A Statistical Analysis of Cost and Yield Optimisation: A Comparison between Indigenous Technical Knowledge Systems and Scientifically Tested Systems used by Crop farmers in Gweru East, Zimbabwe

Shiri A* (alphshiri@gmail.com)
Chirume S* (skchirume@gmail.com)
Mabika H. H* (hmgondera@gmail.com)

*Lecturers at Zimbabwe Open University, Midlands Region

Abstract:
This study sought to compare the effectiveness of indigenous technical knowledge systems (ITKS) and scientifically tested systems (STS) used to minimise costs and maximise crop production by various farmers in Gweru East of Zimbabwe. The study specifically analysed the farming methods used by the crop farmers and compared the methods in terms of finance costs, output, efficiency and effectiveness. Since farmers belong to different categories such as small scale, medium and commercial/large scale, the stratified random sampling technique was used to select the farmers. The sample size was fifty farmers out of a population of 582. The farmers were asked to complete a structured questionnaire which had been subjected to a peer-check for validity and reliability. Two of the famers in each category were purposively sampled and informally interviewed to shed more light on their indigenous knowledge about the farming methods. Independent samples t-tests were used to test for the significance of the differences in the means of the costs and crop out-put between the different groups of farmers who used the two different farming methods. The results of this study showed that for cost of fertilizer, there were significant mean differences between ITKS and STS (t=7.2143) [STS being higher] and between ITKS and BOTH (t=2.2127) [BOTH being higher and being a combination of STS and ITKS]. However there were no statistically significant differences between STS and BOTH. Although mean differences between ITKS and STS, between ITKS and BOTH and between STS and BOTH were observed for cost of controlling pests, they were not statistically significant. For cost of controlling diseases, there were significant mean differences between ITKS and STS (t=7.218) [STS being higher], and no statistically significant differences between ITKS and BOTH and between STS and BOTH. For crop out-put per hectare, there were significant mean differences between BOTH and STS (t=2.140) [STS being higher]. There were no significant mean differences in the crop out-put per hectare between ITKS and STS and between ITKS and BOTH. In the interview excerpts and open-ended sections of the questionnaire, farmers gave a description of some of the ITKS that they used and outlined their effectiveness in terms of crop yield and cost minimisation. The results are critical as they advice farmers on the best practices that they can use to maximize production and reduce poverty in the communities. African universities are advised to focus their research on institutionalizing indigenous technical knowledge since these are opportunities which have not been taped for a long time. This may enhance the development of banks of African knowledge for African farmers.

Keywords: Indigenous Technical Knowledge Systems, Scientifically Tested Systems, crop farmers, quasi-comparative statistical analysis, cost minimisation, yield optimisation.

1.0 Introduction

Most peasant agriculture is based on the use of indigenous technical knowledge which has been developed in that society over time. In any society there are obvious relationships between indigenous knowledge and development over a wide range of activities and locations. In all development programmes it is necessary that development plans take into account the accumulated knowledge, traditional skills and technology of the people who work in those programmes. Mawere (2014) noted that ITKs are quite enduring and dynamic such that they have survived the rest of the time and history. Indigenous people are not empty vessels, they have a lot of knowledge accumulated over time which has made them sail through the difficult period they have or are moving from and towards. The development effects directed towards promotion of development with the indigenous communities should consider indigenous technical knowledge systems (ITKS) being more visualised and more dynamic conception of culture and its values and being the ultimate foundation upon which decision making is hinged on. This is so and should be highly considered because ITKS have always been used to sustain life and that of the environment since the beginning of history of humanity as alluded to by Mawere (2014). This was also supported by Njoki (2014) who noted that the local people of Kenya's activities of food production and processing carried out in their societies translate into unique indigenous knowledge that comprises skills, knowledge and technologies developed by the people within their locality and environment and is embedded in their culture.

2.0 Background to the study

2.1 Introduction to the study

Agriculture in Zimbabwe plays a pivotal role for economic development, growth and poverty reduction, provision of employment, national food supply and provision of industrial raw material. It has been the mainstay of Zimbabwe's economy due to favourable environmental conditions since the last two decades and even beyond. Despite frequent droughts and adverse fluctuations in international economic conditions, agriculture has proved to be very cyclical in Zimbabwe and has demonstrated its ability and resilience to survive under such conditions. Agriculture provides livelihood to the majority of the people of Zimbabwe through incomes and food provision. In the year 2015 agriculture contributed 20.1% of Zimbabwe Gross Domestic Product (GDP) (Global Finance Magazine, August 2016). Major crops grown include the following:- cereals, tobacco, cotton, groundnuts, citrus fruits and horticultural produce.

2.1.1 Area of study

Gweru East Farming Area is made up of communal, resettlement, small and large scale commercial areas. Crops grown include the following cereals (maize, finger millet sorghum), legumes (groundnuts, soyabeans, cowpeas), tubers (sweet potatoes), cash crops and horticultural produce (cabbages and tomatoes). Table 1 gives the average yields in a normal season.

Table 1: Average yields in a normal season

Crop	Average yields (Tonnes/ha)	Range (Tonnes/ha)
Maize	0.4	0.2 to 0.5
Finger millets	0.3	02 to 0.4
Sorghum	0.4	0.2 to 0.5
Groundnuts	0.5	0.2 to 0.6
Soyabeans	0.5	0.4 to 0.8
Cowpeas	0.5	0.2 to 0.6
Cabbages	15,0	10 to 25
Tomatoes	18,0	10 to 20
Sweet Potatoes	20.0	15 to 30

(Source: Agritex Gweru District, 2016)

Farmers send their excess vegetables to the local markets in and around Gweru town in order to raise cash.

2.2 What is ITKS

Mawere (2012) defined ITKS as a phenomena pervasive in an human society, reflecting the dynamic way in which the residents of an area have to come to understand themselves in relationship to their natural environment and how they organise and use their resources. It is local knowledge that has been developed in a locality and is unique to a given culture or society.

Farmers have to use the resources for their sustainability guided by full useful knowledge on how to use them and obtain maximum benefits, within mind the fact that the same resources shall be used for the sustainability of future generations.

Mawere (2014) further illustrated Indigenous knowledge systems as a complex set of knowledge and technologies developed and existing around specific conditions of population and communities indigenous to a particular geographical area. The particular people in the locality where these knowledge systems apply have developed knowledge banks which are well protected and can only be accessed under various conditions.

Sustainability of the traditional knowledge is based on the fact that it is passed from generation to generation and is local knowledge that has been developed by the local people over a period of time. It therefore remains a property of the local people or their traditional science which is location based in terms of development and use.

ITKS are intergenerational showing that they have originated naturally and locally and have the potential to be perpetuated by the local people according to Mawere (2012). They form the basis of certain communication patterns and decision making processes for a society. Indigenous information systems are regarded as dynamic and conclusively influenced. Mawere (2014) further indicate that ITKS can be understood as local knowledge or traditional knowledge generated internally within a cultural community produced through indigenous thinking or exploration.

2.3 Importance of ITKS related to crop farming

ITKS form the bases of the components of any country's indigenous knowledge systems as it takes into considerations the experiences, skills, knowledge and broad insights of the local people. These are the building blocks they use or have used over time to build, improve or maintain their livelihood.

Indigenous communities were able to live in harmony with their environment thereby utilising resources without impairing nature's capacity to regenerate them. They shaped their values and attributes towards sustainable utilisation of the environment.

Indigenous knowledge is more importantly considered as wealth or social capital for the indigenous people to whom they refer to inorder to produce food, provide shelter, to achieve control of their own lives in their struggle for sustainable development.

To concretise its importance it can be recognised in the following scenario:-

- Medicinal products from trees, shrubs and other sources for the successful treatment of various diseases and conditions eg., cancer, venereal diseases, backache and eye ophthalmia in cattle.

- Contribution of architectural structures and homes and some structures which have been adopted as national monuments, for example:

  The special designs of roofs thatched with grass found in the rural areas which have been adopted by guest houses and lodges.
  The complex work at great Zimbabwe which many have failed to understand and explain; this also includes other monuments throughout the country eg., Khami, Nalitali to mention a few.

  On the international scene are the Egyptian Pyramids.

- Production and prevention of locally developed and produced food seed such as pumpkins and sesame.

2.4 Threats to the survival of ITKS

Most ITKS are at risk of becoming extinct due to the rapidly changing natural environment and the fast growing economies, cultural changes and political interventions.

Intrusion of foreign technologies that have no links with the local knowledge systems and development concepts that show gains in the short term are fast replacing ITKS despite their lack of sustainability. The effect of this intrusion is most felt by those people staying in areas where ITKS were developed and continue to be a way of living.

3.0 Contribution of ITKS in the farmer production process

Farming is an industry which requires knowledge and skills for complex decision making such as choosing the technology to use, production quality management and resources distribution (Kurlavicius, 2009). Crop-growing farmers can utilise ITKS to optimise production while reducing the cost and consumption of inputs such as fertilisers and pesticides. Sillitoe (2010) joins the debate on the contribution of ITKS and argues that the use of indigenous knowledge has not significantly contributed to increased crop production. Briggs and Moyo (2012) found that while ITKS have not significantly increased production scale, farmers in Zobwe of Malawi that applied ITKS experienced low but steady yields over time. Contradictory results were found by Nezomba, Mtambanengwe, Tittonell and Mapfumo

(2015) who proposed that indigenous technical knowledge significantly contributed towards the rehabilitation of degraded soils such that the production on such rehabilitated soils increased yields remarkably. Buthelezi, Hughes and Modi (2013) acknowledge that land degradation is a threat to sustainable farming and the application of indigenous technical knowledge by villagers in KwaZulu-Natal, South Africa has been useful in preserving the soil and maintaining high crop yields. Even though there are different research positions as to the extent to which indigenous technical knowledge boosts crop production, such knowledge still remains valuable and it is the objective of this study to find out how significant indigenous technical knowledge is in promoting agricultural production. Literature reviewed reveals that ITKS is practiced in relation to soil management and crop production with the following practices commonly found across the continent of Africa:

Movaraj, Hashemi, Hosseini and Rezvanfar (2012) found out that in Rwanda, indigenous knowledge provides problem solving strategies which in turn help incoming up with local solutions to improve farming systems with environmental sustainability in mind. It is further suggested that combining indigenous and non-indigenous knowledge systems forms an interactional approach which is appropriate as it gives a symbiosis enhancing the depth and breath of both systems.

3.1 Fallow Land

Mushir and Kedru (2012) found that farmers in Ethiopia used fallow land as a traditional soil conservation technique. Fallow land is a traditional practice of leaving the crop land uncultivated for a period of one or more years for the purpose of recovering soil fertility and minimising soil loss. Similarly, Buthelezi et al. (2013) found that farmers in villages of KwaZulu-Natal of South Africa also used fallowing as a way to replenish soil nutrients where the soil had degraded. However, the latter found that for the most part, farmers in KwaZulu-Natal practised mixed cropping and rotation as a way of soil and production management where taro was rotated with maize and beans. Tun, Shrestha and Datta (2015) in their study of local faming practices in the dry zone of Myanmar, found that the local farmers were not very familiar with scientific soil and water conservation methods but were well aquainted with local indigenous measures. Tun et al. (2015) describe the local indigenous soil conservation methods in the dry region of Myanmar as crop rotation and intercropping systems developed to spread the risk over a number of crops due to unreliable rains and scarce water resources for the plants. Eilola, Kayhko, Fagerholm and Kombo (2014) state that it is therefore important to incorporate local indigenous knowledge into modern farming as the local farmers have for decades been able to sustain reasonable crop yields with limited resources. Eilola et al. (2014) argue that identifying sustainable agricultural practices for communities with limited and sensitive resources is only possible with insights drawn from the local indigenous farmers as they have extensive knowledge of the local agroecosystem gained through years of land use strategies and patterns. One can therefore conclude that traditional soil conservation tillage practises may be described as knowledge gained through observation and experimentation over time and from generation to generation.

3.2 Application of manure

Mushir and Kedru (2012) found that farmers in Ethiopia applied animal waste in their fields to replenish soil nutrients. Buthelezi et al. (2013) also found that farmers in KwaZulu-Natal villages used kraal manure to maintain soil nutrients and realise high crop yields.

3.3 Leaving crop residues

Briggs and Moyo (2012) found that crop residues were used to maintain soil fertility where such crops like beans were processed at home after harvest and waste from bean stems and bean pods were placed in ridge troughs to decompose. The result was that crops such as maize grew bigger cobs when planted under decomposed matter.

3.4 Changes in agro-ecological thought and the role of farmer knowledge

Kurlavicius (2009) propose that a farmer's important objectives should include increasing productivity and at the same time managing soil fertility and pests in a way that is not expensive. Balancing the productivity optimisation and soil fertility cost minimisation requires special knowledge and skills about how the physical environment interacts with societal needs and nature. Obsbahr and Allan (2003) observed that in order to deal with such soil fertility management complexities, farmers should shift from farming systems research to production research which focuses on the broad notion of sustainable production. Obsbahr and Allan (2003) define agro-ecology as a combination of agricultural science, ecology and elements of anthropology. Agro-ecology addresses the social system within which farmers work and legitimises farmers' knowledge. This means that a farmer should understand the different social actors in soil management in order to maximise utility value of the soil and increase their output. Indigenous technical knowledge plays an important role in maximising output for farmers as they use such knowledge and skills to identify soil types and match the soil with type of crop for optimum yields. Basu and Scholten (2012) maintain that local farmers should prioritise the sustainability of social relations and environmental resources. This means that it is the farmers' indigenous technical knowledge which enables them to understand the politics of the land in their locality and to produce enough for subsistence given the constraints at hand such as limited farming area and the economic potential of the land. Figure 1 below gives a theoretical framework for sustainable and innovative farming practices.

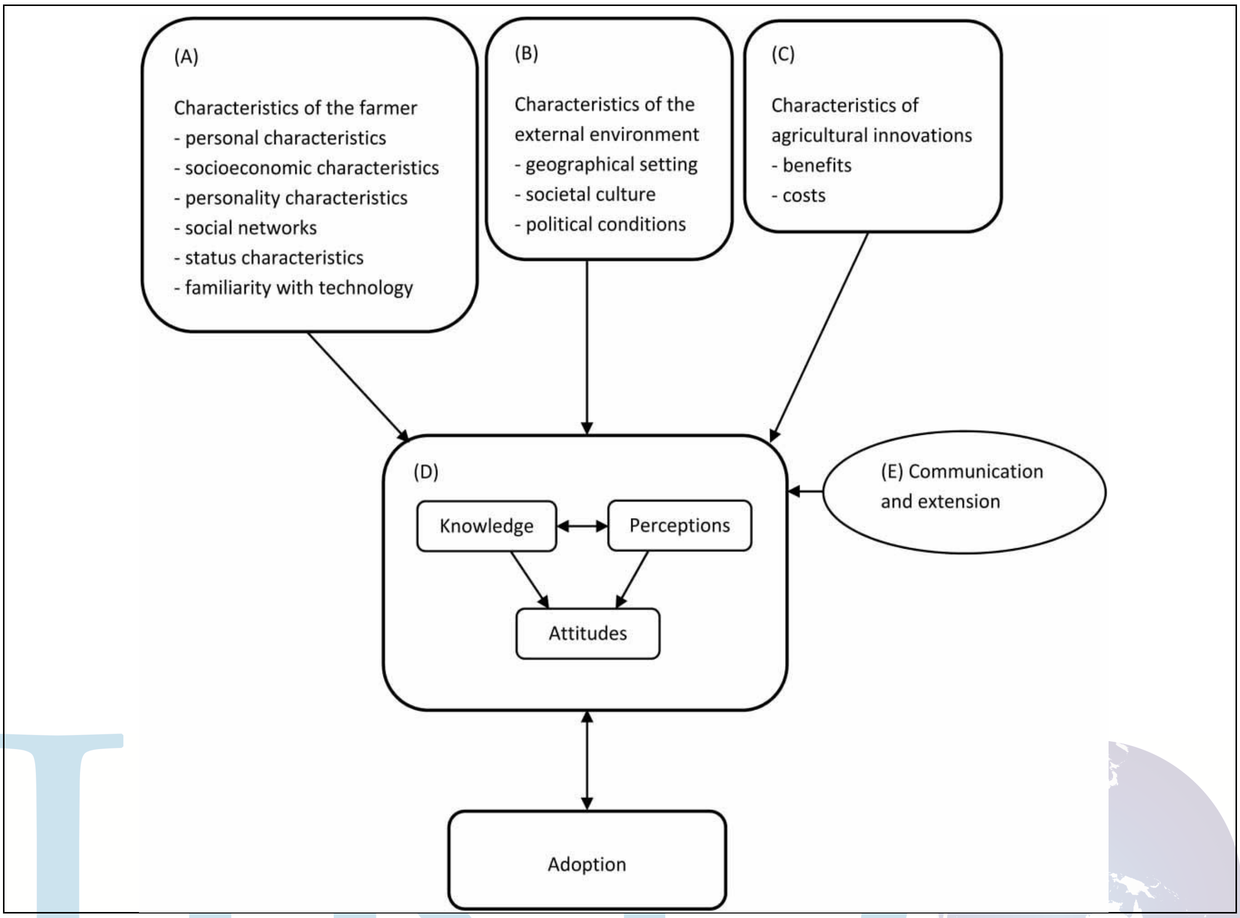

Figure 1: A theoretical framework for sustainable and innovative farming practices. S**ource:** Meijer, Catacutan, Ajay, Sileshi and Nieuwenhuis (2015)

Meijer, Catacutan, Ajay, Sileshi and Nieuwenhuis (2015) maintain that small farmers should embrace the interplay among various factors such as the external environment, the role played by agricultural extension workers and their own knowledge, in order to innovate farming methods that promote sustainability and enhanced productivity. Meijer et al. (2015) suggest that extrinsic factors such as the characteristics of the external environment influence the small farmers or indigenous farmers' knowledge and perceptions in terms of adopting new approaches to farming. Farmers should therefore adapt to new ways of thinking by embracing the various factors such as the environment, the information provided by the government through agriculture extension workers and agricultural innovations mushrooming from different parts of the world and scientific research from universities and colleges.

4.0 Scientifically tested systems

The depletion of soil nutrients is known to reduce crop yields, such that external nutrient application through the use of chemical fertilisers is essential for the provision of phosphorus and nitrogen required by crops for greater yields. Brusaard, Kuyper, Didden, de Goede and Bloem (2004) state that scientific and technical indicators of soil quality usually include basic parameters such as bulk density, pH, effective rooting depth, water content, soil temperature and electrical conductivity. Such scientific knowledge involves laboratory testing of the soil and carrying out quantitative analysis, whereas indigenous technical knowledge involves the qualitative technique of assessing the quality of soil by observing the colour of the soil and the presence of local plants.

Typical biological indicators of soil quality include:

- nitrogen mineralisation, a measure of the release of inorganic nitrogen from soil to organic matter;
- microbial biomass, a measure of total mass of soil microorganisms;
- microbial biomass to total soil carbon ratios;
- soil respiration, a sum of all CO_2 generated by biological activity in the soil;
- respiration to microbial biomass ratios;
- soil fauna population size and diversity of soil arthropods and invertebrates, and
- the rate of litter decomposition (an integrated measure involving interaction of vegetation, soil nutrient availability and microbial populations) (Brussaard, et al., 2004).

5.0 Purpose of the study

Agriculture in Africa is facing a myriad of challenges including soil fertility, population growth and long term rainfall decline. These challenges can be addressed using agricultural technical knowledge and skills. Such knowledge and skills can be scientific knowledge or indigenous technical knowledge. Research so far has found mixed results on the contribution of indigenous technical knowledge, with some claiming that it has not produced significant results towards production levels, while other researchers acknowledge the importance of indigenous technical knowledge in maintaining stable and constant productivity and contributing towards rehabilitation of degraded land, thereby increasing productivity significantly. The purpose of this study is to confirm a position, using statistical analyses, relating to the contribution of indigenous technical knowledge and scientifically tested systems so as to develop an integrated knowledge system for optimisation of crop yields at a minimum cost. Informal interviews with purposively selected farmers were used to shed more light on ITKS.

6.0 Hypotheses (to be tested at 5 % level)

$1H_{0:}$ Cost of replenishing soil nutrients under ITKS is significantly lower than cost of replenishing soil nutrients under lab-tested system (LTS)

$2H_{0:}$ Cost of pest control under LTS is significantly higher than cost of pest control under ITKS

$3H_{0:}$ Cost of disease control is significantly higher under LTS than under ITKS

$4H_{0:}$ Crop output per hectare is significantly higher under LTS than under ITKS

7.0 Research methodology

Strict experimental control was difficult to arrange since the farmers were scattered all over Gweru East and the researchers could not physically measure the crop out-put and the financial costs. Hence the researchers relied on a quasi-comparative design where costs and output could be calculated from the figures indicated on the questionnaires. Fifty small scale, medium scale and large scale framers in Gweru East District in the Midlands province of Zimbabwe were selected from a population of 582 households using stratified random sampling. Structured questionnaires with two sections were administered to the respondents. Section A asked for background/demographic information while section B asked for the size of the area under cropping, type of crops grown, kinds of traditional and scientific farming methods, the respective costs and output per method, among other variables. Two famers belonging to each of the small scale, medium and large scale categories were informally interviewed and asked to shed more light on the indigenous knowledge which they used on their crop farms. Information collected from the questionnaires, the informal interviews carried out with some of the farmers and from the review of literature were triangulated.

8.0 Results

Table 2 shows the demographic data of the respondents.

Table 2: Demographic Data of n=50 Respondents (Section A)

Gender	Male 32	Female 18						
Level of Education	Primary School 7	Secondary School 30	Certificate Course 4	Diploma Course 4	First Degree 4	Masters' Degree 0	PhD 0	N/A 1
Size of Farm	Small 34	Medium 7	Large 7	N/A 2				
Has Agriculture Training	Yes 21	No 27	N/A 2					
If NO how Farming Knowledge Was Acquired	Observed elders 6	Worked on a farm 7	Worked in fields with family 6	Other 7	N/A 1			
Trained as Master Farmer	Yes 29	No 17	No Answer 4	If Yes OMF 17	If Yes AMF 8	Yes but N/A 4		

Key: N/A= No Answer, OMF=Ordinary Master Farmer, AMF= Advanced Master Farmer

From Table 2 the majority (64%) of the farmers in Gweru East were male; few (16%) had attained Diploma or a first degree in Agriculture. Most (60%) had attained only secondary school education. The majority of the farmers (68%) had small farms of 1ha. Only 42% had some agriculture training, 54% had no training and 4% did not respond to the question. Of the respondents, 58% had trained as master farmers, with 58.6% of them being Ordinary Master Farmers, 27.6% being Advanced Master farmers and 13.8% not responding to the question.

The farmers were asked to indicate the area (in ha) under cropping and the type of crops they grew. Table 3 shows the information.

Table 3: Average Area and Major Crops under Cultivation

	ITKS	**STS**	**Both ITKS and STS**
Area under cropping	1 to 2.5 ha	Above 2.5 to 5 ha	Above 2.5 to 5 ha
Type of crop	Maize 48% Sorghum 12% Groundnuts 28% Rapoko 8% Other* 4%	Maize 72% Sorghum 0% Groundnuts 28% Rapoko 0% Other* 0%	Maize 48.7% Sorghum 10.8% Groundnuts 18.9% Rapoko 16.2% Other* 5.4%

Other* = Soya beans, sugar beans and bambaranuts

Table 3 shows that the famers who used ITKS had farms ranging from 1 to 2.5 hectares, while those who used STS or both STS and ITKS had farms of sizes 2.5 to 5ha. Maize was the major crop cultivated by majority of the famers, followed by groundnuts. Sorghum and rapoko were grown to a lesser extent by ITKS and both ITKS and STS farmers while farmers who used only STS did not grow them. Some crops such as soya beans, sugar beans and bambaranuts were grown to a small scale by ITKS farmers.

The farmers were also asked to indicate type of fertilizer (organic or inorganic), cost of the fertilizer, costs of controlling pests, costs of controlling diseases and their crop out-put (in US $) per hectare. Table 4 shows the information provided by the farmers.

Table 4: ITKS vs STS by Average Cost and Average Crop Output (Section B)

	Cost of fertilizer (US$)	Cost of controlling pests (US$)	Cost of controlling diseases (US$)	Crop output (US$/ha)
ITKS (Traditional Methods)	n=13 $\bar{x}$ =31.54 sd=12.65	n=6 $\bar{x}$ =15.58 sd= 8.88	n=1 $\bar{x}$ =10.00 sd= 0.0	n=12 $\bar{x}$=916.67 sd= 1164.5
STS (Western methods)	n=33 $\bar{x}$=274.06 sd=177.28	n=24 $\bar{x}$ =21.79 sd= 13.07	n=16 $\bar{x}$ =16.69 sd= 3.59	n=18 $\bar{x}$=1944.40 sd= 2092.6
ITKS and STS (BOTH)	n=6 $\bar{x}$=205.67 sd= 155.85	n=23 $\bar{x}$ =19.57 sd= 10.29	n=6 $\bar{x}$ =14.17 sd =4.22	n=16 $\bar{x}$=812.5 sd= 602.1

Table 4 shows that the average cost of fertilizer was greatest for the STS and lowest for the ITKS. Cost of controlling pests was higher for farmers who used STS than for those who used both methods. It was least for farmers who used ITKS. Cost of controlling diseases was highest for farmers who used STS, followed by those who used both methods and least for those who used ITKS. However the crop out-put per hectare was highest for STS, followed by ITKS and lowest for both STS and ITKS.

Independent sample t-tests for unequal variances were used to test whether these observed differences in the means were significant (at $\alpha = 0.05$) or not. For cost of fertilizer there were significant mean differences between ITKS and STS (t=7.2143) [STS being higher] and between ITKS and BOTH (t=2.2127) [BOTH being higher]. However there were no statistically significant differences between STS and BOTH. Thus $1H_0$ (Cost of replenishing soil nutrients under ITKS is significantly lower than cost of replenishing soil nutrients under lab-tested system) was not rejected. Although mean differences between ITKS and STS, between ITKS and BOTH and between STS and BOTH were observed for cost of controlling pests, they were not statistically significant. Hence there was no sufficient evidence to retain $2H_0$ (Cost of pest control under LTS is significantly higher than cost of pest control under ITKS). For cost of controlling diseases, there were significant mean differences between ITKS and STS (t=7.218) [STS being higher], and no statistically significant differences between ITKS and BOTH and between STS and BOTH. Thus $3H_0$ (Cost of disease control is significantly higher under LTS than under ITKS) was retained. For crop out-put per hectare, there were significant mean differences between BOTH and STS (t=2.140) [STS being higher]. There were no significant mean differences in the crop out-put per hectare between ITKS and STS and between ITKS and BOTH. Thus $4H_0$ (Crop output per hectare is significantly higher under LTS than under ITKS) was not rejected.

The main pests which were observed to attack crops were, in order of most occurrence, aphids, stalk borer and cut worm. The maize stalk borer was controlled using fine river sand. Baboons and monkeys were also found to be a menace especially on the maize crop. These were controlled by the traditional methods of patrolling and scarring. The main diseases found to attack crops were, in order of occurrence, root rot, leaf spot and blight. They were mainly controlled by STS. The traditional methods used for controlling diseases were: aphids are controlled using *muchacha* leaves and water mixture.

Thus there was no sufficient evidence to conclude that ITKS are better than STS or better than BOTH.

Interviews with farmers

Two small scale farmers (F_1 and F_2), two medium scale farmers (F_3 and F_4) and two large scale farmers (F_5 and F_6) were interviewed and the following is what they said concerning ITKS used for crop farming:-

F_1 "We use goat manure in the production of indigenous kitchen vegetables. We get money to send our children to school by selling the vegetables"

F_2 "As A1 farmers, it is affordable to use black jack or tagetes minuta to prevent sitophilus zeamais (maize weevils) in Chiwundura Communal Lands. We find it to be a very cost effective and efficient way of controlling pests." [*A1 farmers are small scale communal farmers who were resettled on acquired former large scale commercial farms and given plots of 5-50 hectares]*.

F_3 "We usually use lantana camara leaf powder in the control of maize weevils. This is a common practice and cost effective way of controlling maize weevils (sitophilus zeamais) in our area."

F_4 "Sometimes we use intercropping of maize and cowpeas as a technique to boost production of both maize and cowpeas". *Most communal farmers also practice this technique as it yields more and has an added advantage of nitrogen fixation.*

F_5 "I have seen some neighbouring farmers using fish poison tree (tephrosia vageli) on the control of weevils on stored maize grain. Their grain storage was more effective compared to mine. I want to try this method on my stored grain this season."

F_6 "As a large scale commercial farmer I have used pounded sodom's apple leaves (solanum incanum) in the control of sweet potato weevils. The method was cost effective and resulted in large yield of potatoes which I sold at the Gweru market."

9.0 Discussion

Famers' indigenous knowledge and scientific knowledge share a number of common core concepts such as illustrated in Figure 2 below. The gaps found under each system can be filled by integrating the two knowledge systems which can result in the creation of a "hybrid knowledge base" Barrios, E., Delve, R.J., Bekunda, M., Mowo, J., Agunda, J., Ramisch, J., Trejo, M.T., Thomas, R.J., (2006: 3).

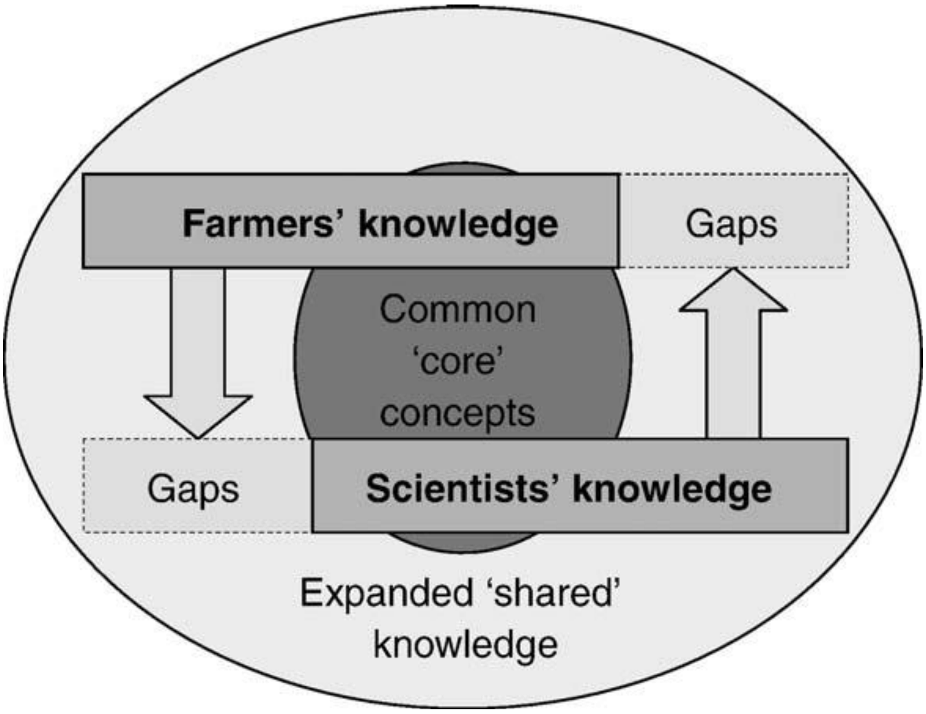

Figure 2: Integrating knowledge systems into a hybrid knowledge base
Source: Barrios, E., Delve, R.J., Bekunda, M., Mowo, J., Agunda, J., Ramisch, J., Trejo, M.T., Thomas, R.J., (2006: 3)

The study reveals that the average cost of fertilizer outweighed the cost of using ITKS. Cost of controlling pests was higher for farmers who used STS than for those who combined the use of ITKS and STS (what this study calls the 'hybrid method'). The cost of controlling pests was lowest for farmers who used ITKS. Cost of controlling diseases was highest for farmers who used STS, followed by those who used hybrid method and least for those who used ITKS. However the crop out-put per hectare was highest for STS, followed by ITKS and lowest for both STS and ITKS. The study therefore shows that it is important to develop indigenous technical knowledge to a commercial level where pest controls are produced in bulk to assist farmers in reducing inputs costs. Hybrid fertilisers can be developed and laboratory tested to increase crop yields per hectare. Such an approach will create sustainable agricultural practices that ensure food security in the developing countries and may reduce poverty and starvation.

9.0 Recommendations
The following recommendations are based on the findings of the study and also from the review of related literature.

The future of ITKS
Local communities should engage and educate young people on these indigenous knowledge systems to develop and build knowledge banks that are peculiar to their communities.

Development agents, who include government departments, donor community and the private sector should seek knowledge about ITKS before bringing in new ideas in a community or locality. In this noble process they need to:-

- Recognise the presence and effectiveness of the existing knowledge systems,
- Appreciate and obtain all appraisal on the extend to which these systems have served society,

- Establish how long they have been in existence, find out why and what contributions they have made to society,
- Build on their appreciation by local communities and any further research or development be based on that,
- Involve the people who use these systems in their future researches and development,
- Scientifically test them with their involvement and avoid introduction of sweeping changes.

Indigenous knowledge is not only important in its own right but it also brings benefits to the people who own and live with it, other people elsewhere learn its benefits which include sustainability.

Foreigners should check and observe protocol for inviting local people to talk to them. It is not everyone who has the right and ability to talk about various issues. Issues that are sacred and secret knowledge may not be accessed from all the people. Foreigners should know who to talk to and when.

Academic institutions should vigorously search and pursue new research methods for studying indigenous knowledge while promoting diversity by valuing the way of knowledge that is characteristic of various cultures.

Inclusion of ITKS in the school curriculum

It is important that ITKS be included in the school curriculum so that the children grow up with an appreciation of this noble cause.

Children will learn:-

- Attitudes and values for a sustainable future. In so doing children can develop sensitive and caring values and attributes thereby promoting a vision of a sustainable future.

- Use of various forms of culture in the learning process such as customs, folk stories, folk songs, folk drama, poems and myths.

Should ITKS be taught across generations, school children would then consult their fathers and grandfathers making schools act as agencies for transforming the culture of society from one generation to the next.

10.0 Conclusion

It can be concluded that ITKS provide a low cost input model for farmers in the developing countries and affords them the opportunity to profit from crop production. High yields can be realised using ITKS as evidence from the study shows that some farmers that did not combine the use of local knowledge with STS produced better yields than those that adopted STS in combination with ITKS. It is therefore important to tap into local knowledge (ITKS) and develop it to produce pesticides and fertilizers on a large scale.

11.0 References

Barrios, E., Delve, R.J., Bekunda, M., Mowo, J., Agundu, J., Ramisch, J., Trejo, M.T. and Thomas, R.J. (In-press). Indicators of soil quality: a south-south development of a methodological guide for linking local and technical knowledge. Georderma.

Basu, P and Scholten, B.A. (2012). Crop-livestock systems in rural development: linking India' green and white revolutions. International Journal of Agricultural Sustainability 10(2), 175-191.

Buthelezi, N.N., Hughes, J.C. and Modi, A.T. (2013) The use of scientific and indigenous knowledge in agricultural evaluation and soil fertility studies of two villages in KwaZulu-Natal, South Africa. African Journal of Agricultural Research 8(6), 507-518.

Briggs, J. and Moyo, B. (2012). The resilience of indigenous knowledge in small scale African agriculture: Key drivers. Scottish Geographical Journal, 128(1), 64-80.

Brussaard, L., Kuyper, T.W., Didden, W.A.M., de Goede, R.G.M., Bloem, J. (2004). Biological soil quality from biomass to biodiversity- importance and resilience to management stress and disturbance. In Schjonning, P., Elmholt, S., Christensen, B.T. (Eds.) Managing Soil Quality: Challenges in Modern Agriculture. CAB International, Wallingford. pp 139-171

Eilola, S., Kayhko, N., Fagerholm, N. and Kombo, Y.H. (2014). Linking farmers' knowledge, farming strategies and consequent cultivation patterns into the identification of healthy agroecosytem characteristics at local scales. Agroecology and Sustainable Food Systems, 38(9), 1047-1077.

Global Finance Magazine (2016). Zimbabwe GDP forecast 2015 and Economic Data GF: Zimbabwe-gdp-country report. Retrieved on 3/8/16 from www.gfmag.com/globaldata/contry-data/

Kurlavicius, A. (2009). Sustainable agricultural development: Knowledge based decision support, technological and economic development of economy. Baltic Journal on Sustainability, 15(2), 294-309.

Meijer, S.S., Catacutan, D., Ajay, O.C., Sileshi, G.W. and Nieuwenhuis, M. (2015). The role of knowledge, attitudes and perceptions in the uptake of agricultural and aforestry innovations among smallholder farmers in Sub-Sahara Africa. International Journal of Agricultural Sustainability, 13(1), 40-54.

Mawere, M. (2012). Struggle for African Indigenous Knowledge Systems in an age of Globalisation. A case for Children's Traditional games in South Eastern Zimbabwe. Langaa RPCIG 2012.

Mawere, M. (2014). Culture, Indigenous Knowledges and development in Africa. Reviving interconnections for sustainable development. Langaa RPCIG 2014.

Movarej, M., Hashemi, S. M. K., & Hosseini, S. M. (2012). In: Cercetari agronomice in Moldova (Romania). 2012. no.1(149) p. 93-103 Language: English, Database: AGRIS.

Mushir, A. and Kedru, S. (2012). Soil and Water conservation management through indigenous and traditional practices in Ethiopia: A case study. Ethiopian Journal of Environmental Studies and management EJESM 5(4), 343-355.

Norton, J.B., Pawluk, R.R and Sandor, J.A. (1998). Observation and experience linking science and indigenous knowledge at Zuni, New Mexico. Journal of Arid Environments, 39, 331-340.

Nezomba, H., Mtambanengwe, F., Tittonell, P. and Mapfumo, P. (2015). Point of no return? Rehabilitating degraded soils for increased crop productivity on smallholder farms in Eastern Zimbabwe. Geoderma, 239-240, 143-155.

Njoki, N.W. (2014). Indigenous African Knowledge production: Food processing practices among Kenyan Rural Women; University of Toronto Press, Scholarly Publishing Division.

Obsbahr, H. and Allan, C. (2003). Indigenous knowledge of soil fertility management in Southwest Niger. Geoderma, 111, 457-479.

Sillitoe, P. (2010). Trust in development: some implications of knowing in indigenous knowledge. Journal of the Royal Anthropological Institute. 16, 12-30.

Tun, K.K.K., Shrestha, R.P. and Datta, A. (2015). Assessment of land degradation and its impact on crop production in the dry zone of Myanmar. International Journal of Sustainable Development and World Ecology 22(6); 533-544.