Sokoine University of Agriculture

MA Dissertation

Assessment of the Sustainability of Agricultural Technologies: A Case of "*Bustani ya Tushikamane*" (ByT) Programme in Morogoro Region

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May 2024

ASSESSMENT OF THE SUSTAINABILITY OF AGRICULTURAL TECHNOLOGIES: A CASE OF "*BUSTANI YA TUSHIKAMANE*" (ByT) PROGRAMME IN MOROGORO REGION

Dissertation submitted to Sokoine University of Agriculture in Fulfilment of the Requirements for the Degree of Project Management and Evaluation

By

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EXTENDED ABSTRACT

The sustainability of agriculture technologies is a topic of growing importance in today's world, as the global population continues to expand, and the demand for food and resources escalates. The study aims to undertake a systematic assessment of the sustainability of agriculture technologies, with a focus on factors affecting sustainability and compliance of the technologies with the Agro ecological principles using the Agroecological Criteria Tool(ACT). The study employed cross-sectional research design with a sample size of 90 participants. Quantitative data was gathered through questionnaire, while qualitative data was collected through interview, focused group discussion (FGD) and observations. The analysis of the data involved both descriptive and inferential statistics, as well as thematic analysis of qualitative information. Factors like market availability ($p = 0.000$), training ($p = 0.021$), and cost of the agricultural technologies ($p = 0.000$) significantly predicted the likelihood of sustainability of agricultural technologies at 5% level of significance. Technologies introduced under the ByT programme were highly sustainable (60%), followed by medium sustainability (27.8%). The findings indicate that the agricultural techniques implemented by ByT have adhered to agroecological principles at every level, including efficiency (86%). This encompasses methods aimed at decreasing the use of resources such as water, pesticides, and fertilizers, while simultaneously enhancing crop yield. It is concluded that training, market availability, and cost of introduced agriculture technologies are crucial factors influencing sustainability of agricultural technologies. Also, the agriculture technologies introduced by ByT program are highly sustainable. This study offers a holistic perspective on the challenges and opportunities associated with sustainable agriculture technologies. The study concludes with recommendations that introduced agriculture technologies by stakeholders should consider the cost of introduced technologies, market availability of agriculture product and training of the technologies so as to ensure sustainability of those technologies. Also, need of future research and policy interventions to foster the sustainable adoption of agriculture technologies and advance the overall sustainability of the agricultural sector.

Keywords: Sustainability, Agro ecological practices, Small-scale farmers, Agriculture technologies.

IKISIRI KUU

Uendelevu wa teknolojia za kilimo ni mada inayozidi kuwa muhimu katika dunia ya leo, wakati idadi ya watu duniani inaendelea kuongezeka na mahitaji ya chakula na rasilimali yanapanda. Utafiti huu unalenga kufanya tathmini ya kimfumo ya uendelevu wa teknolojia za kilimo, kwa kuzingatia mambo yanayoathiri uendelevu na ulinganifu wa teknolojia hizo na kanuni za kileo-kilimo kwa kutumia Agroecological Criteria Tool (ACT). Utafiti ulitumia muundo wa utafiti wa kipengele-moja na sampuli ya washiriki 90. Takwimu za kiasi zilikusanywa kupitia dodoso, wakati takwimu za ubora zilikusanywa kupitia mahojiano, FGD, na uchunguzi. Uchambuzi wa takwimu ulijumuisha takwimu elekezi na za kidokezi, pamoja na uchambuzi wa mada wa taarifa za ubora. Mambo kama upatikanaji wa soko (p = 0.000), mafunzo (p = 0.021), na gharama za teknolojia za kilimo (p = 0.000) yalitabiri kwa kiasi kikubwa uwezekano wa uendelevu wa teknolojia za kilimo kwa kiwango cha umuhimu cha 5%. Teknolojia zilizotambulishwa chini ya mpango wa ByT zilikuwa na uendelevu wa juu (60%), ikifuatiwa na uendelevu wa kati (27.8%). Matokeo yanaonyesha kuwa mbinu za kilimo zilizotekelezwa na ByT zimezingatia kanuni za kileo-kilimo kwa kila ngazi, ikijumuisha ufanisi (86%). Hii inajumuisha mbinu zinazolenga kupunguza matumizi ya rasilimali kama maji, viuatilifu, na mbolea, huku zikiongeza mavuno ya mazao. Inahitimishwa kuwa mafunzo, upatikanaji wa soko, na gharama za teknolojia zilizotambulishwa za kilimo ni mambo muhimu yanayoathiri uendelevu wa teknolojia za kilimo. Pia, teknolojia za kilimo zilizotambulishwa na programu ya ByT ni za uendelevu wa juu. Utafiti huu unatoa mtazamo wa jumla juu ya changamoto na fursa zinazohusiana na teknolojia za kilimo endelevu. Utafiti unahitimisha kwa mapendekezo kwamba teknolojia za kilimo zinazotambulishwa na wadau zinapaswa kuzingatia gharama za teknolojia zilizotambulishwa, upatikanaji wa soko la bidhaa za kilimo, na mafunzo ya teknolojia hizo ili kuhakikisha uendelevu wa teknolojia hizo. Pia, kuna haja ya utafiti wa baadaye na hatua za sera ili kuimarisha kupitishwa kwa teknolojia endelevu za kilimo na kuendeleza uendelevu wa sekta ya kilimo kwa ujumla.

Maneno muhimu: Uendelevu, mbinu za kilimo ikologia, wakulima wadogo, teknologia ya kilimo ikologia

DECLARATION

I, Anna Leonard Mhando do hereby declare to the senate of Sokoine University of Agriculture that this dissertation is my own original work done within the period of registration and that it has neither been submitted nor being concurrently submitted in any other institution.

Anna Leonard Mhando   Date
(MSc. Candidate)

The declaration above is confirmed by;

Dr. Anthony Funga   Date
(Supervisor)

Dr. Michael Kadigi   Date
(Supervisor)

LIST OF PUBLISHED PAPERS

Factors Affecting Sustainability of Agricultural Technologies in Tanzania: A Case of Bustani ya Tushikamane (ByT) Project in Morogoro Region.

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I would like to thank God, for your grace that carried me through all the difficulties. I have seen you day by day you have provided me to finish this dissertation. Glory is to God as I trust you with my future.
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DEDICATION

I dedicate this work to my parents Mr & Mrs Leonard Mhando, Mr & Mrs Erick Mhando and my friends and family. I am also dedicating this work to anyone who feels like giving up in their academic journey I believe with God and determination you can make it. Special dedication to my future family as a motivation in your academic journey.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF ABBREVIATION

ACT	Agroecological Criteria Tool
ByT	Bustani ya Tushikarmane
FAO	Food and Agriculture Organisation
FGD	Focused Group Discussion
GDP	Gross Domestic Product
OECD	Organization for Economic Cooperation and Development
SAT	Sustainable Agriculture Tanzania
SPSS	Statistical Package for Social Sciences
UN	United Nations
URT	United Republic of Tanzania

CHAPTER ONE

1.0 General Introduction

1.1 Background Information

Agriculture is a sector that grows fast due to high increase of demand of agriculture products. This increase in demand is due to its importance in food provision as there is a need to meet the world's rapidly growing population (UN, 2015). Agriculture is the main source of income for majority of poor households who live in rural areas and it contributes 29% of the GDP and accounts 65% of all employment in developing countries (IPC, 2020). Therefore, there is need for immediately transformative change in agricultural sector. Moreover, the transformation of the agriculture sector requires the adoption of new and innovative agricultural technologies to increase agricultural production. Globally, many agricultural technologies are available as pathways for improved agricultural productivity and food security, but they have had relatively little success in Sub Saharan Africa countries including Tanzania (FAO, 1996). Smallholder farmers in the rural areas have low adoption and poor scaling up of agriculture tools (Makate, 2018). This indicates a need for introduction of new agricultural technologies and training of rural farmers to ensure adoption of agricultural technologies. This stimulated government institution as well as the private sector, and non-governmental organization including Sustainable Agriculture Tanzania (SAT) to come up with different program like Bustani ya Tushikamane for training rural farmers on different agricultural technologies.

"Bustani ya Tushikamane" program (ByT) as one of the agricultural projects introduced to improve food security and poverty reduction through sustainable agricultural technologies. This project was implemented by SAT (Sustainable Agriculture Tanzania) in Morogoro. It is a grassroots program that was launched in 2009 and ended in 2016. The project aimed to promote sustainable agriculture through dissemination of knowledge, application, research and networking. Farmers were introduced to sustainable agriculture technologies such as intercropping, use of manure, natural pesticides, and terracing. According to Bustani ya Tushikamane report (2011) the project aimed to reduce agricultural cost, conserve the environment and as well increase awareness on organic products. However, most of the agriculture projects tend to be unsuccessful or ultimately inactive as the project ends leaving their beneficiaries poor, food insecure due to the unsustainability of agriculture project.

Sustainability in project evaluation is the continuation of benefit from development intervention after major development assistance has been complete. The probability of continued long-term benefits and resilience to risk of the net benefits flow over time (Bourn, 2015). In addition, as defined by Ntebutsi (2015) sustainability means providing long-term solutions to community needs that the beneficiaries can maintain after grant funding ends. According to Corral *et al*. (2017) sustainability is a challenge in most agriculture projects. Since in order for an agriculture project and practices to be sustainable it has to be economically viable, meets people’s needs for a long period and environmentally friendly.

Agricultural technologies and practices are highly linked to sustainability of agricultural projects. Therefore, sustainability of agriculture projects includes activities that seek or tend to sustain farmer’s resources and populations by way of encouraging agricultural practices and techniques that are profitable, friendly to the environment and good for people (Mairura, 2019). Hence if a project cannot maintain its value and usefulness to the society in long term progression then it’s not sustainable.

Therefore, this study has paid particular attention in assessing sustainability of the agricultural technologies taught under ByT. Furthermore, this research delves into the challenges and barriers associated with the implementation and adoption of sustainable agriculture technologies. It explored factors such as cost-effectiveness, knowledge dissemination, policy frameworks, and stakeholder engagement that influence the successful integration of these technologies into mainstream agricultural practices. By identifying the obstacles and potential solutions, this research aims to provide valuable guidance to policymakers, farmers, researchers, and other stakeholders involved in sustainable agriculture.

1.2 Problem Statement

The majority of impoverished households in developing nations rely on subsistence agriculture for both food production and income generation (Baiphethi *et al.,* 2009). Consequently, implementing agricultural interventions through projects serves as an appropriate strategy to enhance the well-being of the poor. Previous research studies (Larsen and Lilleor, 2014; Levinson and Herforth, 2014) have investigated the impact of agricultural projects, highlighting their influence on productivity, food security, and poverty alleviation. Additional studies conducted by Nwaiwu *et al*. (2013) and Saysel *et al*. (2014) have explored various factors that affect the sustainability of agricultural projects, including socio-economic characteristics, facility types, training programs, agricultural extension services, and market dynamics. Saysel *et al*. (2014) specifically examined the sustainability of agricultural technologies and addressed water distribution management policies. However, the aforementioned studies (Nwaiwu *et al.,* 2013; Levinson and Herforth, 2014; Larsen and Lilleor, 2014; Saysel *et al.,* 2014) have largely failed to capture the comprehensive evaluation of the long-term sustainability of agriculture technologies introduced by interventions. Additionally, there exists a gap in the methodological approach employed to study the sustainability of these agriculture technologies.

While existing studies have examined the adoption rates and short-term impacts of agriculture technologies, few have thoroughly examined the environmental, social, and economic dimensions of sustainability over an extended period. This gap in research limits our understanding of the overall effectiveness and long-term viability of these technologies in promoting sustainable agricultural practices.

Furthermore, the methodological approach used in studying the sustainability of agriculture technologies has often been limited in scope and lacks a holistic perspective. Many studies rely heavily on quantitative indicators and fail to capture the complexity and interconnectedness of sustainability factors. The overemphasis on quantitative analysis neglects the qualitative aspects, including socio-cultural factors, institutional support, necessary for the successful implementation and long-term sustainability of these technologies.

Therefore, there is a pressing need for research that addresses the gap in understanding the sustainability of agriculture technologies introduced through interventions. This research has adopted a comprehensive and integrated methodological approach that considers both quantitative and qualitative indicators, encompassing environmental, social, and economic dimensions.

Ntebutsi (2015) reported that many agricultural projects tend to be unsuccessful or inactive once the project period ends, leaving the beneficiaries in poverty and food insecurity due to the lack of sustainability. This highlights the need for evaluating the long-term progress and continuity of agricultural interventions, as well as assessing farmers' adherence to agro-ecological principles for sustainable agriculture. Hence the proposed study aims to fill the gap left by assessing sustainability of agricultural project activities more than 5 years from accomplishment of the project. This study explored the extent to which agricultural technologies comply with agro-ecological principles using ACT tool. ByT program is the case study project which is an agriculture project that has 5 years since it has ended. By bridging this research gap, we can gain deeper insights into the true sustainability of these technologies and develop informed strategies for promoting sustainable agricultural practices in the future.

1.3 Justification of the Study

Based on the problem statement, this study enables to come up with information on the sustainability of agricultural technologies brought by Bustani ya Tushikamane Program and on the compliance of those technologies to the agro ecological elements. The outcomes of this research will contribute to the existing body of knowledge on sustainable agriculture technologies, provide practical insights to beneficiaries and other stakeholders for decision-making processes, and facilitate the transition towards more sustainable agricultural systems. The study is linked with the national agriculture policy of 2013 with the mission to deliver quality agriculture and cooperative services with a goal to developing an efficient, competitive and profitable agricultural industry that contributes to the improvement of the livelihoods of Tanzanians and attainment of broad-based economic growth and poverty alleviation (URT, 2016). Besides, the study is in line with some sustainable development goals such as ending poverty, zero hunger reduction and combating climate change as it is considered as a main strategy which aim to sustainable management of environment and resources and the Tanzania development vision 2025 which aims to ensure environmental sustainability (UN, 2015).

1.4 Objectives of the Study

1.4.1 General Objectives

The main objective of the study is to assess sustainability of agriculture technologies introduced through agricultural interventions a case of ByT program.

1.4.2 Specific Objectives

i) To assess sustainability index of the agriculture technologies brought by ByT.

ii) To determine factors affecting sustainability of agriculture technologies.

iii) To assess the extent at which ByT technologies comply with the agro-ecology principles.

1.5 Research Questions

1. How sustainable are the agricultural technologies brought by ByT? This research question aims to assess the level of sustainability achieved by the agricultural technologies implemented by ByT. It involves evaluating the environmental, social, and economic aspects of these technologies to determine their overall sustainability.
2. What are the agriculture technologies brought by ByT? This research question seeks to identify and describe the specific agricultural technologies that have been brought forth by ByT. It involves documenting and explaining the various techniques, practices, or innovations that ByT has introduced in the agricultural sector.
3. What are the factors that influence sustainability of such agriculture technologies? This research question aims to explore the factors that affect the sustainability of the agricultural technologies implemented by ByT. It involves identifying and analyzing variables such as farmer behavior, resource availability, market conditions, and socio-cultural aspects that impact the long-term viability and success of these technologies.
4. Have the agricultural activities complied with agro ecological principles? This research question focuses on evaluating whether the agricultural activities promoted or supported by ByT align with agroecological principles. It involves assessing whether the practices employed by ByT and adopted by farmers adhere to principles such as biodiversity conservation, soil health improvement, reduced chemical inputs, and ecosystem resilience.

1.6 Theoretical Framework

This study is guided by the Driving force, Pressure, State, Impact and Response (DPSIR) model (OECD, 1998) as modified by (Rao and Rogers 2006). The DPSIR model envisages the causal-effect relationship of state to response. The state indicators show current conditions of the environment (observed). Impact indicators describe ultimate effects of changes of state (such as environmental, economic and social changes). The chain of causal links is therefore driving forces, that is, the underlying causes (human activities as agricultural practices) to pressures, that is, the activities affecting environment directly (CO_2 emissions, using up of scarce farm resources) to state (soil fertility, water availability) to impacts (reduced yield, resurgence in pest population, social equality) to responses (new policy, agriculture projects).

1.7 Conceptual Framework

The research was conducted with the underlying principles of sustainable development as its guiding framework. It consisted of dependent variable, independent variables and intermediate variables as shown in Figure 1.1. Where by the dependent variable is sustainability and can be affected by three interconnected dimensions: environmental, social, and economic factors. These dimensions are mutually dependent and must be balanced to achieve sustainability (Waas *et al.*, 2014). Environmental sustainability focuses on preserving and enhancing natural resources, reducing pollution, and mitigating climate change. Social sustainability emphasizes equity, inclusivity, social justice, and the well-being of communities which can be influenced by factors such as (engagement, empowerment level of education) (Iyabano *et al.,* 2016). Economic sustainability involves promoting long-term economic growth, improving resource efficiency, and fostering equitable distribution of wealth.

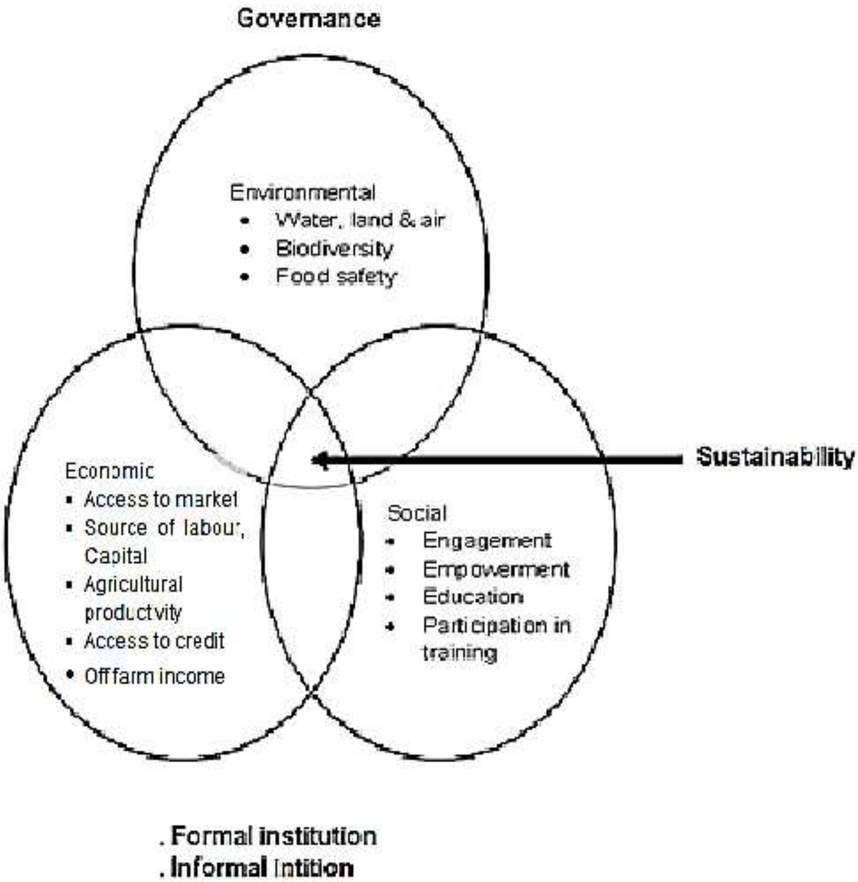

Figure 1.1: Conceptual framework (source; Author)

Additional factors that can affect our dependent variable include formal institutional variables, informal institutions, and governance, among others. These factors may affect the independent variables or the dependent variable directly such as government policies such as “Kilimo kwanza” can affect sustainability of the agriculture project as it keeps on emphasizing on awareness of agriculture.

1.8 Study Limitations

The study was limited by scope and generalizability since the study was conducted on a specific geographic area hence the result can be used in areas with similar geographic and culture characteristics. Also, unwillingness of some respondents to provide reliable information this is due to them expecting to receive funds after the study.

1.9 Description on Organization of Dissertation

The dissertation is organized according to the guidelines for preparation and submission of dissertations fifth edition prepared by SUA. Where the first chapter includes the general introduction and the papers in chapter two and three are organized in form of guideline for authors in Tanzania Journal of Agricultural Sciences, chapter four consist of general discussion and chapter five general conclusion and recommendation.

CHAPTER TWO

2.0 Factors Affecting Sustainability of Agricultural Technologies in Tanzania: A Case of Bustani ya Tushikamane (ByT) Project in Morogoro Region

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Abstract
Sustainability of agricultural technologies is crucial for improving farmers' livelihoods, food security and poverty reduction. Most agricultural projects tend to be ultimately inactive as they end leaving their beneficiaries poor and food insecure due to unsustainability of the projects. The study on which this paper is based assessed sustainability of agricultural technologies and factors affecting it. The study employed cross-sectional research design. Data were collected from 90 respondents using a questionnaire. Descriptive and ordinal logistic regression analyses were done. Factors like market availability ($p = 0.000$), training ($p = 0.021$), and cost of the agricultural technologies ($p = 0.000$) significantly predicted the likelihood of sustainability of agricultural technologies at 5% level of significance. It is concluded that training, market availability, and cost of introduced agriculture technologies are crucial factors influencing sustainability of agricultural technologies. For increased sustainability of agricultural technologies, it is recommended that introduction of agricultural

technologies should be utilizing locally available resources to minimize cost of the technologies.

Keywords: Agricultural technologies, Sustainability, Small-scale farmers.

2.1 Introduction

Human population growth has exerted pressure on the environment and food requirement to feed the population. Human population causes environmental degradation, soil erosion, shortage of agricultural land, and water scarcity leading to demand for sustainable agricultural technologies to reduce the effects (Nazu *et al.,* 2021). Agriculture, as the world's main source of food, requires sustainable agricultural technologies to protect the environment while increasing production (Santiteerakul *et al.,* 2020). Improved agricultural technologies have received attention as a way to address low production, climate challenges, and increasing population challenges in both developed and developing countries (Ochieng *et al.,* 2021). Farmers need to increase production of food and income while optimizing practices, inputs and conserving the environment. To sustain food production, farmers need to adopt and sustain agricultural technologies that are viable and reduce cost to the farmers through maximizing uses of locally available resources (Ochieng *et al.,* 2021, and Yusuf *et al.,* 2021). Sustainability of agricultural technologies helps to reduce poverty and increase income by providing employment opportunities. However, the adoption and sustainability of various agricultural technologies in Sub-Saharan African countries, including Tanzania, are still low (Muhonja, 2017). This stimulated governments and non-governmental organizations to introduce agricultural technologies with lower impact on the environment and biodiversity, and with minimum inputs with higher yield.

Agricultural technology is defined as the knowledge or information that allows different agricultural activities to be done more easily (Muhonja, 2017). These are mainly done in terms of physical activities or methods of organization to simplify work. Therefore, in this study agricultural technology is defined as the application of different techniques to control the growth and harvesting of vegetables (Yusuf *et al.,* 2021). The technology should have a direct benefit to the farmers in terms of production, and conserving the soil so that it can be sustainable. Sustainability is the ability of fulfilling the needs of the current generations without compromising the needs of future generation while ensuring a balance between economic growth, environmental care and social well-being (Setsoafia *et al.,* 2022). Sustainability is simply the ability to maintain or support a process over time. It consists of three pillars economy, society and the environment. Agricultural technologies will be sustainable if the farmer has the right training, information, clear goals from government policies and profitability of the technologies (Xie, H., and Huang, Y, 2021). Where benefits of agricultural technologies do not accrue to farmers, their sustainability will be low. Agricultural technologies' characteristics like complexity, observability and compatibility, and divisibility affect their sustainability. Farmers are encouraged to sustain agricultural technologies with sufficient information for technology dissemination, technologies that lower cost of production, availability of extension services to explain the merits of the technologies to the famers, technologies that are participatory to farmers, (Xie, H., and Huang, Y, 2021, Nazu *et al.,* 2021, Afrous and Abdollahzadeh, 2011a). An agricultural technology is most likely to be sustainable when its benefits (socially, economically and environmentally) are quickly realized by small-scale farmers.

"Bustani ya Tushikamane (ByT)" is a grassroots programme which later led to formation of Sustainable Agriculture Tanzania (SAT), which is based in Morogoro Region. ByT aimed to introduce organic agricultural technologies to small scale farmers. SAT introduced agricultural technologies that encourage production of organic vegetables such as cabbage, pea leaves, Chinese leaf, tomatoes and amaranth. The mission of SAT is to provide networking, promotion, advocating, undertaking and facilitating sustainable agricultural technologies through research, dissemination and application in Tanzania (SAT, 2017). The main aim of SAT is to improve food security, reduce poverty by offering agricultural technologies packages, and guide small-scale farmers to increase

production through employing sustainable agricultural technologies to improve livelihoods. The ByT programme was started as a grassroots project to help small-scale farmers from Mvomero, Morogoro District and Morogoro Municipality.

Small-scale farmers' livelihoods are improved through agricultural technologies that help to improve production and protect natural resources, increase profit, increase soil fertility, and improve food quality and small-scale farmers' income. It is important to concentrate on sustainability of introduced agricultural technologies for land improvement and small-scale farmers' livelihoods (Afrous and Abdollahzadeh, 2011a). Sustainability of the agricultural production technologies is crucial for improving farmers' livelihood and poverty reduction. This paper therefore assesses the extent to which the introduced agricultural technologies in the study area are sustainable, and the factors influencing the sustainability a time after the completion of the project.

2.2 Methodology

2.2.1 Study area

Mvomero District, Morogoro Rural District, and Morogoro Municipality were purposively selected because ByT project had been being implemented in the districts since 2009. The districts lie within longitudes 37˚25'00"E, 37^{0}68'12" E and 37˚40'14"E and within latitudes 6˚19'59"S, 6^{0}78'00'S and 6˚49'49"S in that order (URT, 2015). The project covers 14 villages and 15 vegetables farmer groups each with 6-40 members. Two (2) of the groups are in Mvomero District; 5 groups are in Morogoro Rural District; and 8 groups are in Morogoro Municipality. A large part of the area is warm and semi-tropical, characterized by an average annual rainfall range of 487-1951 mm. The study area was chosen since it is a potential area for agriculture as the main source of income (URT, 2017).

2.2.2 Study design

In this study, a cross-sectional research design was used. The design allows a researcher to compare many different variables at the same time (Levin, 2014) which is pertinent to this study which aimed to compare different variables and was a population-based study. The design allows to make inferences about the population of interest at one point in time (Lavrakas, 2008).

2.2.3 Population, sample size and sampling procedures

The study population consisted of all group members involved in the ByT programme. The programme consisted of 15 groups with at least 6-40 group members, from three districts and 14 villages in Mvomero District, Morogoro Municipality, and Morogoro Rural District. Seven farmer groups were purposively selected based on them having been in the programme since its inception. In this study, proportionate stratified sampling was used to select respondents involved in the *Bustani ya Tushikamane* programme.

The sample size was first obtained by the Neuman formula (2000) which is $n = \frac{Ncv^2}{cv^2+(N-1)e^2}$. Where: n = sample size, N = Population size, e = Error term and cv = coefficient of variation, where: N = 825 e = 0.05 and cv = 0.5. Therefore,

$$n = \frac{825\ (0.5)^2}{(0.5)^2+(825-1)0.05^2}$$

n = 90

The following formula was used to determine number of respondents from each group in order to ensure equal representation of respondents:

$$n_i = n_{(\frac{N_i}{N})} \text{…………………………………….. Equation 1}$$

Where:

n_i = Sample selected from the group,

n = Total sample size,

N_i = Total group members, and

N = Total population from all the groups.

Table 2.1: Number of respondents selected from each village/ group

District	Ward	Village/Street	Group name	Number of group members	Number of respondents
Mvomero		Mgeta	Tughetse	33	17
		Towelo	Maendeleo	18	9
Morogoro Municipality		Mwanzo Mgumu	Twawosa	19	10
		Mangala	Lamka	28	15
Morogoro Rural		Kibuko	Muungano	23	12
		Mkuyuni B	Twiyame	11	6
		Luhololе	Jitegemee	40	21
Total				**172**	**90**

Then, a list of farmers involved in the ByT programme was obtained from the implementing organization (SAT). After obtaining the sub-samples indicated in Table 2.1, the “=Rand ()” command in Microsoft Excel was used to generate random numbers for each of the seven (7) groups. Group members whose serial numbers corresponded with some of the random numbers that were generated were selected and requested to be interviewed for data collection for the research.

2.2.4 Data collection

Data were collected through a questionnaire. Questionnaires were assigned to the farmers who participated in ByT program to collect quantitative data on socio-economic characteristics, sustainability and factors affecting sustainability. Secondary data such as report of ByT was used to understand the nature and assist in prior preparation of questionnaire.

2.2.5 Data analysis

The data collected using the questionnaire were coded and analysed using Statistical Package for Social Sciences (SPSS) Version 20. Data cleaning was first done to ensure quality. Sustainability was measured by a sustainability assessment tool according to the procedures of measuring sustainability provided by OECD (2001). The dependent variable, sustainability index, was captured as a categorical variable. According to Munyaneza (2018), the sustainability index was generated using normalized indicators for environmental indicators, social indicators, and economic indicators. Sustainability was obtained by first selection of relevant indicators (social, environmental and economic) which were obtained from literature, brainstorming and discussions with project implementers. Then indicators were measured, normalized and lastly aggregation of indicators in to sustainability indices. According to Afrous and Abdollahzadeh (2011), the generated sustainability indices were categorized into low sustainability(< 0.33), medium sustainability(0.33 ≤ and < 0.66), and high sustainability(≥ 0.66). Frequencies and percentages were used to describe the level of sustainability of agricultural technologies.

Factors affecting sustainability were analysed by ordinal logistic regression since our dependent variable has ordinal responses (lower to higher) with categorical data. Where different factors obtained from literatures, brainstorming and consulting project implementers were collected. According to Schreiber-Gregory and Jackson (2017), then multicollinearity was tested to avoid negative impact on the analysis. Equation 2 is presented hereunder, based on Singh *et al.* (2020) who assert that ordinal logistic regression model with more than one predictor variables can be written as:

$$logit\big(P(Y \leq j)\big) = \beta_{j0} + \beta_{j1x_1} + \cdots \ldots \ldots \ldots + \beta_{jpx_p} \ldots\ldots\ldots\ldots \text{Equation 2}$$

Where:

$logit(P(Y \leq j))$ is the cumulative probability of the farmer to fall under a certain sustainability level*,*

B_{j0} are the respective intercept parameters; β_j is a vector of regression coefficients corresponding to sustainability, and

$X_{1,}$ X_2 , and X_p are the predictors or independent variables included in the model as shown on Table 2.2.

Table 2.2: Variables included in the model

Variables	Types	Description of the variable
Sustainability	Categorical	1 = Lower sustainability 2 = Medium sustainability 3 = High sustainability
Sex	Dummy	Gender of household head
Market	Dummy	The availability of reliable market for organic products
Training	Dummy	Household received training on organic farming
Technology availability	Dummy	Availability of technology introduced
Technology cost	Dummy	Cost of using the organic technologies is it cheap or expensive

2.3 Results and Discussion

2.3.1 Socio-economic characteristics of the respondents

Table 2.3 shows the comparison of socio-economic characteristics of respondents and level of sustainability of ByT technologies. The results showed that respondents who were older had higher sustainability compared to younger respondents. This implies that older people had adopted ByT agricultural technologies more compared to younger ones. This is because elder people are mainly involved in agricultural production that makes them regard introduced agricultural technologies as opportunities to them, compared to younger ones who are reluctant to be involved in agriculture but are mainly involved in other income generating activities. These results are similar to results by Usman (1997) who reported that younger generation people are reluctant to do farm work and that they are rather involved in other income generation activities. The results in Table 2.3 show that women have higher sustainability (64%) on the agriculture technologies in comparison to men. Women in rural areas are the main producers of family food that makes them adopt agricultural technologies for a long time. Introduction of improved agricultural technologies helps women in family food production that makes the technologies more sustainable to women compared to men. These findings are consistent with findings by Setsoafia *et al.* (2022) who reported that women are more likely to adopt and sustain agricultural technologies to increase productivity.

As for the marital status, the results showed that agricultural technologies from ByT adopted by married people were more sustainable (67.3%) (Table 2.3). This implies that technologies adopted by married people have higher chances of being sustainable than those adopted by other categories of marital status. Married people have more labour to help each other in production and require more food to feed their family; hence adoption of agricultural technologies which improve production makes the family to sustain the technologies for food production.

Table 2.3: Socio-economic characteristics of the respondents and sustainability of technologies

Social Characteristics		**Sustainability index group** Low sustainability	Medium Sustainability	High sustainability
Age groups	18-35	2(13.3)	5(33.3)	8(53.4)
	36-50	3(9.4)	12(37.5)	17(53.1)
	51 and above	6(14)	8(18.6)	29(67.4)
Sex	Male	3(12.0)	6(24.0)	16(58.5
	Female	8(12.3)	19(29.2)	38(64.0)
Marital status	Single	3(25.0)	4(17.4)	3(5.5)
	Married	4(33.3)	12(52.2)	37(67.3)
	Separated	2(16.7)	3(13.0)	9(16.4)
	Widow/Widower	3(25.0)	4(17.4)	6(10.9)
Level of education	No formal education	1(12.5)	4(50.0)	3(37.5)
	Primary education	11(14.1)	19(24.4)	48(61.5)
	Secondary education	2(33.3)	2(33.3)	2(33.3)
Main occupation of the respondents	crop production	12(14.3)	21(25)	51(60.7)
	trade	2(33.3)	2(33.3)	2(33.3)

N.B.: The numbers in brackets are per cents

More than three-fifths (61.5%) of the respondents with primary education had higher sustainability, unlike those with secondary education. This implies that most of the people with primary education level had no other options of being employed in other job categories unlike people with higher level of education; they had to concentrate on agriculture. People with higher education level see agriculture as an occupation with low status; hence, they are reluctant to undertake farming activities, a thing that leads to agricultural technologies introduced being unsustainable.

As for the occupation, the results showed that technologies adopted by respondents who were crop producers had higher sustainability (60.7%) (Table 2.3), which implies that crop producers regarded introduced agricultural technologies as an opportunity to improve production. Small-scale farmers are conscious of technologies which improve their production at minimum costs. The ByT programme has introduced vegetable production technologies which are typical organic with higher production and lower cost of production.

2.3.2 Sustainability of agricultural technologies

The results in Table 2.4 show that technologies introduced under the ByT programme were highly sustainable (60%), followed by medium sustainability (27.8%). This implies that farmers in the project area were able to sustain the introduced agricultural technologies by 60%.

Table 2.4: Level of sustainability

Sustainability index group	Frequency	Per cent
Low sustainability	11	12.2
Medium Sustainability	25	27.8
High sustainability	54	60.0

Farmers in the project area were trained to produce organic vegetables to increase their income. The findings suggest that access to training, participation in demonstration plots, and access to market information improve social networking leading to sustainability of agricultural technologies. Similar results were observed by Ochieng *et al*. (2021) who found that access to training on the demonstration plots, market information and group membership influence sustainability of agricultural technologies. Sustainable Agriculture Tanzania (SAT) under the *Bustani ya Tushikamane* (ByT) programme introduced different agricultural technologies for vegetable production. SAT have been forming farmer groups and training them to use agricultural technologies that are cost-effective so as to reduce cost of production while conserving the environment.

2.3.3 Factors affecting sustainability of agriculture technologies

Factors affecting sustainability of agricultural technologies introduced by ByT were identified. It was reported that attending training, availability of the agricultural technologies, sex of the farmers, cost of the introduced agricultural technologies, and crop market availability predict sustainability of agricultural technologies adopted by farmers. Sustainability was categorized into three categories (Low sustainability, medium sustainability, and high sustainability) in which case high sustainability was a reference category.

Table 2.5: Factors affecting sustainability of ByT sustainable agriculture technologies

Parameter	Estimate	Std. Error	Wald	df	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Lower sustainability	0.648	1.203	0.290	1	0.590	-1.709	3.006
Medium sustainability	3.383	1.257	7.243	1	0.007	.919	5.847
Sex	-0.486	0.619	0.617	1	0.432	-1.699	.727
Market availability	3.000	0.641	21.874	1	0.000	1.743	4.257
Attending training	1.324	0.573	5.343	1	0.021	.201	2.447
Technology availability	0.321	0.617	0.271	1	0.603	-.888	1.530
Technology cost	2.029	0.568	12.757	1	0.000	.916	3.142

The results in Table 2.5 show that technology cost, market availability, and attended training were significantly influencing sustainability of agricultural technologies introduced to small scale farmers. The results show that the costs of technologies introduced to the farmers were significantly predicting the level of sustainability ($p = 0.000$). This implies that change in status on the cost of technologies from cheaper to expensive decreased the likelihood that agricultural technologies would be sustainable. This means that changes in status of agricultural technologies from cheaper to expensive agricultural technologies would restrict farmers from adopting the agricultural technologies, leading to lower sustainability. Expensive agricultural technologies involve different levels of technologies, leading to more cost of practising them. Small-scale farmers capture and adopt agricultural technologies in order to optimize inputs and maximize outputs using locally available technologies that are also cheaper, depending on their level of production. Expensive agricultural technologies hinder sustainability of agricultural technologies. These findings are supported by Thi *et al*. (2002) who reported that farmers prefer agricultural technologies with lower inputs but bring higher benefits and ensure higher productivity.

The results show that markets were positively predicting sustainability of the agricultural technologies introduced in the study area ($p = 0.000$). This implies that, change on status of market for the crops produced from market available to non-available the level of agriculture technologies sustainability introduced to the farmers' decreases. This means that market availability for the crops produced using the introduced agricultural technologies were more likely to influence agricultural technologies sustainability among the small-scale farmers. Small-scale farmers produce at a small-scale with intention to generate income from the crops produced. Market availability will influence the farmer to sustain the agricultural technologies used to produce crops that are easily marketable with good prices. These results are consistent with results by Ochieng *et* *al.* (2021) who reported that market imperfection such as production risk plays an important role in agricultural technology sustainability. Small-scale farmers in the study area were trained and assured for market to the produced organic vegetables that are bought by ByT.

The results show that attending training was positively predicting the likelihood that agricultural technologies adopted by farmers would be sustainable (p = 0.021). This implies that change in status on farmers attending training to not attending training decreased the likelihood that agricultural technologies would be sustainable. This suggest that, farmers who had attended training for specific agricultural technologies were more likely to use relevant technologies in more sustainable ways compared to those who had not attended training. Training involved facilitating farmers to use the technologies, both agronomic practices and technical know-how, and making farmers knowledgeable on planting techniques, crops rotation, and post-harvest management. These helped farmers to increase yield, improve their income, food security, and protect their crops against hazardous weather conditions and pests. The findings are in conformity with Xie and Huang (2021) and Mutiso (2015) who reported that training farmers on agricultural technologies improves farmers' knowledge, access to information and reduces uncertainty on production. ByT had been training farmers on production of organic vegetables, involving making compost, use of farm yard manure, and raised seed beds for vegetable production. These findings are consistent with arguments of FGD participants who reported that the ByT programme had trained them to use farmyard manure and compost manure which had helped them increase volumes of organic vegetables they produce.

2.4 Conclusions and Recommendations

The study aimed to determine levels and factors influencing sustainability of agricultural technologies among small-scale farmers under the ByT programme. Based on the study findings, it is concluded that technologies introduced were highly sustainable. It is further provided insight that market availability, training, and the cost of introduced technologies influence sustainability of agricultural technologies. The ByT programme plays a crucial role in provision of market for the vegetables produced, offering training on good agricultural practices, and provision of cheaper agricultural technologies which ensure greater yield among beneficiary small-scale farmers. It is implied that factors like training, market of the produced crops and the cost of introduced agricultural technologies offer restrictions and incentives necessary for agricultural technologies to be sustainable among small-scale farmers.

Based on the study findings and conclusions, the study recommends to the Ministry of Agriculture and Co-operatives and to non-governmental organization that agricultural technologies introduced to the farmer should be of lower operational costs with relatively high yield to reward small-scale farmers to increase sustainability of the agricultural technologies. Securing market for the crop products produced using the technologies, the technologies will help improve wellbeing and influence the sustainability of the agricultural technologies. In addition, the study recommends that further research should be done in the study area on the role of agricultural technologies in improving livelihoods across the land catena of Uluguru Mountains.

References

Afrous, A., & Abdollahzadeh, G. (2011a). Assessing Factors Affecting on Sustainability of Agriculture A Case of Dezful County , Southwest Iran. *Australian Journal of Basic Ansd Applied Sciences* 5(11): 1444–1449.

Afrous, A., & Abdollahzadeh, G. (2011b). *Assessing Factors Affecting on Sustainability of Agriculture A Case of Dezful County , Southwest Iran* 5(11): 1444–1449.

Bryman, A. (2008). *Social Researchh Methods* (4th ed.). education. OXFORD [www.academia.edu › 35170331 › Alan_Bryman_Social] site visited on 12/09/2022.

Lavrakas, P. (2008). *Encyclopedia of Survey Research Methods.* 4th Ed. Sage Publications, Inc. 1072pp.

Levin, K. A. (2014). *Study Design III : cross-sectional studies Study design III : Cross-sectional studies* (Issue February). https://doi.org/10.1038/sj.ebd.6400375

Muhonja, C. V. (2017). *Determinants of Adoption of Agricultural Technology in Kenya :* Strathmore University.

Munyaneza, C. (2018). *Assessing Sustainability of Smallholder Dairy and Traditional Cattle Milk Production Systems in Tanzania*. Disserta for Award Degree of Sokoine University of Agriculture. 191pp.

Mutiso, F. M. (2015). *Determinants Influencing Sustainability of Agricultural*. Disserta for Award Degree of University of Nairobi.

Nazu, S. B., Khan, M. A., Saha, S. M., Hossain, M. E., & Rashid, M. H. A. (2021). Adoption of improved wheat management practices: An empirical investigation on conservation and traditional technology in Bangladesh. *Journal of Agriculture and Food Research* 4: 1-11.

Ochieng, J., Afari-sefa, V., Muthoni, F., Kansiime, M., Hoeschle-zeledon, I., Bekunda, M., Thomas, D., Ochieng, J., Afari-sefa, V., Muthoni, F., & Kansiime, M. (2021). Adoption of sustainable agricultural technologies for vegetable production in rural Tanzania : trade- offs , complementarities and diffusion. *International Journal of Agricultural Sustainability* 0(0): 1–19.

OECD. (2001). Adoption of Technologies for Sustainable Farming Systems. *Wageningen Workshop Proceedings*. 149pp.

Santiteerakul, S., Sopadang, A., Tippayawong, K. Y., & Tamvimol, K. (2020). The role of smart technology in sustainable agriculture: A case study of wangree plant factory. *Sustainability (Switzerland)* 12(11): 1–13.

SAT. (2017). An evaluation of the program Comprehensive Evaluation of the Bustani. Routledge. *In Farming Food and Nature* 2017:107-115.

Setsoafia, E. D., Ma, W., & Renwick, A. (2022). Effects of sustainable agricultural practices on farm income and food security in northern. *Agricultural and Food Economics* 2022: 1–15.

Schreiber-Gregory, D. N. and Jackson, H. M. (2017). Multicollinearity: What is it, Why should we care, and how can it be controlled? paper 1404-2017. Foundation/National University. 12pp.

Singh, V., Dwivedi, S. N., & Deo, S. V. S. (2020). Ordinal logistic regression model describing factors associated with extent of nodal involvement in oral cancer patients and its prospective validation. *BMC Medical Research Methodology* 20(1): 1–8.

Thi, T., Chi, N., & Yamada, R. (2002). Factors affecting farmers ' adoption of technologies in farming system : A case study in OMon district , Can Tho province , Mekong Delta . *Japan International Research Center for Agricultural Sciences* 10: 94–100.

Usman, A. (1997). *Socio-Economic Factors Influencing Farmers' Adoption of A New Technology : The Case Study on The Groundwater Pump Irrigation Rn Lombok , Tndonesta Faculty of Agricultural And Natural Resource Sciences*. Disserta for Award Degree of The University of Adelaid. 187pp.

Xie, H., & Huang, Y. (2021). Land Use Policy Influencing factors of farmers ' adoption of pro-environmental agricultural technologies in China : Meta-analysis. *Land Use Policy*, 109: 1–13.

Yusuf, R., Fuadi, I., Swastika, S., & Sinaga, H. (2021). The Study of Economic Factors Affecting Sustainability of Rice Farming. *Advances in Biological Sciences Research* 13: 533–540.

CHAPTER THREE

3.0 Compliance of Agriculture Practices with the Agro Ecology Principles: A Case of Bustani ya Tushikamane (ByT) Project in Morogoro Region, Tanzania

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Abstract

Agro-ecological practices are important for ensuring a life sustaining agricultural system that is more resilient and increases agricultural production, while conserving natural resources and biodiversity. Agro ecology has been presented as a reliable alternative to conventional agriculture. This study was done to assess how the agriculture practices that were passed on to farmers during the execution of the ByT project in Morogoro region comply with the agro ecological principles. This study was conducted using a cross-sectional research design. Data were collected from 90 respondents using a questionnaire and interviews. The quantitative data was analyzed through descriptive analysis using Agroecological Criteria tool (ACT), while the qualitative data was analyzed through thematic coding. Results show that the agricultural practices introduced by ByT have complied with the agro ecological principles in all levels such as efficiency (86%) this refers to practices that reduce input consumption (e.g. water, pesticides, and fertilisers) and improve crop productivity. The majority of farmers are implementing various agroecological practices, such as biological pest management (92%), crop rotation (91.1%), the utilization of organic fertilizer (80%), and intercropping (87.8%). It concludes that to ensure sustainability of agricultural technologies efficiency and participatory approach and use of local perspectives is important in introducing modern technologies.

Keywords: Agro ecological practices, Sustainability, Small-scale farmers.

3.1 Introduction

Today's food and agricultural systems have succeeded in supplying large volumes of food to global markets. However, high-external input, resource-intensive agricultural systems have caused massive deforestation, water scarcities, biodiversity loss, soil depletion and high levels of greenhouse gas emissions, posing a serious threat to sustained crop productivity and food systems. Despite significant progress in recent times, hunger and extreme poverty persist as critical global challenges. Even where poverty has been reduced, pervasive inequalities remain, hindering poverty eradication (FAO, 2018). This makes it impossible to look at food, livelihoods, health and the management of natural resources separately. Embracing systems thinking through holistic approaches is needed to address these complex and interdependent challenges. According to the FAO (2022), the accomplishment of eradicating poverty and attaining zero hunger, alongside fostering inclusive growth and effectively managing the Earth's natural resources in the face of climate change and biodiversity decline, can only be achieved by embracing comprehensive and interconnected strategies that uphold human rights.

Produce growers are increasingly expected to not only provide safe, healthy, and affordable food to consumers, but to do so in sustainable ways that reduce or reverse the deleterious effects of intensive, industrial agricultural practices on the environment. Many on-farm practices that have a positive impact on the environment, such as cover cropping, diverse crop rotations, intercropping and non-crop vegetation management, have also been shown to benefit farm productivity. The sustainability of agricultural technologies highly requires the farmer to receive the right training, information, clear goals from government policies and profitability of the technologies (OECD, 2001).

To reverse the damage brought by agricultural activities farmers need to adapt sustainable ways of farming that improve the resilience to climate change, prevent erosion, reduce contamination of water and improve soil health. Agro-ecological practices offer a sustainable farming technique that protects environment from pollutions and other impacts caused by agricultural activities. These practices are such as agricultural diversity, reduced tillage, crop rotation, carbon sequestering, intercropping, composting and the use of botanical pesticides for pest control (Imogen, 2020).

The adoption of agro ecological practices will optimize the interactions between plants, animals, humans and the environment while taking into consideration the social aspects that need to be addressed for a sustainable and fair food system. According to research carried out by Mdee *et al*. (2017) in the Uluguru Mountains of Tanzania, it was revealed that farmers willingly embrace agro-ecological practices. These practices have been instrumental in enhancing the profitability and well-being of their livelihoods. Additionally, the adoption of agro-ecology has yielded positive outcomes in terms of reducing detrimental agricultural practices like veld fires, deforestation, and conventional plugging. However, the study also stated that there is institutional resistance from some government agencies to considering alternatives forms of agriculture and concluded that agro ecology has considerable potential to support inclusive and green agricultural transformation in Sub-Saharan Africa, and requires far greater attention from donors and policy-makers.

Bustani ya Tushikamane (ByT) project conducted by Sustainable Agriculture Technology (SAT) had the objective of introducing organic agricultural technologies to small scale farmers. The mission of SAT is to provide networking, promotion, advocacy, undertaking and facilitating sustainable agricultural technologies through research, dissemination and application in Tanzania (SAT, 2017). ByT programme is a SAT project implemented in Mvomero district, Morogoro Rural district and Morogoro Municipality. The primary objective of the SAT is to enhance food security and alleviate poverty by providing agricultural technology packages, while also assisting small-scale farmers in increasing production through the adoption of sustainable agricultural technologies, thereby improving their livelihoods.

In this study, we will employ a comprehensive approach, combining literature reviews, field observations, and data analysis to assess the compliance of agriculture practices with agroecology principles. We will examine various aspects, including soil management, water conservation, pest control, crop diversity, and resource utilization, among others. Understanding the level of compliance with agroecology principles is essential to provide a comprehensive overview of the current state of compliance with agroecology principles and identify potential barriers and opportunities for improvement. It can serve as a valuable guide for policymakers, farmers, and stakeholders involved in agricultural decision-making, helping to promote and support the transition towards more sustainable and resilient food production systems.

3.2 Methodology

3.2.1 Study area

This study was conducted in Morogoro at Mvomero District, Morogoro Rural District, and Morogoro Municipality as shown in Fig 3.1. The area was purposively selected because the Bustani ya Tushikamane project was implemented in these areas since the year 2009 and also because no other project was implemented by the organization in those areas (SAT, 2017). The districts lie within longitudes 37˚25'00"E, 37^{0}68’12” E and 37˚40'14"E and within latitudes 6˚19'59"S, 6^{0}78’00’S and 6˚49'49"S respectively (URT, 2015). A large part of these areas is warm and semi tropical, characterized by an average annual rainfall range of 487-1951 mm (URT, 2017).

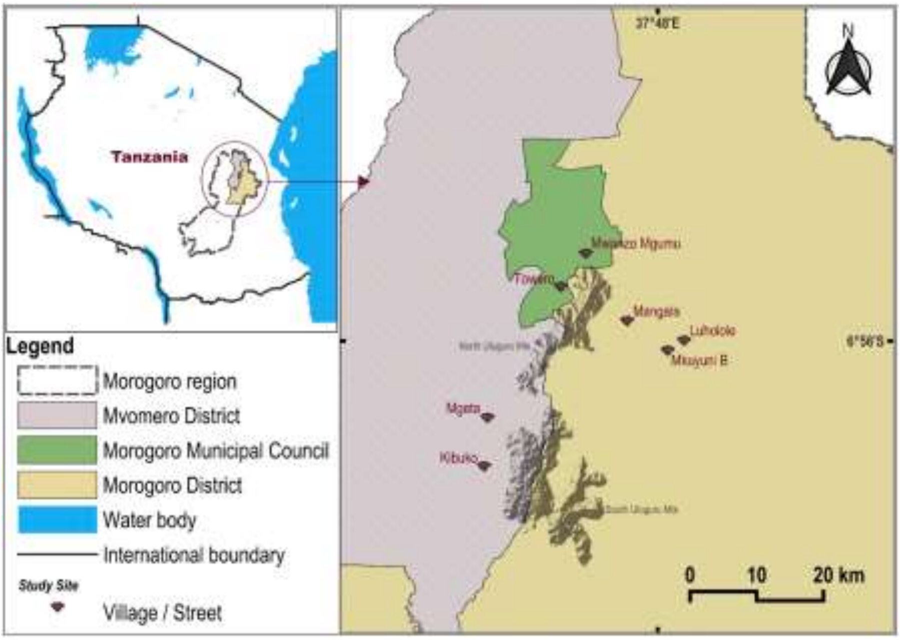

Figure 3.1: Map of Mvomero District, Morogoro Rural District, and Morogoro Municipality showing the study area.

3.2.2 Study design

The research design used in this study was a cross-sectional design. This is the design whereby data is collected from many different individuals at a single point in time. In cross-sectional research, you observe variables without influencing them. This study design was selected because it is effective when examining the prevalence of some outcome at a certain moment in time (Thomas, 2022).

3.2.3 Population, sample size and sampling procedures

The study population consisted of all group members involved in the ByT Programme. The programme consisted of 15 groups with at least 6-40 group members, from 3 districts and 14 villages in Mvomero District, Morogoro Municipality, and Morogoro Rural District. Seven farmer groups were purposively selected based on them having been in the programme since its inception. In this study, proportionate stratified sampling was used to select respondents involved in *Bustani ya Tushikamane* programme.

The sample size was first obtained by the Neuman formula (2000) which is $n = \frac{Ncv^2}{cv^2+(N-1)e^2}$. Where; n=sample size, N= Population size, e= Error term and cv= coefficient of variation. Given, N = 825 e = 0.05 and cv = 0.5

$$n = \frac{825\ (0.5)^2}{(0.5)^2+(825-1)0.05^2}$$

n = 90

In order to ensure equal representation of respondents from each group, proportionate stratified sampling was used, using the following formula:

$$n_i = n_{(\frac{N_i}{N})} \text{..................................... Equation 1}$$

Where:

n_i = Sample selected from the group

n = Total Sample Size

N_i = Total group members

N = Total population from all the group

Table 3.1: Number of respondents selected from each village/ group

District	Village/Street	Group name	Number of group members	Number of respondents
Mvomero	Mgeta	Tughetse	33	17
Morogoro Municipality	Towelo	Maendeleo	18	9
	MwanzoMgumu	Twawosa	19	10
	Mangala	Lamka	28	15
Morogoro Rural	Kibuko	Muungano	23	12
	Mkuyuni B	Twiyame	11	6
	Luholole	Jitegemee	40	21
Total			**172**	**90**

Then a list of farmers involved in ByT programme was obtained from implementing organization (SAT). After obtaining the sub-samples indicated in Table 3.1, the “=Rand ()” command in Microsoft Excel was used to generate random numbers for each of the seven (7) groups. Group members whose serial numbers corresponded with some of the random numbers that were generated were selected and requested to be interviewed for data collection for the research.

Three focus group discussions (FGDs) were conducted from the ByT participants' one from each district where ByT programme was being implemented. In this regard, one FGD was conducted at Mvomero, one at Morogoro Rural and one at Morogoro Municipality. Six to eight respondents were selected for each FGDs considering gender and age (Bryman, 2008). The key informant's interview included 3 project staffs and 1 project manager.

3.2.4 Data Collection

Data were collected through a questionnaire survey, interview and focus group discussion. Quantitative data was obtained from questionnaire administered to project participants. Qualitative data on agriculture practices was obtained from interview checklist, focused group discussion and secondary data from reviewing project reports.

3.2.5 Data analysis

Qualitative data collected through group discussion and interview was analyzed through content analysis where texts were broken down into manageable codes according to the coding rules and results were analyzed to draw conclusion. Qualitative data was cleaned to ensure quality. Percentages and frequencies were run to determine social economic characteristics, agriculture practice, extent of practicing, activities conducted to ensure sustainability and challenges faced in ensuring sustainability of the agriculture technologies.

ACT (Agro-ecology criteria tool) was used to determine the compliance of the agriculture technologies to the 10 FAO agro-ecological elements and the five levels of food system changes where scores in terms of percentage were obtained to give descriptive analysis on how the project performed on each level.

3.3 Results and Discussion

3.3.1 Social economic characteristics of the respondents

From Table 3.2 it shows most of the respondents were elder farmers (47.8%) at the age of 51 and above followed by farmers at the age of 36 to 50 (35.6%) whereas fewer farmers belonged to the age group of 18 to 35 years (16.7%). This brings the attention to low participation of youths in agriculture who are more interested in working in formal offices rather than pursuing agriculture. Previous research (Kritzinger, 2002; Mibey, 2015; Njeru, 2017) on youth in agriculture affirms the negative perceptions that young people have towards agriculture and farm life in general. Furthermore, it can be confirmed that young people’s non-participation in the agricultural sector is perpetuated not only by low financial income, or the apparent challenges of the unavailability of factors of production, or poor access to resources (such as land, physical capital and other inputs), but also by their attitudes and perceptions (Njeru, 2017). This makes many young people to move to urban or cities in search of opportunities where they end up crowding the cities making opportunities limited. Youth should be encouraged to take advantage of opportunities in agriculture rather than living it to the elder farmers who are becoming less productive and are less exposed to innovative ways of conducting agriculture.

Table 3.2: Social-economic characteristics

Social Characteristics		Frequency	Percent
Age groups	18-35	15	16.7
	36-50	32	35.6
	51 and above	43	47.8
Sex	Male	25	27.8
	Female	65	72.2
Marital status	Single	10	11.1
	Married	53	58.9
	Separated	14	15.6
	Widow/Widower	13	14.4
Level of Education	No formal education	8	8.9
	Primary education	78	86.7
	Secondary education	4	4.4
Main Occupation of the respondents	crop production	84	93.3
	Trade	6	6.7

As of sex, women outnumbered the male by 44.4% this is because women are the main producers in the family level. They work on their farms to produce food for the family and even for selling but in most cases, they don’t benefit from it since the men are the ones who do all the planning and they control whatever is obtained from farm which the women work tirelessly. According to Lastarria-Cornhiel (2006), in sub-Saharan Africa where men control most of the land, women's work in high-value cash crops does not guarantee their control over the generated income. This way of production leaves women overburdened with sex specific roles and agricultural roles that can affect their productivity. For sustainable productivity, equal participation by both male and females is of paramount importance.

3.3.2 Agricultural practices implemented in the ByT project area

From the results on agricultural practices implemented by farmers it shows that most of the farmers are practicing the good agro ecological practices as trained during the ByT project. Most farmers (92.2%) adopted the use of biological methods for pest control. This method of pest control is more environmentally sustainable as it protects the biodiversity and the soil health and is even less harmful to the user so the farmer is at a lower risk of health complications caused by industrial pesticides and these biological pesticides are often locally available therefore cheaper in terms of cost. 80% of farmers were found to employ organic fertilizers as part of their agroecology practices. This approach promotes ecosystem services, facilitates soil regeneration, enhances productivity, and fosters sustainability. Additionally, it offers cost advantages compared to alternative methods

Table 3.3: **Agricultural practices implemented in the ByT project area**

ByT technology		Frequency	Percent
Organic fertilizer	Using	72	80.0
	Not using	18	20.0
Terracing	Use terrace	80	88.9
	Not using terracing	10	11.1
Intercropping with other crops	Intercropping	79	87.8
	Not intercropping	11	12.2
Marketing	Marketing of the agricultural produce	80	88.9
	No Market of the agricultural produce	10	11.1
Credit serving group	Member of the group	78	86.7
	Not a member of the group	12	13.3
Biological pest management	Using biological pest	83	92.2
	Not using biological best management	7	7.8
Crop rotation	Doing crops rotation	82	91.1
	Not doing crop rotation	8	8.9
Certified seeds	Using certified seeds	66	73.3
	Not using certified seeds	24	26.7
Irrigation	Irrigate crops	69	76.7
	Not irrigating crops	21	23.3
Water pump	Using water pumps	42	46.7
	Not using water pumps	48	53.3

A good number of farmers were also seen to implement crop rotation (91.1%) and intercropping (87.8%) which are very key in promoting soil health, intercropping with legumes helps making nitrogen available in the soil and hence can be acquired by the plants, it also makes food available because a farmer can plant different crops on the same piece of land. Crop rotation on the other hand is known to be useful in breaking the cycle of pest, reducing soil erosion and improve the health of the soil because the land does not get depleted of the same nutrient.

A study on the determinants of agro ecological practices adoption revealed that the effect of intercropping on soil fertility was good to excellent by all producers who practice the trained agro ecological techniques (Coulibaly *et al*., 2019).

In terms of marketing SAT has played a vital role in ensuring market for the farmers' agricultural produce but the challenge is farmers are producing more than SAT can actually buy therefore it becomes a challenge. Farmers seek for the government to give a chance to the organic growers in local markets to sell their goods as organic and at fair organic prices.

3.3.3 Compliance of agricultural practices to agro ecology

Using the agro ecological criteria tools, in terms of efficiency the score was high (86%), Efficiency involves practices that reduce input consumption such as water, pesticides, and fertilizers while improving crop productivity Wezel *et al*. (2014). Respondents have been observed to have reduced the use of industrial pesticides, herbicides and fungicides and they have switched to the use of bio-pesticides. For example, the use of neem leaves and other botanical pesticides was common among farmers. Farmers have also shown success in reducing seed use through planting seeds using correct spacing. A good number of farmers have transitioned from broadcasting seeds to planting in optimal spacing thus it has improved seed use

Table 3.4: Results for ByT from the agro-ecological criteria tool

Level of transition	Element of transition	Score
Level 1: Increase efficiency of industrial and conventional practices	1.1. Efficiency	86%
Level 2: Substitute industrial or conventional inputs with more sustainable alternatives	2.1. Recycling	50%
	2.2. Regulation and balance	70%
Level 3: Redesign whole agro-ecosystems	3.1. Synergies	50%
	3.2. Diversity	67%
	3.3. Resilience	67%
Level 4: Re-establish connections between growers and eaters, develop alternative food networks	4.1. Circular and solidarity economy	33%
	4.2. Culture and food traditions	100%
	4.3. Co-Creation and sharing of knowledge	100%
Level 5: Rebuild the global food system so that it is sustainable and equitable for all	5.1. Human and social value	83%
	5.2. Responsible governance	80%

At the fourth level, re-establishing connections between growers and eaters and developing alternative food networks is highlighted, including elements; circular and solidarity economies, culture and food traditions, and co-creation and sharing of knowledge. Circular and solidarity economy (33%) element has shown that they have failed to reconnect producers and consumers and provide innovative solution for living within while ensuring social foundation for inclusive and sustainable development. In contrary to that the project has achieved elements such as culture and food traditional (100%) and co-creation and sharing of knowledge (100%) in the same level. Hence the ByT has enhanced inclusion of local perspective of modern technologies (participatory approach) which brings into light demands and requirements of small holder farmers that can increase their productivity (Povageau *et al.,* 2020).

Several practices show that farmers have and are still transitioning from conventional to agro ecology for instance the use of organic fertilizers, biological pest control, compost manure, and mulch.

Farmers are still finding their way through new agro ecological techniques. Some techniques have been adopted more than others for example practices such as zero tillage, carbon sequestering, and the use of green manure are not commonly practiced by the farmers. A group in Mvomero pointed out that it takes time to prepare the bio pesticides and the other commented on getting an alternative to animal manure and the need of more sophisticated ways and technologies to save time.

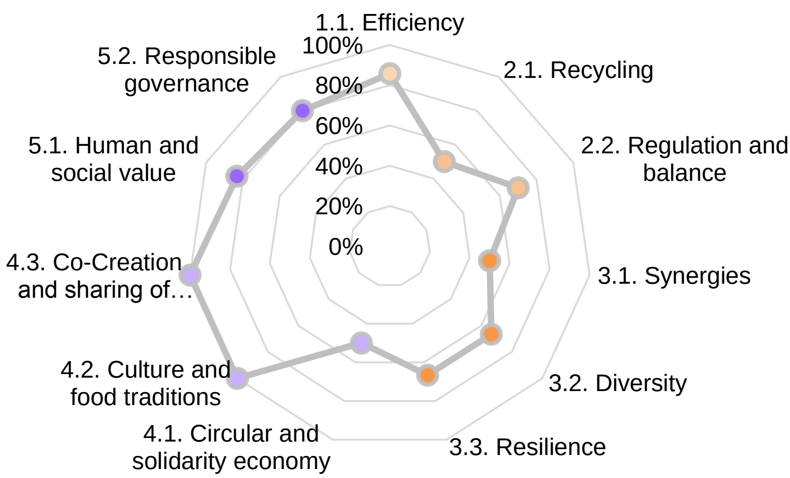

Figure 3.2: Score portfolio for ByT project

3.3.4 Activities conducted to ensure sustainability of the Agricultural technologies implemented

From the responses given by the beneficiaries of the ByT project it has shown that SAT has been doing follow ups over the years which encourages farmers to practice what they have been trained. There are several activities in place to ensure the sustainability of the agricultural technologies implemented including farmers' groups have been provided with smartphones that ease up communication with their experts and can immediately share photos, videos of what is going on at the farm or the challenges they are facing which assists the farmers to get immediate help. A key informant as quoted below supported this;

> *"Organic farming has been such a game changer for myself and my fellow farmers we received these trainings from ByT programme and I am motivated to keep up with organic farming because apart from being trained me and my fellow farmers we have smartphones provided to us in groups where we share our challenges and various observations from the farm and we get timely feedback for example in case of pests and diseases attacking our crops, and other information needed"(key informant, Farmer, Tugese group, Mvomero, August 2022).*

SAT organizes meetings with the farmers whereby serious and deep discussions are held. This creates a space for farmers to speak out the challenges they face when implementing the agro ecology practices, and what they think can be done to assist them in tackling the challenges they face. Farmers have also indicated how important the savings group that SAT have helped them create. One of the key respondents supported this observation as seen from the quote below.

> *"Through ByT programme we have been able to form stable and effective saving groups which assist us in getting inputs on time also from these groups we have also formed credit saving group that help us get loans at affordable rates and making investments such as buying shares." (key informant, Farmer, Twawosa, Mwanzo mgumu, July 2021).*

Making market available for the organic produce from the farmers has also contributed to the sustainability of the project which is one of the biggest setbacks that could completely discourage a farmer to adopt a new technology. Although there is a need for market, SAT has been buying organic products from farmers, this keeps the farmers motivated as they can see the benefits of selling organic produce.

3.3.5 Challenges Faced in Ensuring Sustainable Agricultural Technologies

Fig 3.3 below shows that farmers in the study area faced different challenges in production of vegetables under the ByT programme. The results show that 67.8% of the farmers involved in the ByT programme reported pests and diseases to be the main challenge in sustainability insurance. This could be due to the fact that farmers in this area produce organic vegetables which, among other things, should not be contaminated by industrial chemicals. The ByT programme trained farmers to use organic pest control and organic fertilizers that are different from industrial chemicals which leave harmful chemical residue in plants. Organic pest control stays for at least two to three days and requires reapplication compared to industrial chemicals that leave some harmful chemical residues in the plants (vegetables) for a long time. This was confirmed during FGDs in which the participants reported that organic pest control requires to be applied twice to thrice in a week to ensure that the gardens are safe from pests.

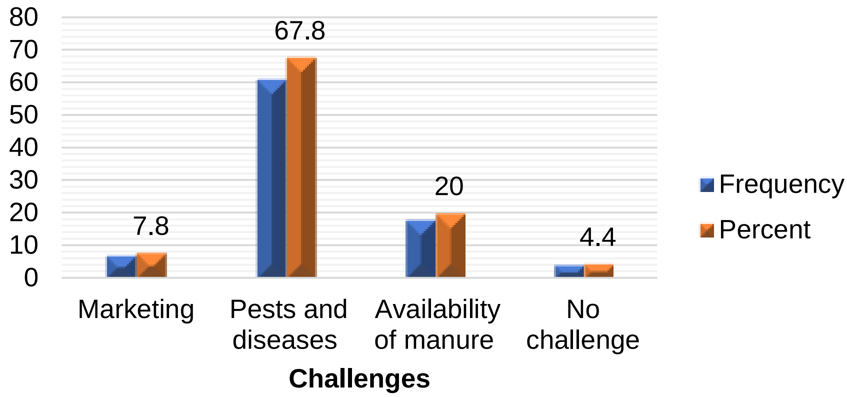

Figure 3.3: Challenges facing farmers under ByT programme

The results showed that farmers had challenges in obtaining manure (20%), which hindered the crops production. Farmers in the study area are not livestock keepers making it difficult for them to obtain manure as needed. This could be due to low integration of both livestock and crops production to provide synergies between crops and livestock. Under agro-ecology, synergies between livestock and crops production are important for biodiversity conservation and crops production. Lack of livestock decreases the availability of manure causing farmers to travel for long distance searching for manure leading to extra cost. FGDs participants at Mgeta village who reported that farmers in that area were not keeping livestock due to the land terrain, making it difficult for them to keep livestock, supported this.

3.4 Conclusion and Recommendation

The study points out that the ByT project has been environmentally sustainable by the way farmers have adopted to agriculture practices that comply with the agro-ecology principles. The complying with agroecological principles means the program offers an agricultural production system that is environmentally friendly and one that protects ecosystem services. From this study results it shows that farmers are transitioning from conventional agriculture to more sustainable agricultural practices like the use of bio pesticide in place of industrial pesticide, the use of organic fertilizer such as manure and other practices such as crop rotation and intercropping. Farmers are more aware of how these practices are important in protecting the health of the soil, protecting their own health and ensures that food production through agriculture is sustainable.

The sustainability of agriculture practices has been a result of farmers actually witnessing how organically produced food is healthy and more profitable since organic produce is sold at a premium price and organic production is relatively cheaper in terms of cost. In addition to farmers being influenced by these factors, SAT has significantly contributed to supporting them. This support includes purchasing their produce and selling them at SAT's organic shop, conducting follow-up visits to provide extension services, providing group leaders with smartphones for easy communication with experts, and organizing farmers into credit savings groups to access inputs on credit. These factors have largely been a contribution to the sustainability of the agriculture practices implemented by the ByT programme.

To ensure that these good agro ecological practices remain sustainable, it is recommended that the market for organic products should be boosted. Market is one of the major reasons a farmer will adopt or abandon agricultural technologies such as these agro ecological practices therefore the government should put policies and action in place to promote markets for organic certified products such that there can be public market areas for organic products. Also, a good amount of effort should be put in research and development to come up with better innovations of these practices such as the availability of well packed organic pesticides which will save time for preparation.

References

Altieri, M. A. (2018). *Agroecology: the science of sustainable agriculture*. CRC Press.

Coulibaly, A., Motelica-Heino, M. and Hien, E. (2019) Determinants of Agroecological Practices Adoption in the Sudano-Sahelian Zone. *Journal of Environmental Protection*, *10,* 900-918. doi: 10.4236/jep.2019.107053.

Coulibaly, A., Motelica-Heino, M., &Hien, E. (2019). Determinants of Agroecological Practices Adoption in the Sudano-Sahelian Zone. *Journal of Environmental Protection*, *10*(7), 900-918.

FAO. (2018). The 10 elements of agroecology: Guiding the transition to sustainable food and agricultural systems. The Food and Agriculture Organization, Rome Italy. ISBN: I9037EN/1/04.18. (http://www.fao.org/documents/card/en/c/I9037EN

International (2017). *What is regenerative agriculture?* Available online at: https://regenerationinternational.org/why-regenerative-agriculture-draft (accessed March, 2000).

Kritzinger, A. (2002). Rural youth and risk society: Future perceptions and life chances of teenage girls on South African farms. *Youth & Society*, *33*(4), 545-572.

Mdeei, A., Wostryii, A. and Coulsoniii, A. (2017) The potential for inclusive green agricultural transformation: creating sustainable livelihoods through an agroecological approach in Tanzania Challenge Paper for Chronic Poverty Advisory Network of Overseas Development Institute http://www.chronicpovertynetwork.org/resources/2016/10/31/compatible-or-contradictorythe-challenge-of-inclusive-structural-economic-and-environmental-transformationRegeneration

Povageau, C., Pondini, S. and Geck, M. (2020). Money flows: What is holding back investment in agroecological research for Africa. 157pp.

SAT. (2017). An evaluation of the program Comprehensive Evaluation of the Bustani. Routledge. *In Farming Food and Nature 2017*, 107-115.

Thomas, L. (2022). *Cross-Sectional Study | Definition, Uses & Examples.* Scribbr. *Retrieved November 29,* 2022, from https://www.scribbr.com/methodology/cross-sectional-study/

URT, United Republic of Tanzania (2017). National Five Years Development Plan 2016/17–2020/21: Nurturing Industrialization for Economic Transformation and Human Development. 293pp

Wezel, A., Bellon, S. and Doré, T. (2009). Agroecology as a science, a movement and a practice. A review. *Agron. Sustain. Dev. 29*, 503–515.

Wezel, A., Bellon, S., Doré, T., Francis, C., Vallod, D. and David, C. (2009). Agroecology as a science, a movement and a practice, a review. *Agronomy for Sustainable Development, 29,* 503-515.

Wezel, A., Casagrande, M., Celette, F., Vian, J. F., Ferrer, A., and Peigné, J. (2014). Agroecological practices for sustainable agriculture. A review. *Agronomy for Sustainable Development*, *34*(1), 1-20.

Wezel, A., Herren, B. G., and Kerr, R. B. (2020). Agroecological principles and elements and their implications for transitioning to sustainable food systems. A review. Agron Sustain Dev. 40pp.

CHAPTER FOUR

4.0 General Discussion

The study aimed to measure the sustainability index of the agricultural technologies brought by the ByT program, factors affecting sustainability and extent to which the agriculture technologies comply with the agro ecological principles.

More than three-fifths (61.5%) of the respondents with primary education had higher sustainability, unlike those with secondary education. This implies that most of the people with primary education level had no other options of being employed in other job categories unlike people with higher level of education they had to concentrate on agriculture.

The results shows that the agriculture practices implemented by ByT in the project areas includes organic fertilizer, terracing, intercropping with other crops, marketing, credit serving group, biological pest management, crop rotation, certified seeds and irrigation. Practices such as biological pest management (92.2%), crop rotation (91.1%) and group membership (96.7%) are more practiced. As reported by Ocheng *et al*. (2021) that group membership has high influence on sustainability of agricultural technologies.

The results have shown that (60%) of the farmers fall in the high sustainability index whereas few (12.2%) of farmers have low sustainability. Similar results were observed by Ochieng *et al.* (2021) who found that access to training on the demonstration plots, market information and group membership influence sustainability of agricultural technologies. ByT program has provided training to the farmers in groups on use of technologies that are cost efficient and also provided market to farmers to sell their produced goods.

The results suggest that factors such as market availability, attending training, and technology cost significantly affect the sustainability of ByT sustainable agriculture technologies. However sex, and technology availability do not show significant relationships with the sustainability of ByT technologies. The estimate for the factor "Technology cost" is 2.029. The Wald statistic is 12.757, indicating a highly statistically significant relationship between technology cost and the sustainability of ByT technologies ($p < 0.001$). Whereas this implies the change in cost of technologies from high to low this will influence sustainability of the technologies. Same implies to the availability of market and good training of farmers.

The agriculture technologies introduced by ByT have high score in terms of efficiency (86%). Whereby efficiency in the ACT includes reduced application of pesticide, water consumption, use of synthetic fertilizer and waste and improved plant varieties and animal breed. This implies that they have managed to reduce input consumption and increase productivity (Wezel *et al.,* 2014). In this element they have failed to have improved plan varieties and animal breeds. Results in level 4 elements such as co creation and sharing of knowledge (100%) have shown the use of participatory approaches in the project.

Challenges identified among farmers participating in the ByT programme include marketing, pests and diseases, and manure management. Pest and diseases (67.8%) have been the leading challenge to the farmers. This is due to the use of biological pest control mechanisms such as use of the plants such as neem trees also intercropping vegetables with some plants that act as push and pull plants to pests. Pests and diseases can cause substantial crop losses, reduced yields, and negatively impact farmers' incomes. Integrated pest management practices, such as proper monitoring, early detection, use of resistant varieties, cultural practices, and judicious pesticide use, are crucial for mitigating these challenges and maintaining sustainable production (Oerke, 2006).

Farmers face difficulties in accessing markets, finding buyers, and negotiating fair prices based on their organic products. The ByT program has offered market of the produced goods but due to surplus production the market is limited. Limited market infrastructure, inadequate market information, and lack of market linkages can hinder farmers' ability to sell their products profitably and sustainably (Mishra & Kumar, 2018).

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CHAPTER FIVE

5.0 General Conclusions and Recommendations

5.1 General Conclusions

Factors such as, market availability, training, and technology cost have been found to have statistically significant influence on sustainability. This suggests that focusing on these factors can contribute to enhancing the sustainability of agriculture practices brought by agriculture projects

The agricultural technologies introduced by ByT program have complied with the elements of agro ecology elements in the five levels of the food system change. They have ensured efficiency increase by reducing input consumption and improve crop productivity. They have also used participatory approaches which have enabled the requirements and demand of small holder farmers to be incorporated with modern technologies to ensure productivity.

The challenges faced by farmers under the ByT programme include marketing obstacles, pest and disease management, and manure handling. Addressing these challenges requires a combination of improved market linkages, integrated pest management strategies, and effective manure management practices. By recognizing and addressing these challenges, farmers can enhance their sustainability and maximize the benefits of the ByT programme.

5.2 General Recommendations

These findings highlight the need for stakeholders in the agriculture sector, including policymakers, researchers, and farmers, to prioritize and address key factors on market availability, provision of training, and technology cost when implementing and promoting sustainable agriculture technologies. By focusing on these factors, it is possible to enhance the sustainability of agricultural practices and maximize the benefits of technologies.

The government should put policies and action in place to promote markets for organic certified products such that there can be public market areas for organic products. Also the introduction of agricultural technologies should utilize locally available resources to minimize cost of technologies.

Further research and studies are warranted to validate and expand upon these findings. Continuation on investigating the multifaceted nature of sustainability in agriculture, stakeholders can work towards the development and implementation of more effective strategies and interventions to support sustainable farming practices.

References

Baiphethi, M. N., & Jacobs, P. T. (2009). The contribution of subsistence farming to food security in Sub-Saharan countries. *Agrekon* 48(4): 459-482.

Bourn, D. (2015). From development education to global learning: Changing agendas and priorities. *Policy and Practice-A Development Education Review.* pp20.

Corral, S., Díaz, A. S., Monagas, M. D. C., & García, E. C. (2017). Agricultural policies and their impact on poverty reduction in developing countries: Lessons learned from three water basins in Cape Verde. *Sustainability* 9(10): 1841-1856.

FAO, Food and Agriculture Organisation of the United Nations (1996). *World Food Summit: Rome Declaration on World Food Security*. FAO, Rome, Italy. 68pp.

IPC, Integrated Food Security Phase Classification (2020). Renewal through participation in global food security governance: implementing the international food security and nutrition civil society mechanism to the committee on world food security. *International Journal of the Sociology of Agriculture and Food* 19(2): 143-161.

Iyabano, A., Faure, G., & Klerkx, L. (2016). Farmers Organisations Position in the Development of Sustainable Agriculture Practices in Burkina Faso. In: The proceedings of Solidarity in a competing world — fair use of resources. 19-21 September 2016, Tropentag, Vienna

Larsen, A. F., & Lilleør, H. (2014). Beyond the Field: The Impact of Farmer Field Schools on Food Security and Poverty Alleviation. *World Development* 64: 843–859.

Levinson, J., & Herforth, A. (2014). Monitoring and Evaluating the Food Security and Nutrition Effects of Agricultural Projects. In: *Presentation at the ICN2 Second International Conference on Nutrition*, Rome, Italy. pp. 19-21.

Mairura, E. O. (2019). *Influence of Agricultural practices on sustainability of agricultural projects in Narok-north sub county of Narok county Kenya.* Dissertation for Award

Degree of Master of Arts in Project planning and Management of the University of Nairobi. 80pp.

Makate, C., Wang, R., Makate, M., & Mango, N. (2017). Impact of Draught Tolerant Maize Adoption on Maize Productivity, Sales and Consumption in Rural Zimbabwe. *Agrekon*. [http://hdl.handle.net/10568/79963] site visited on 24/7/2020.

Mishra, A. K., & Kumar, S. (2018). Agricultural marketing: Issues, challenges, and future strategies. *International Journal of Current Microbiology and Applied Sciences*, 7(11), 3773-3778.

Ntebutsi, S. E. (2015). *Assessing the effect of project activities on its sustainability after its closure a case study of: Proba Ngororero District.* Dissertation for Award of the Degree of Master's Degree of Science in Project Management of Jomo Kenyatta University of Agriculture and Technology. 72pp.

Nwaiwu, I. U. O., Ohajianya, D. O., Orebiyi, J. S., Eze, C. C., & Ibekwe, U. C. (2013). Determinants of agricultural sustainability in Southeast Nigeria -the climate change debacle. Department of Agricultural Economics, Federal University of Technology, Owerri Nigeria. *Global Journal of Agricultural Research* 1(2): 1- 13.

Oerke, E. C. (2006). Crop losses to pests. *The Journal of Agricultural Science*, 144(1), 31-43.

Saysel, A., Barlas, Y., & Yenigün, O. (2014). Environmental sustainability in an agricultural development project: a system dynamics approach. *Journal of Environmental Management* 64: 247-260. 10.1006/jema.2001.0488

UN, United Nations (2015). Transforming Our World: The 2030 Agenda for Sustainable Development.[www.https://sustainabledevelopment.un.org/content/documents/21252030%20Agenda%20for%20Sustainable%20Development%20web.pdf] site visited on 12/06/2020

URT, United Republic of Tanzania (2016). National Five Years Development Plan 2016/17–2020/21: Nurturing

Industrialization for Economic Transformation and Human Development. 293pp.

Waas, T., Hugé, J., Block, T., Wright, T., Benitez-Capistros, F., & Verbruggen, A. (2014). Sustainability Assessment and Indicators: Tools in a Decision-Making Strategy for Sustainable Development. *Sustainability* 6(9): 5512 – 5534

Wezel, A., Casagrande, M., Celette, F., Vian, J., Ferrer, A., & Peigne, J. (2014). Agroecological practices for sustaibable agriculture. A review. *Agronomy for Sustainable Development* 34: 1-20.

Zhao, L., Huang, W., Zheng, Y., Cai, C., Wang, H., Wang, X., & Yang, L. (2019). Manure management contributes to the environmental impact of greenhouse gas emissions in pig production: A life cycle assessment study in China. *Science of the Total Environment,* 646, 1071-1081

APPENDICES

Appendix 1: A copy of questionnaire used for research

SOKOINE UNIVERSITY OF AGRICULTURE
COLLEGE OF SOCIAL SCIENCE AND HUMANITIES
DEPARTMENT OF POLICY PLANNING AND MANAGEMENT

A Household Questionnaire for Research on

ASSESMENT OF SUSTAINABILITY OF AGRICULTURE TECHNOLOGIES A CASE: BUSTANI YA TUSHIKAMANE PROGRAM IN MOROGORO, TANZANIA

BY

ANNA MHANDO
M.A. (Project Management and Evaluation) Student
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INTRODUCTION

Dear respondent, my name is **Anna Mhando**. I am a student master's student pursing a Master of Arts in Project Management and Evaluation at Sokoine University of Agriculture in Morogoro. I am caring an academic research titled "Assessment of the ssustainability of Agriculture ttechnologies a Case: Bustani ya Tushikamane (ByT) Program in Morogoro". I further wish to confirm that the information you provide will be confidential and used for the academic study. I am kindly asking for your cooperation and thank you for your willingness to participate.

Please feel free to answer the questions that will be asked. Would you be willing to participate? If NO, put a tick in the bracket ( ), end interview and find a replacement household; If YES, put a tick in the bracket ( ), to acknowledge that the respondent consented.

INSTRUCTIONS

- **Please complete the following questionnaire by placing a tick of filling the box space provided**
- **Please answer the questionnaire honestly and in case of failure to understand the question ask for more elaboration.**

HOUSEHOLD HEAD GENERAL INFORMATION

1. Household head's name: …………………………………………
2. Name of village: ………………………………………........................
3. Ward: ………………………………...
4. District: ………………………………..…
5. Date of interview: …………………………………………..................

Socio-Demographic Characteristics	**Person (P) 1 Household head**	**P2**	**P3**	**P4**	**P5**	**P6**	**P7**	**P8**	**P9**	**P10**
Sex *										
Year of birth										
Marital status**										
Household head's education level ***										
Main Occupation****										

A: SOCIO-DEMOGRAPHIC CHARACTERISTICS

A6. Particulars of the household head and his/her household members

Key:
***Sex:** 1. Male, 2. Female
****Marital status:** 1. Single, 2. Married, 3. Separated, 4.Widow/Widower, 5. Others (***Specify)***
*** **Household head's education level:** 1 = No formal education, 2 = Primary education, 3 = Sec. education, 4= Post-secondary education
******Main occupation:** 1. Salaried employment, 2. Crop production, 3. Livestock keeping, 4. Trade, 5. Others (***Specify)***

A7. Do you own land

1 = Yes

2 = No

A8. What type of land ownership?

1 = Inherent

2 = Bought

3 = Rented

C. ByT PROGRAM FACTORS

C1. Did ByT program introduce new crop varieties in your village?

1 = Yes

2 = No

C2. If yes, what are the crops?

1. ……………………………………………………………………
2. ……………………………………………………………………
3. ……………………………………………………………………

C3. Since when (year) have you been doing the main economic activity indicated in Question B6?

………..………………………………………………..……………………
……………………

C4. Since when (year) have you been a beneficiary of ByT?

………………………………

C5. (a) Have you attended any training offered by ByT?

1 = Yes

2 = No

(b) If Yes, how many times?

……………………………..……………………………………………
…………………………..

(c) If Yes, on which technologies?

……………………………………………………………………………………
…………….

D: FACTORS AFFECTING LONG TERM ADOPTION (SUSTAINABILITY) OF SUSTAINABLE AGRICULTURE TECHNOLOGIES.

D1. Are the agriculture technologies brought by ByT easily available?

1. Yes
2. No

D2. How are the technologies brought by ByT in terms of cost?

1. Cheap
2. Expensive

D3. What are the cost in the use of the technologies brought by ByT?.........……………......

D4. How do you see practicability of the agriculture technologies brought by ByT?

1. Easy to use
2. Difficult to use

D5. (a)Is there a market for organic crops?

1. Yes
2. No

(b) if yes is it sufficient?

………………………………...…………

……………………………

D6. Is there availability of capital to engage in agriculture activities?.......................................

D7. How is the production after use of ByT agriculture technologies?

1. Increased
2. Decreased

D8. What challenges that you are facing in the practice of the agriculture technologies?

..……………………………………………………………………………

……………………………………………………………………………

……………………………………………………………………………

……………..

D9. What are the benefits from practising agriculture technologies brought by ByT?

.........…………………………………………………………………

…………………………………

D10. How many times per year do you have training of improved technologies?

1. 2 times per month
2. 4 times per month
3. 5 times and above

E. IDENTIFICATION OF RELEVANT INDICATORS

Please, rate the listed indicators using a 5-point Likert Scale:

(5. Highly important, 4. Important, 3. Moderately important, 2. Least important and 1. Not important)

Attribute	Measurable indicators	Importance				
		1	2	3	4	5
Economic indicators	1. Agricultural productivity					
	2. Source of capital					
	3. Access to credit					
	4. Source of labor					
	5. Access to market					
	6. Off farm income					
	7. Pests and diseases control					
Social indicator	1. Education					
	2. Age of the farmer					
	3. Working hours					
	4. Women empowerment					
	5. Participation of farmers in training					

	6. Participation of farmers in organization					
	7. Accessibility					
	8. Applicability					
	9. Transportation					
	10. Access to information					
Environmental indicators	1. Proportion of manure used					
	2. Distance from water use					
	3. Land ownership					
	4. Existence of animal farm					
	5. Water haversting/ conservation					

F. THE EXTENT OF ByT TECHNOLOGY ADOPTION

F1. Please indicate whether you apply the technologies listed in the following table. Write 1 (Yes) or 0 (No).

Extent of Technology adoption	**Yes (1)**	**No (0)**
ByT disseminated technologies		
Use of Organic fertilizers – like farmyard manure, Green manure		
Terracing		
Intercropping		
Marketing of agricultural produce		
Credit serving group		
Biological pest management		
Crop rotation		
Other technologies		
Use of certified seeds (Hybrid seeds)		

Use of inorganic fertilizer (Inorganic fertilizers- like D.A.P, C.A.N etc.		
Use of irrigation		
Use of water pumps		

F2. What are the reasons for applying ByT technologies?

………………………………………………………………………………………
………………………………………………………………………………………
…………………………

F3. What are the reasons for not applying ByT technologies?

………………………………………………………………………………………
………………………………………………………………………………………
…………………………

G: AGRICULTURE TECHNOLOGIES COMPLY WITH THE AGRO-ECOLOGY PRINCIPLES. (This objective will use the excel based agro ecological criteria tool (ACT)

Agroecological Criteria Tool

AGROECOLOGY CRITERIA TOOL					
Element of transition	**Criteria ID**	**Criteria of transition**	**Examples of practices/ systems/ topics**	**Project Indicator present (0/1)**	**Notes**
Level 1: Increase efficiency of industrial and conventional practices					
1.1. Efficiency	**1.1.1.**	**Reduced water consumption:** reduction of	Drip irrigation, improved monitoring,		

		water use while maintaining/increasing yields through improved practices	precision agriculture, improved varietals, reduced waste water		
	1.1.2.	**Reduced application of pesticides and veterinary drugs:** reduced application of herbicides, fungicides, insecticides, fumigants or use of veterinary drugs. This subcategory includes general integrated pest management (IPM) programmes or references to general pest/livestock disease research in case no other specific practices are mentioned (including research aiming to reduce pesticide use or plant incorporated protectants)	Improved monitoring, precision agriculture, improved plant varietal that reduce pesticide use, vaccines that reduce the need for antibiotics		

	1.1.3.	**Reduced synthetic fertilizer application and use of animal fed:** reduced application of synthetic fertilizer or nitrogen leakage, more efficient use of animal feed	Improved monitoring, precision agriculture		
	1.1.4.	**Reduced energy use:** reducing fuel consumption in farming by improved technology, equipment or through renewable, low-carbon energy sources that can be used on farms (biofuels are rated separately)	Energy-smart farming system relying on windmills, solar or photovoltaic panels, renewable energy-powered vehicles, renewable energy-powered equipment for water supply, distribution and purification, monitoring systems to reduce energy use, improved cooking stoves		
	1.1.5.	**Reduced seed use:** improved or efficient storage and use of planting materials that result in better crop growth and	Optimal seed spacing		

		reduced early mortality			
	1.1.6.	**Reduced waste:** reduction of losses at harvesting, processing, storage or post-harvest through improved technologies and equipment	Timely harvest, improved storage facilities, hermetic bags		
	1.1.7.	**Improved plant variety and animal breed:** improved variety or breed that reduces the use of external inputs of at least two of the following categories: water, pesticide, fertilizer, seed and/or drug	Plant and animal breeding using conventional, marker-assisted breeding or other breeding methods		
Level 2: Substitute industrial or conventional inputs with more sustainable alternatives					
2.1. Recycling	**2.1.1.**	**Alternative soil inputs:** substituting synthetic fertilizers through alternate amendments	Compost, manure, cow dung		

	2.1.2.	**Green manure:** cover crops or other plants that are left in the field to decompose, reducing dependence on synthetic fertilizers and increasing nitrogen fixation, or improving nutrient availability	Nitrogen fixing cover crop and leguminous green manures, crop sown for mulch		
	2.1.3.	**Recycling of waste water:** recycling of waste water for agricultural use, agricultural water reuse	Recycling domestic, municipal, industrial waste water, use of desalinated water		
	2.1.4.	**Use of biomass residues for energy generation:** energy derived from biomass residues: primary waste from harvesting residues, secondary waste from processing industries (e.g. using agro-forestry products) or from post-consumer residues and	Bioenergy from corn stalk, rice husk, slaughter waste, third generation biofuels, biogas from manure,Organic agricultural waste		

		waste. This category includes energy generation from organic waste and residues only.			
	2.1.5.	**Climate mitigation through alternative practices:** adoption of practices that mitigate climate emissions by sequestering soil carbon or reducing GHG emissions. This category includes only Gliessman Level 2-type practices where the agroecosystem is not altered from its more simplified form	Increase soil carbon stock through reduced or no tillage,deep rooting plants		
	2.1.6.	**Other practices that enhance recycling of biomass and organic matter:** other recycling of biomass residues and waste	Recycling of crop residues for other uses, wood waste recycling for construction		

2.2. Regulation and balance	**2.2.1.**	**Biological pest management:** pest management through biological control methods that import, enhance or conserve pest enemies/antagonists (including predators, parasitoids, pathogens and competitors)	Conservation of snakes against rodent, introduction of exotic natural enemies like wasps		
	2.2.2.	**Cover crops for pest management:** planting cover crops specifically for weed control or pest reduction. This category includes cover crops grown primarily for pest management.	Cover crop for weed suppression		
	2.2.3.	**Other pest management:** non-chemical pest management practices that treat pest problems rather than preventing their occurrence, or biochemical pesticides that control pests by non-toxic	Use of steam, UV treatments, LED lighting, insect sex pheromone, plant extract that attract insect pests to traps, neem spray, wood ashes		

		mechanisms (naturally occurring substance). This category excludes biological pest management and crop cover			
	2.2.4.	**Cover crops for improved soil conditions:** planting cover crops specifically to reduce erosion, run-off, increase soil organic matter, improve soil drainage, soil structure, alleviate soil compaction, improve overall soil condition	Provide non-living mulch to conserve soil moisture		
	2.2.5.	**Perennial crops:** adoption of perennial plant species in place of annual crops	Improved perennial varieties, general perennial grain crop program (perennial wheat…)		
	2.2.6.	**Reduced tillage:** adoption of conservation tillage or no-till practices. This category includes general or other reduced tillage practices that are not	Direct seeding, strip tillage		

		considered in previous categories already.			
	2.2.7.	**Adoption of organic and low-input farming:** general organic or low-input systems if not considered in other categories already	General organic farming systems		
	2.2.8.	**Domesticated pollinators:** improved pollination through the temporary introduction of domesticated pollinators or introduction of exotic domesticated species	Introduction of imported species/subspecies of honeybees		
	2.2.9.	**Improved animal welfare and health:** improved livestock health, and further efforts to support livestock well-being	Species-appropriate husbandry		

Level 3: Redesign whole agro-ecosystems					
.1. Synergies	**3.1.1.**	**Non-crop plants:** incorporating non-crop plants in agro ecological systems for ecological functions such as conservation, water quality or pest management. This category does not include integration of trees.	Use of weeds for food and forage in maize system		
	3.1.2.	**Agroforestry:** diversified farming system integrating crop production and trees	Alley cropping with trees, coffee agroforestry		
	3.1.3.	**Rotational/regenerative grazing:** improved grazing methods/management to improve soil quality and forage yield	Grazing systems based on forage availability and demand		

	3.1.6.	**Integrated pest management by habitat manipulation:** landscape planning (focussed on habitat) or habitat management as systemic precondition for biological pest control	Preserving or enhancing plant diversity or providing adequate refuge for pest's natural enemies		
	3.1.7.	**Other landscape planning and synchronised landscape activity leading to improved agricultural ecosystem services:** consideration and coordination of activities including land use, land cover or other components) at the landscape level that optimise ecosystem services that benefits agricultural production. Habitat conservation	Reforestation/restauration/ preservation of natural habitats with clear benefits for agricultural production, diversified land-use or alternate flowering at the landscape level to improve pollination services, windbreaks, soil erosion control e.g. using hedgerows, half-moon, terracing, stone bunds, contour bounding, Zaï holes		

		around agricultural lands, landscape-scale management interventions			
	3.1.8.	**Climate mitigation through redesigned system (increasing carbon stocks, reducing GHG emissions):** identifying or adopting practices that can mitigate climate change by sequestering soil carbon or reducing GHG emissions. This category includes only Level 3-types of systems where the agroecosystem is fundamentally redesigned.	Increase carbon stock through agroforestry		
3.2. Diversity	**3.2.1.**	**Improving local seed/breed diversity:** supporting the development and promotion of	Development of local breeds/varieties, local seed system, seed banks,		

		local, regional, organic seeds/breeds, including classical breeding	participatory breeding		
	3.2.2.	**Integrating locally adapted crops/races:** incorporating native or locally/regionally adapted crops and animals			
	3.2.3.	**crop rotation:** supporting a simple crop rotation with just two crops or where the number of crops included is unclear, but excluding cases where the second crop is specified to be a cover crop			
	3.2.6.	**Biodiversity:** specific attention to protect or enhance functional agro-biodiversity	Conservation of forest fragments around agricultural lands		
	3.2.7.	**Natural pollinators:** specific attention to protect or enhance local and natural	Flower strips		

		pollinators (and their habitats)			
	3.2.8.	**Multi-habitat approach:** increase land-use diversity or diversity at the landscape scale	Sustainable shifting cultivation, management of heterogeneous landscape		
	3.2.9.	**Diversification of diets and consumption:** promotion of diversified locally produced healthy diets through a diversified food production system (at the landscape/territorial level), macro-and micronutrients, other bioactive components	Diversification of crop production with a nutrition focus		
3.3. Resilience	**3.3.1.**	**Systemic resilience of agroecosystems to extreme weather events and other disturbances:** promotion of the resilience of agroecosystems to specific disturbances (windfall, storm, heavy rain, winter freeze,		1	

		floods, draught, wildfire), including developing frameworks to assess resilience of food systems and measuring the impact of management on the recovery of one or more ecosystem services in response to that disturbance			
	3.3.2.	**Systemic resilience and adaptive capacity to changing environmental conditions due to climate change:** research promoting resilience of agroecosystems to future conditions (salinity, average temperatures, new emerging pests and diseases), development of adapted system to future conditions	Improved locally adapted varieties/breeds to future climate conditions		

	3.3.3.	**Livelihood resilience:** diversified income, production and access to market to be resilient against stress and shocks (economic, weather...). The project should measure the impact of livelihood strategies (based on the agricultural sector) on the capacity of farmers to respond to a disturbance and recover from it	Project exploring diversification of the production (temporal, nutritional), diversification of work type, access to markets, impact of access to local food on farmer's resilience. Other topics: interactions between agriculture and the wider economy, agritourism		
4.1. Circular and solidarity economy	**4.1.1.**	**Business support for re-establishing the connection between producers and consumers:** assisting in the development of local food systems, short value chains and webs, developing trading relationships with local	Community-supported agriculture (CSA), re-localisation of food systems and markets within same territories, engagement of communities and businesses in sustainable operations, new innovative markets, participatory guarantee schemes (PGS),		

		growers	local producer's markets/more traditional territorial markets, denomination of origin labelling and certification, e-commerce schemes		
	4.1.2.	**Supporting regional value generation:** embedding food systems into local economies, connecting local producers with other value-adding activities at the local or regional level, including post-harvesting, processing, packaging	Targeted investments and subsidy programs, access to finance to smallholders, barriers and opportunities to regional value generation, public procurement schemes targeting regional demand		
	4.1.3.	**Encourage and sensitise for seasonal and regional demand:** action supporting a stronger seasonal and regional demand	Education program on sustainable, seasonal and local comsumption, campaign on the benefits of local and seasonal consumption, seasonality chart		

4.2. Culture and food traditions	**4.2.1.**	**Support healthy, diversified and culturally appropriate food traditions and diets:** build food systems based on the culture, identity, tradition, social and gender equity of local communities that provide healthy, diversified, seasonally and culturally appropriate diets, support and protect cultural identity and values tied to food systems	Assessment of cultural values around food system, promotion of local breeds/varieties/products for their specific taste and nutritional value, scheme that protect cultural identity (territorial approach…), subsidies for traditional/cultural performances in food system		
	4.2.2.	**Support the right to adequate and culturally appropriate food:** support the ability of people to make decisions about the quality and type of food they hunt, fish, gather, grow and eat	Policy support or supportive policy frameworks for culturally-adapted food		

4.3. Co-creation and sharing of knowledge	**4.3.1.**	**Connecting farmers to share knowledge:** engage farmers in co-creation and sharing of knowledge, integrate producer's knowledge and management experience to research (through specific participatory research design), support for farmer-researcher networks	Farmer-to-farmer programmes, farmer's groups to share experiences, bottom-up models of technology transfer (participatory ICT tools), social media groups, community of practices		
	4.3.2.	**Promote participatory and multi-stakeholder approaches in knowledge generation:** integrate farmers and other actors' views in all stage of decision-making, increase participation and exchange between different types of actors	Farmer field schools, climate field schools, participatory research designs, integrate producer's knowledge of agricultural biodiversity and management experience (to research)		

	4.3.3.	**Promote formal and non-formal "production and food" education:** support for farmer-education networks, formal and non-formal education	Accessible lessons on farming system for the public, access to extension, sensitisation in schools, sensitisation program on sustainable consumption		
Level 5: Rebuild the global food system so that it is sustainable and equitable for all					
5.1. Human and social value	5.1.1.	**Gender and vulnerable group approach:** developing and informing policies and approaches that empower women or other vulnerable groups (including youth)	Collective action targeting woman , creating opportunities for commercialization , participation in producer groups & education, developing higher levels of autonomy		
	5.1.2.	**Strengthen organisational capacities:** increasing organisational capacities of farmers' communities and	Self-organisation, associations, capacity to stand for labour rights, land rights, strengthen self-empowerment		

		other local food system actors			
	5.1.3.	**Equity, dignity, inclusion:** support fair, dignified and inclusive livelihoods for all actors engaged in food systems, especially small-scale food producers	Policies and programmes that promote inclusive market systems, fair trade, fair employment, fair treatment of intellectual property rights		
	5.1.4.	**Support right to food (sufficient, access, adequate):** developing and informing policies and approaches that ensure the right for people to feed themselves in dignity, implying that sufficient food is available, that people have the means to access it, and that it adequately meets the individual's dietary needs			
	5.1.5.	**Promote food sovereignty:** developing and informing policies and			

		approaches that allow communities to decide the way food is produced, traded and consumed			
	5.1.6.	**Creating decent jobs for rural youth based on agriculture:** developing policies and incentives for decent job creation for rural youth	„Policies making rural areas and professions more attractive for youth, structural transformation to boost youth labour demand, promote entrepreneurship and access to productive resources		
5.2. Responsible governance	**5.2.1.**	**Policy development on producer-consumer links:** developing or informing policies to help re-establish the connection between producers and consumers, market regulations allowing for branding of differentiated agroecological products	Policies promoting local public procurement, school feeding programs		

	5.2.2.	**Inclusive policy-making:** developing or encouraging inclusive policy-making that aim for sustainable and equitable food system	Support multi-stakeholder policy dialogues (integrate CSO/farmer's organisations' demands), evidence-based policy planning, support and strengthen science-policy interfaces		
	5.2.3.	**Establishment of equitable governance and rights over natural resources:** developing, informing or encouraging traditional and customary governance models, policies that ensure and protect equitable land tenure systems and secured access to natural resources	Recognition of traditional rights over natural resources		
	5.2.4.	**Policy development on the links between agroecology and global changes:** developing or	Integrating agroecology in climate change policy process (UNFCCC, national climate change plans)		

		informing policies on the integration of agroecology and other policy processes tackling global changes, such as climate change			
	5.2.5.	**Policy development that rewards agricultural management that enhances biodiversity and the provision of ecosystem services:** developing, informing and encouraging national level legislation, policies and programmes that protect biodiversity and multifunctional agriculture, subsidies and incentives for ecosystem services	Payment for ecosystem services, biodiversity-friendly agricultural regulation and subsidies		

Appendix 2: Checklist for focus group discussion

1. What kinds of technologies provided by ByT?
2. What is the importance's of technologies which you mentioned above?
3. Is there any support of the technologies used?
4. Do farmers still continue to use those technologies?
5. Give the reasons for using or not using the technologies?