IOSR Journal of Agriculture and Veterinary Science (IOSR-JAVS)
e-ISSN: 2319-2380, p-ISSN: 2319-2372. Volume 13, Issue 4 Ser. I (April 2020), PP 59-65
www.iosrjournals.org

Influence of Technology Transfer Methods on Sustainability of Urban and Peri-urban Agriculture in Nairobi County

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Abstract:
Background: *Urban and Peri- urban Agriculture (UPA) provides food and income to urban residents in Nairobi County. UPA is under threat from increased built environment, rapid urbanisation, high population, competition of resources and limited extension services.Majority of farmers experience several challenges and do not receive adequate extension services to empower them to make sustainable farming decisions. Farmers receive limited information from the few extension officers available and operate on limited facilitation and use of inadequate extension methods. The purpose of the study was to examine the influence of technology transfer methods (TTM) on farmer empowerment to make decisions on sustainability of UPA in 13 of the 17 Sub counties of Nairobi County.*
Methodology: *The study employed a cross-sectional survey method with multistage sampling to randomly select 150 respondents. The independent variables were 8 technology transfer methods of farm visits, office visits, information and communication technology (ICT), group trainings/demonstrations, tours, field days, shows and printed materials. The dependent variable was a calculated UPA sustainability index. The index was derived from computation of 3 indicators, number of UPA technologies adopted, average annual income from the UPA technologies and years of farmer experience in practicing UPA. Descriptive and inferential statistics of multiple linear regressions were used to analyse the data.*
Results: *Multiple Linear Regressions (MLR) indicated that TTMs provided an R^2 of 0.619 indicating that they contributed 62% to empowerment of farmers. TTMs of ICT, farm visits, office visits, trainings and demonstrations and field dayswere found to positively and significantly influence farmer's abilities to make decisions. Farm visits and ICT were the highest contributors to empowerment of farmers by 0.520 and 0.492 ($p<0.05$) respectively.*
Conclusion: *Technology transfer methods used by the extension officers were found to positively and significantly influence the empowerment of farmers to make decisions on their farming systems for sustainability of UPA.The study recommended a transformation of the extensiondesign to an integrated TTM systemto meet the individual needs of the UPA farmer and contribute towards empowering farmers to make decisions to change their farming activities towards sustainability of UPA.*
Keywords: *Multiple Linear Regressions, Nairobi-Kenya.Sustainability, Technology Transfer Methods, Urban and Peri-Urban Agriculture.*

Date of Submission: 06-04-2020 Date of Acceptance: 20-04-2020

I. Introduction

Sustainability is the assurance of a continuous availability of resources to protect human activities and the environment. It creates and maintains a balance in the social, economic and ecological requirements for present and future generations. Rapid urbanisation in Nairobi County has contributed to increased challenges for the urban residents. In Kenya, approximately 33 % of 47,564,296Kenyans (Kenya National Bureau of Statistics (KNBS), 2019) live in the cities and towns. The current Nairobi County population is 4,397,073 (KNBS, 2019) and is expected to rise to 5,433,002 in 2020 and 5,958,338 in 2022 respectively (CIDP, 2018).

Nairobi County faces several challenges such as high unemployment levels leading to poverty, air and water pollution, food and nutrition insecurity, consumption of unsafe food, competition on resources, increased crime rate and congestion of infrastructure. The City was ranked as number two in poverty levels in the country at 22.5% (Ogendi, MukundiandOrege, 2014) with increased household food demand. The city has approximately 30% of households who benefit from urban and peri-urban agriculture either directly or

indirectly. UPA has grown tremendously since the 1970s as a response to food prizes, food shortages and lack of income and has contributed to improved livelihoods and supported the urban environment (UN, 2005).

The prevalence of food insecurity contributing to hunger in Nairobi's informal areas indicated that only one household out of five were food secure according to Faye, Baschieri, Falkingham and Muindi, (2011). Other households were found to survive on one meal a day or less. Food insecurity in Nairobisinformal areas has continued to escalate and there is need for urgent intervention (Oxfam, 2017). Approximately 60%, of Nairobi residents live in the informal areas according to Ohito, (2013). Most of these people rely on casual labour while others have no income generating activities and rely on relatives and donations for survival. They depend on food bought from markets to feed their families and when food is scarce or expensive their livelihoods are highly affected targeting mainly children and women (Oxfam, 2017).

Urban and peri-urban agriculture entails crop and fruit tree production, livestock keeping and fish farming in and around the cities and towns for household food supply and sale of surplus for income. UPA also includes other activities such as value addition, transportation and marketing of processed products (Bareja, 2010). The UPA technologies mainly used include open field farming, container and multi-storey gardens, hydroponics, irrigations, rooftop gardening, hanging gardens, greenhouses and shade net farming. Livestock production technologies include poultry production, zero-grazing, goat rearing, rabbit production and fish farming.

These technologies are resource intensive, use small spaces, environmentally safe and provide high returns. However, adoptions of most of these technologies are low due to insufficient and delayed information flow which has contributed to competition from other city development activities and hence affecting the sustainability of agriculture. According to Kurgat*et al.* (2018), the continued use of improved technologies such as irrigation and soil management methods were found to be low in peri-urban areas. In Nairobi County, there have been recommendations towards a systems approach to include other technologies such as waste management and energy production in UPA (Njenga and Karanja, 2013) for sustainability. In the informal areas UPA is considered a response to poverty and a survival strategy while in the upmarket areas it's practiced mainly for income generation (Ayaga *et.al*, 2005).

Sustainability of UPA contributes to achievements of the Sustainable Development Goals (SDGs) according to United Nations (UN, 2015). UPA has the potential to contribute to SDG one, which targets the end of poverty everywhere, SDG two targets elimination of hunger to achieve food and nutrition security and SDG twelve which targets the assurance of sustainable production and consumption patterns. One of the Kenyan presidents "big four agenda" includes ensuring food security for all as a contribution towards vision 2030 (Bankelele, 2018). Sustainability of UPA can contribute towards achievements of this agenda. Nairobi County is associated with the "100 Resilient Cities and the Milan Urban Food Policy Pact" with a purpose of mapping out agriculture and food spatial plans to achieve food sufficiency (CIDP, 2018).

Urban and peri-urban agriculture in Nairobi faces various challenges such as climate change, a high competition for basic resources like land, water and finances. Other challenges include high cost of inputs, theft on the farms and provision of limited extension services to the farmer by the County Government. However, the National Government of Kenya has provided subsidized fertilizer to cushion farmers from the high cost of fertilizers, although the cost of other inputs remains relatively high. City farmers need adequate and timely information to empower them to make decisions to change their farming systems in favour of sustainability of UPA.

During the 1980s public extension services were well staffed, well facilitated and distributed up to the sub-location levels. The officers made fortnightly farm visits especially during the training and visits mode of extension services. These extension services were also strengthened by functional farmers training centres (FTCs) which held regular trainings for the farmers. This situation was similar for Nairobi. However, staffing and facilitation in agriculture sector has declined in the past 15 years due to a government freeze in employment, and natural attrition. The ratio of frontline extension workers to farmers is approximately 1:5,000 in Kenya(Mbugua, 2018). Public extension offers the dominant extension service to the farmers but are however complimented by a lean private service. In Nairobi County agricultural services were devolved in 2013, and since then the work force has reduced affecting the staff: farmer ratio.

A study was conducted by Mwasi*et al.*, (2017) in Nairobi on the contribution of livestock farming under UPA in Nairobi County. Results showed that 77.5% of livestock city farmers indicated that limited availability of extension services was one of the major challenges they experienced while farming in the city. Another study was conducted by Muyanga and Jayne, (2008) on the policy lessons learnt from private agricultural extension systems in Kenya. The purpose of the study was to understand the efficiency of public and private sectors in terms of service delivery. The findings indicated that private extension was skewed towards certain regions or certain products with a purpose of achieving high profits or quick results. Muyanga and Jayne, (2008) recommended that public and private extension should complement each other to prevent competitionand overlap in activities.

The current characteristics of technology transfer approaches in Nairobi include farmer demand driven services, participatory services, individual, groups, and mass methods as well as networking and collaborations (CIDP, 2018). Farmers and clients are reached through individual methods of farm visits, office visits, and inadequate use of ICT. Group methods include training and demonstrations, tours and visits. Mass methods include field days, exhibitions, and distributions of print materials. Other methods include demonstration plots for trainings at the show ground during the Nairobi International Trade Fair (CIDP, 2018).

The theory of Andragogy is defined as "the art and science of helping adults learn" (Knowles, 1990). Knowles postulated the consideration of adult learning principles such as internal motivation, self-directedness, considerations of past experiences, and practicalapproaches to learning as a vital learning model.This andragogical model is not designed to fit equally to all adult learners but provides flexibility in planning and implementing quality adult education programs for expected results, Knowles (1984 cited in Franz *et al.,* 2010).

The current extension approaches do not provide for immediate feedback of agricultural technologies and information from extension workers and researchers (Cho & Boland, 2004). According to Garforth and Lawrence (1997), sustainable agriculture can be supported through extension. The author indicated that, though extension programs included sustainable technologies, the extension methodology continued to reflect a technology transfer paradigm that did not empower farmers to change their farming practices in order to achieve sustainability.

According to Papageorgiou, (2004), top- down technology transfer methods do not assist in the endogenous development of the human mind. The author conceptualized an "integrated learning package" which drives sustainable development and recommended that extension workers needed more capacity building to acquire new skills to be able to implement new designs.Knowles postulated that adults are self-directed, andthey should be consulted in the production of content and the process of information delivery. Their learning should be focused on the experiences they have acquired in the past and focus the content on issues to solve their immediate problems. However, Knowles realised that this theory did not apply to all adults and hence suggested that learning should be considered on individual basis.

According to Lovren, (2004), sustainability was dependent on partnerships, consideration of various disciplines, culture and lifelong learning. The author recommended a renewable agricultural extension method with organisational characteristics in sustainable agriculture to sustain livelihoods. A study was conducted in Eastern Libya to analyse the impact of alternative extension approaches for sustainable agriculture. Quantitative analysis indicated that, public private approach, participatory approaches and farmer field schools had more impact on sustainable agriculture (Omar *et al*., 2011). This indicates that the technology transfer method used can impact on sustainability.

Adult learning principles considered in this study include 1) drawing on learners experiences to aid their learning,2)learners learning to solve immediateproblems, 3) the motivation to achieve internal other than external satisfaction, 4) the readiness to acquire new social roles and build partnerships 5) adult learners are driven by self-concept that drives self-directedness and therefore requireflexibility and, 6) the desire for lifelong learning. The considerations of these principles in adult learning provide a better learning environment and ultimately empower the learner to make logical decisions to change their farming systems for improved livelihoods.

Nairobi County had over 200,000 households practicing agriculture according to a survey conducted by Lee-Smith and Lamba (2017), which translates to an approximate staff: farmer ratio of 1:2500 compared to the desired level of 1:400 (Mbugua, 2018). These has ultimately led to reduced spatial coverage, delayed and insufficient information flow resulting to reduced effectiveness in information transfer. The use of non-specific and inadequate extension methods has affected knowledge transfer and farmer empowerment.

The major aim of the TTMs has been to transfer knowledge, skills and various physical technologies to the farmers. The technology transfer methodologies do not employ all the adult learning principles (ALPs) in consideration of individual farmer's socio-economic status and convenience. These methods have contributed to lack of farmer's empowerment by not transferring responsibilities and authorities to assist the farmer to make appropriate decisions to change their farming systems(Allahyari, 2009).

Several studies have been conducted in Nairobi on the contribution of UPA to food security mainly concentrating on production in selected slum areas according to Omondi, (2018). There is however limited information on the contribution of technology transfer methods to the empowerment of farmers for sustainability of UPA in Nairobi. The purpose of the study was to find out the influence of the current technology transfer methods on empowering farmers to make changes in their farming systems in favour of Sustainability of UPA in Nairobi County.

II. Methodology

Study Design: The study utilized a cross-sectional surveymethod to collect information from a sample of respondents in order to understand the attributes of the population (Creswell, 2013). The design was found

favourable in quantifying variables, description of conditions and change of strategies at that specific point in time (Omair, 2016).

Study Location: The study was carried out in13 of the 17 Sub Counties of Nairobi County. These were urban areas of Starehe, Mathare, Makadara, Roysambu, Kibra, Embakasi West, Embakasi Central and Embakasi South, while peri-urban areas were Dagoretti North, Dagoretti South, Kasarani, Westlands, and Langata.

Study Duration:The study and research were carried out between 2016-2018.

Sampling and Sample Size: The target population of the study was approximately 985,000 households residing in Nairobi County according to (KNBS, 2009) with an approximate 200,000 households(Lee-Smith and Lamba, 2017), practicing farming. It is estimated that approximately 10-30% of city residents practice UPA farming worldwide depending on specific location (Mwangi &Foeken 1996). Multistage sampling methodology was used whereby sub-counties and wards were purposively selected to assist the researcher to gather the relevant data and achieve the purpose of the study (Mugenda and Mugenda, 1999). Due to the heterogeneity of the population, the UPA clients were stratified whereby each stratum represented an area (ward) in order to maintain an adequate cross-section of the study. Nairobi County is comprised of 85 wards of which 75 wards were purposively sampled depending on the farming activities. The sample size was determined by use of the Cochran formula, Cochran, (1963 cited in Singh and Masuku, 2014) and simple random sampling was employed to achieve a sample size of 150 farmers. Questionnaires were used to gather current and adequate information about the population.

Variables and Construction of a Sustainability Index: The study was multi-factorial in nature, with more than one indicator that impacted on the dependent variable. The independent variables were farm visits (FV), office visits (OV), ICT as individual methods, group trainings/demonstration (T&D) and tours/visits (T/V) as group methods while field days (FD), shows and print media (PM) were considered as mass media methods. Independent variables were measured in nominal scale while the dependent variable was a calculated composite sustainability index.

The composite sustainability index was constructed using 3 indicators. The methodology was borrowed from the universal Sustainable Society Index (SSI) which integrated 3 factors to be considered in the measurement of sustainability according to Sustainable Society Foundation (SSF, 2017). These factors include the human,environmental and the economic wellbeing. The Framework for the Evaluation of a Sustainable Land Management (FESLM) pillars by Food and Agriculture Organisation (FAO) was considered as a guide for indicators of UPA sustainability (Drechsel&Dongus, 2010). The average annual income from UPA in Kenya shillings was considered as an economic indicator, the length of time in years a farmer had engaged in UPA as a livelihood was considered as a social indicator while the number of technologies the farmer had adopted was considered as an environmental indicator.

The SSI methodology aggregates the scores of the 3 indicators each from the 3 different dimensions (SSF, 2017) into a single score. SSI uses the geometric average as opposed to the arithmetic average for computation of aggregations. Arithmetic average offers compensation, indicating that variables with low scores can be compensated by another variable with a high score. However geometric average accounts for compounding of indicators over time. SSI also indicated a lack of scientific evidence for the award of different weights to different sustainability indicators and thus appoints the same weights to the various dimensions. The combination of these different dimensions according to Mazziotta and Pareto, (2013) forms a composite index. SSI employs different formulas for different indicators.

Statistical Analysis: The hypothesis postulated from the objective indicated that there was no significant influence of technology transfer methods on sustainability of urban and peri - urban agriculture in Nairobi City County. Descriptive analyses of frequencies and percentiles were used to summarize datum while inferential analysis of Multiple linear regressionswas used and inferences made at 95% level of significance. This was achieved by use of the Statistical Package for Social Sciences (SPSS) to analyse the data. Multiple Linear Regressions allows the researcher to explain the relationship of the independent variables on the dependent variables as a parametric test (Frost, 2015). The regression analysis also provides the strength of change of the dependent variable by the independent variables.

III. Results and Discussions

The study achieved 149 respondents and results in Table 1 indicatethat, 96 farmers had participated in farm visits (FV), 84 in trainings and demonstrations (T&D), 75 had participated in field-days, 54 had received print media materials(PM), 46 had made office visits (OV), and 29 had participated in ICT. However, even though few farmers had participated in ICT as a method of technology transfer, most of these farmers(61%) indicated that ICT considered most of the ALPs. Results also indicatedthat50% of those who used FV and 47% of those who used T&D revealed that these methods empowered them to make decisions to adjust their farming activities. However, only 37 % of farmers who participated in tours and visits and 35% of those who used print media indicated that the methods empowered them to make decision on their farming systems.

Table 1: Considerations of Adult Learning Principles by a Technology Transfer Method

Technology Transfer Method used	No of farmers N=149	Flexibility %	Experiences %	Provision of Solutions %	Building of Partnerships %	Farmers Life Long Learning %	Farmers satisfaction %	% Mean (Empowerment)
Farm visits	96	60	55	76	40	34	32	50
Office Visits	46	45	39	56	42	36	40	43
ICT	29	66	52	70	67	57	56	61
Train/ Demonstration	84	34	58	60	34	32	62	47
Group Tours	40	24	38	37	47	34	39	37
Field days	75	39	33	50	43	38	48	42
Print Media	54	34	36	36	32	28	41	35
Shows	29	24	36	39	45	40	58	40

Source: (Field survey, 2017)

Multiple linear regressions were used to analyse the influence of the 8 technology transfer methods on a composite sustainability index. A pearson product moment correlation was run to determine the extent to which changes in the value of the dependent variable attributes were associated with each other. Thefindings indicated that the variables for the sustainability index which formed the dependent variable were not correlated (r = 0.028 and 0.018). There was no relationship between the independent variable indicators.

The MLR modelwith 8 TTMs variablesrevealed an $R^2$of 0.619 indicating that the technology transfer methods contributed 62% of the sustainability index.The F- Test regression coefficient indicated that the TTMs (predictor variables) contributed significantly ($p < 0.05$), to the variance accounted for in the sustainability index and the model as a whole was significantly fit.

Technology transfer methods of farm visits, office visits, ICT, trainings and demonstrations and field dayswere statistically significant ($p < 0.05$) and contributed positively to the empowerment of farmers to make decisions to adjust their farming activities towards sustainability of UPA. These results indicated that any unit changes in the frequency of use of farm visits would improve sustainability by 0.520 units, office visits would yield 0.145, ICT would yield 0.492.Training/demonstrationsyielded 0.407 and field days would yield 0.149towards sustainability of UPA. The sustainability index regression model was

$$Y = a + b1F/V + b2O/V + b3ICT + b4T/D + b5T/V + b6F/D + b7Print + b8Shows$$

Table 2: Coefficients for Technology Transfer Methods

	Unstandardized Coefficients			
	B	Std. Error	t	Sig.
(Constant)	3.136	.419	7.483	.000
Farm visits	0.520	0.041	12.841	0.000***
Office Visits	0.145	0.052	2.782	0.006***
ICT	0.492	0.142	3.460	0.001***
Train/Demos	0.407	0.171	2.383	0.019**
Group Tours	-.458	0.131	-3.504	0.001***
Field Days	0.149	0.055	2.703	0.008***
Print Media	0.130	0.148	0.879	0.381
Shows	-.119	0.140	-.850	0.397

a. Dependent Variable: Sustainability Index
b. N=149

Source: (Field survey, 2017)

A review of related literature indicated that few studies have been conducted in this area.Sanyang *et al.* (2009), conducted a study on the impact of technology transfer components on women in vegetable production and marketing in the Gambia. The author indicated thattechnology transfer is a combination of many different components. These components were described by Kumar *et al*. (1999, cited in Wahab, (2012), as physical components such as products, tools, equipment's, techniques and processes. They also included an informal component which consists of knowledge and skills. In the process of technology acquisition, the users must access the different components of technology that are appropriate to them through effective and efficient methodologies.

IV. Conclusions and Recommendations

The study concluded that not all technology transfer methods used contribute to empowering the farmers. Technology transfer methods that were found appropriate for urban farmers empowerment were ICT, farm visits, office visits, trainings and demonstrations and field days. These methods empowered farmers to make decisions to adjust their farming activities for sustainability of UPA.

The study recommends a transformation of the extension system design to one that will consider ALPs to meet specific farmer needs. The study suggests an Individualized and Digitized Farmer Information Systems (IDFIS) to curb the continued decrease in number of extension staff and be able to meet the farmer's information needs effectively and efficiently for sustainability of Agriculture.

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Mary Njoki Mwaura,*etal*. "Influence of Technology Transfer Methods on Sustainability of Urban and Peri-urban Agriculture in Nairobi County." *IOSR Journal of Agriculture and Veterinary Science (IOSR-JAVS)*, 13(4), 2020, pp. 59-65.