brings low interaction of seaweed farmers with other stakeholders. In that case, an ideal seaweed farmer is supposed to identify various distribution channels for increasing bargaining power on price. Up to now, Zanzibar seaweed farmers have stuck to only one distribution channel (Producer-Wholesaler) which deprives their opportunity to use other profitable channels like connecting with manufactures. These challenges are results of weak seaweed farmers' cooperatives which fail to play their critical role of linking farmers with various stakeholders and improve farmers' bargaining powers for competitive prices and access to financial services. Experience from other countries show farmers organizations help farmers in price bargaining and credit linkage (Rathsman, 2014).

Business Organisations

A business organisation could be an individual or group of people who collaborate to achieve a certain commercial goal. In Zanzibar seaweed sector, there are few enterprises specializing in various seaweed value chain activities. The study found that only 0.7 percent of farmers knew the existence of other forms of specialization that could engage in, therefore, a need to build enterprising and enterprise specialisation is paramount.

Observations indicate that farming is the main form of organization that consists of large number of people. Other forms of business specialization that include storage structures, manufacturing, financing and input supplying are very weak and involve very small number of people. For instance, the study found that dried seaweed is stored in homes where there is limitation of space and moisture control. Local manufacturers whose products consume seaweed as material for production import large amount of seaweed in the form of carrageen from overseas. Also there is no specialized financial institution with financial services targeting seaweed enterprise promotion. Input suppliers are very few and unspecialized. However, there is different experience in value chain specialisation from other countries such as Indonesia and Philippines

which brought a significant impact in the sectoral development and economic development (Valderrama, 2013).

Conclusion

Despite the fact that Zanzibar is exporting large volume of raw seaweed, the producers have not yet realized economic returns that significantly transform their livelihoods. The industry is dominated by women and middle aged farmers who have low capacity in managing enterprises profitably and not linked to different stakeholders for immediate support. Innovation in Zanzibar seaweed is at low level compared to innovation development in other seaweed producing countries (e.g. Solomon Islands) due to persistent traditional farming system and lack of upscaling mechanisms. This situation has triggered low economic returns, low prices and little involvement of youth and men in the sector. It is fact that the sector can become among the activities of higher impact on Zanzibar economic growth and poverty reduction if the sector is carefully managed and its potentials revealed to increase its competitiveness. Therefore, there is potential in Zanzibar Seaweed farming and that the sector is key for competitive economic growth if innovation is considered paramount.

Recommendations

1. **Seaweed Policy, Strategic Plan and Programme**: The government should develop seaweed policy to address sector challenges, design strategic plan for sectoral growth and programme for implementation.
2. **Research, Entrepreneurship, Innovation and technology:** Promote research and innovation in seaweed science and business; promote entrepreneurship culture among seaweed farming communities; promote technology transfer and up scaling of existing innovation.
3. **Seaweed Development Trust Fund:** Establish seaweed trust fund to finance the development of seaweed sector.
4. **Seaweed Sectoral linkage**: Promote linkage of seaweed industry with Financial Agencies, Markets, Technology, Research, Extension and Commercial Services.
5. **Local Seaweed Industrial Development**: Promote the local use of raw seaweed into local manufacturing industry aimed at creating local consumption.
6. **Youth Employment**: Promote engagement of youth in seaweed value chain activities in order to reduce unemployment and increase sector production.
7. **Clusters and Cooperative Societies:** Strengthen seaweed clusters and cooperative societies to enhance access to market information, lobbying and advocacy

ACKNOWLEDGEMENT
The authors would like to extend sincere gratitude to Tanzania Commission for Science and Technology (COSTECH) for funding this research work and to Dr. Flora Tibazarwa and Ms Neema Tindamanyire at COSTECH Dar es Salaam for effective coordination of the Project.

We would like to extend our gratitude to the Management of Zanzibar Institute of Financial Administration (ZIFA, especially to the Principal Mr. Iddi Haji Makame) and the Institute of Marine Sciences (especially the Director) for supportive collaboration and assistance on technical issues. Director of Research, Consultancy and Publication at ZIFA Dr. Estella Kombo Hassan and Chief Accountant, Mrs Rukia Awadhi and her assistant Mrs Halima Khamis Jabu are thanked for their support and effectiveness in processing various project documents and handling of financial matters.

Many thanks also go to the Ministry of Livestock and Fisheries Zanzibar, for providing a team of extension officers in both Unguja and Pemba Islands in preparing meetings with seaweed farmers. These officers include; Mrs. Batuli Yahya, Mr. Hashim Chande Moumin, Mrs Pavu Mcha (in Unguja), Mr. Ali Said Hamad, Mr. Juma Khamis Jaffar and Mr Moh'd Salum Othman in Pemba.

The research team heartily thank seaweed farmers in both islands of Unguja and Pemba who participated in the interviews in all 48 villages visited. The authors would like to thank Mr. Adil Juma Faki, Senior Officer, Planning Commission Pemba for logistics support in Pemba and Mr. Khamis Ahmada, Head of Price Statistics Unit of Office of Chief Government Statistician (OCGS, Unguja) for his assistance in data analysis.

We appreciate the contribution of members of National Annual Scientific Conference and Exhibition of 2015 organized by COSTECH and comments from stakeholder meetings conducted in Pemba and Unguja. These contributions have improved and approved the quality of report and study findings respectively.

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