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Socioeconomic Factors Influencing Uptake of Regenerative Agriculture Technologies in the Dry-lands of Embu County, Kenya

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Abstract

This study evaluated socioeconomic factors influencing the uptake of regenerative agriculture technologies in the dry lands of Embu County. Semi-structured questionnaires were administered to 400 farm households. Multivariate Probit model (MVP) and percentage were used to analyse the data. The findings of the study indicate that several socioeconomic factors including farming experience, farm size, main occupation, off-farm activities, age, gender, marital status and education level influenced the uptake of various regenerative agriculture technologies. Government and other inventors should take these factors into consideration while making decisions and formulating policies to support the dissemination and uptake of agricultural innovations.

Introduction

Dry-land degradation is a critical agricultural production and socio-economic challenge worldwide (Wahba et al., 2019). Mainly, soil infertility is a menace to smallholder farmers in Sub-Saharan Africa (SSA) (Pozza and Field, 2020) who depend mostly on subsistence agriculture. Smallholder agriculture is highly dependent on rainfall, thus susceptible to harsh weather conditions including drought and prolonged dry spells (Kom et al., 2022). This has prompted food insecurity for the escalating world population (Betts et al., 2018).Thus, more pressure has been put on land, due to increased demand for land for settlement and farming (Pozza and Field, 2020). To meet the increased demand, production systems have opened up new lands for cultivation and transformed land use and cultivation patterns (Lai et al., 2020). However, the new lands are still prone to soil degradation resulting from poor farming methods. The dry-lands of Embu County face challenges of land deterioration, declining soil fertility, declining productivity, as well as extreme climatic weather stress (Kiboi et al., 2019; Ndeke et al., 2021).These challenges necessitate the transformation of agricultural production systems through adoption of new technologies including regenerative agriculture approaches (Gosnell et al., 2019).

Regenerative agriculture is a farming approach that considers soil conservation as the entry point to regenerate and promote multiple provisioning, regulating, and supporting ecosystem services, with the objective of enhancing environmental sustainability and social and economic dimensions of sustainable food production (Schreefel et al., 2020). Regenerative agriculture in its core, has the intention of improving soil health and restoring highly degraded soils in order to improve water quality, vegetation and land productivity (Newton et al., 2020).This approach goes beyond that of Climate Smart Agriculture (CSA) as it involves holistic, regenerative and resilient practices that improve the ecosystem processes (Gosnell et al., 2019).Further, regenerative agriculture comprises farming and grazing techniques that aim to increase food production (Lal, 2020) with lower negative environmental impacts (Newton et al., 2020). There is no single regenerative agriculture approach that fits all the practices for different soils and agro-ecological zones (Lal, 2020), thus farmers may adopt multiple technologies at the same time, allowing for use of several closely related practices. Regular cultivation with minimal nutrient replenishment accompanied with poor farming methods has led to declining soil fertility thus keeping agricultural productivity in the area of study low. Regenerative agriculture innovations seem to offer solutions and opportunities to these problems to farmers (LaCanne and Lundgren, 2018), to scale up productivity as well as profitability and household food security while ensuring environmental sustainability.

Uptake of new innovations is affected by perceptions, personality, and social characteristics (Taherdoost, 2018).Three models namely, perception of adoption model, diffusion of innovation model and economic constraint model have been used to explain the behaviour and forces that influence adoption of agricultural innovations (Malesse, 2018). Diffusion of innovation model considers if the technology is technically and culturally relevant, economic model considers the affordability and cost implications of the technology on local users, while the perception of adoption model takes into consideration the attributes of the technology that affect the farmers' technology use and adoption behaviour (Ikehi et al., 2022). This implies that, even if inventors come up with new innovations deemed to be good and appropriate, farmers still interpret the technologies differently (Malesse, 2018).Thus, there is need to understand the interlinks between the farmers, inventors/agents and researchers

(Ikehi et al., 2022). Based on this, Farm Africa through the Alliance for a Green Revolution in Africa (AGRA) disseminated regenerative agriculture technologies to farmers in Embu County. However, household socioeconomic factors influencing uptake of these technologies have not been evaluated. Therefore, this study was designed to evaluate socioeconomic factors influencing uptake of regenerative agriculture technologies in the dry-lands of Embu County at the farm/household level.

Methodology

The study was conducted in Embu County which is located at an altitude of 700M to 900M with mean annual temperature ranging from 20.7^0C to 22.5^0C and covers an area of approximately 1,312km^2 with a population of about 163,476 (KNBS, 2019). The rains are bi-modal with short rains occurring from mid-October to February and long rains from mid-March to June and with annual rainfall ranging between 700mm to 900mm. The County is classified as a Lower Midland (LM4) zone with latitude and longitude of 0°46′S and 37°39′E. The crops commonly grown in the area are pigeon pea, sorghum, millet, green gram, and cowpea (Kiboi et al., 2019; Muthee et al., 2019).

The study targeted approximately 27,274 rural-based farming households in Mbeere South Sub County (KNBS, 2019). Cochran formula was used to estimate the sample size as shown below;

$$\boldsymbol{n}_{0=} n_{0=} \frac{Z^2PQ}{d^2} = \frac{(1.96)^2(0.5)(0.5)}{(0.049)^2} = 400 \qquad (1)$$

Where n_0 = sample size, Z = (1.96) t value from normal table, p = (0.5) probability success, q = (0.5) probability failure and d= (0.049) level of significance.

Purposive, multistage stratified, and probability proportionate to size sampling procedures were used to select the respondents. Mbeere South Sub County was purposively chosen based on its semi-arid characteristics and the presence of interventions on regenerative agriculture. In the first stage, all the five wards in the selected Sub County were selected. In the second stage; one sub-location was randomly selected from each ward, and lastly, one village was selected randomly from each sub-location. Probability proportionate to size sampling procedure was then used to calculate the number of households that were interviewed in each village using a sample frame obtained from ward agricultural offices. A sample size of 400 households was therefore obtained.

A semi-structured questionnaire was used to collect data. Descriptive statistics were performed. A Multivariate Probit model (MVP) was employed to examine socio-economic factors that influence uptake of regenerative agriculture technologies. The model was preferred because factors influencing uptake of various regenerative agriculture technologies could be correlated. MVP model allows for simultaneous regression of binary equations that are correlated against a single vector of predictor variables (Okello et al., 2020).The model can be empirically specified as:

$$Y_{i1} = X_{ij1}\,\beta_1 + \varepsilon_{i1}$$

$$Y_{i2} = X_{ij2}\,\beta_2 + \varepsilon_{i2}$$

$$Y_{i3} = X_{ij3}\,\beta_3 + \varepsilon_{i3}$$

$Y_{i4} = X_{ij4}\,\beta_4$+$\varepsilon_{i4}$

$Y_{i5} = X_{ij5}\,\beta_5$+$\varepsilon_{i5}$

$Y_{i6} = X_{ij6}\,\beta_6$+$\varepsilon_{i6}$

$Y_{i7} = X_{ij7}\,\beta_7$+$\varepsilon_{i7}$

Where i is the household identification number,$Y_{i1} = 1$ if the household practices cereal legume intercropping system and 0 if otherwise, Y_{i2}=1 if the household practices mulching and 0 if otherwise, Y_{i3}=1 if the household practices minimum tillage and 0 if otherwise, Y_{i4}=1 if the household practices cover cropping and 0 if otherwise, Y_{i5}=1 if the household practices pasture cropping and 0 if otherwise,Y_{i6}=1 if the household practices crop rotations and 0 if otherwise,Y_{i7}=1 if the household uses compost manure and 0 if otherwise,X_i is the vector of factors influencing uptake of regenerative agriculture technologies, β_j = $\beta_1, \beta_{2,}\beta_3, \beta_4$, β_5, β_6,β_7 are the vectors of unknown parameters and $\varepsilon_i$is the disturbance term.

Results and Discussion

Main Regenerative Agriculture Technologies used by Farming Households

Main Regenerative Agriculture technologies used by farming households are shown in Table 1.The results are as follows: cereal-legume intercrop (71.3%), mulching (76.3%), minimum tillage (31.5%), cover cropping (14.5%), and use of compost manure (24%), pasture cropping (72.0%) and crop rotation (96.05).The findings are consistent with those by Kalungu and Filho, (2018) that these technologies are the most appropriate technologies adopted by smallholder farmers in the arid and semi-arid areas in Kenya.

Table 1: Regenerative agriculture technologies used by farming households

Technology	Percentage (n=400)
Cereal legume intercrop	71.3
Mulching	76.3
Minimum tillage	31.5
Cover cropping	14.5
Use of compost manure	24
Pasture cropping	72.0
Crop rotations	96.0

Challenges Encountered by Farming Households in Undertaking Regenerative Agriculture

The results in Table 2 show that inadequate knowledge on regenerative agriculture (56.5%) and unfavourable weather conditions (56.3%) were the biggest challenges faced by most farming households in the study area. Also, 26.3% experienced poor performance of the adopted technologies, and 26.5 % were hindered by cultural factors, while 34.3% faced the challenge of labour and argued that RA was labour intensive. The findings relate to those of Chan et al., 2018 who demonstrated that resistance to change from use of traditional technologies, inadequate professional knowledge and awareness pertaining to particular innovation, risks such as extreme weather events and uncertainties on performance were the common barriers towards adoption of innovations among farmers in developing countries. Weed management makes regenerative agriculture labour intensive thus farmers may avoid adoption due to fear on production costs moreover, ageing farmers avoid labour intensive technologies (Senyolo et al., 2018).

Table 2: Challenges faced in undertaking regenerative agriculture by farming households

Challenge	Percentage (n=400)
Inadequate knowledge on RA	56.5
Poor performance of adopted technologies	26.3
Cultural factors	26.5
Labor intensive	34.3
Unfavourable weather conditions	56.3

Support Required by Farming Households to increase Uptake of Regenerative Agriculture Technologies

Results on Table 3 illustrate that 80.3% of the respondents would need to be trained on how to undertake Regenerative Agriculture, 48.5% would need field demonstration, while 37.8% would need credit for inputs and labour to facilitate uptake of various technologies. These results concur with Senyolo et al. (2018) who assert that farmer training, field experiments and credit provision were important determinants in technology adoption. Training creates awareness and provides knowledge and skills to the end users and this is likely to scale out uptake of innovations.

Table 3: Support required by farming households to increase uptake of regenerative agriculture technologies

Support	Percentage (n=400)
Training	80.3
Field demonstrations	48.5
Credit provision	37.8

Socioeconomic Factors that Influence Uptake of Regenerative Agriculture Technologies

Results on Table 4 illustrate that age significantly and positively influenced uptake of minimum tillage, implying that, as the age of farmer increases using minimum tillage increases as well. This is associated to the farmer's experience in farming which improves farming skills. Contrarily, Worku (2019) argued that age of a farmer was negatively correlated with adoption of new technologies as older farmers were not willing to take risks and possessed little know-how on the new technologies. A study by (Gebru et al., 2019) indicated a negative relationship between age and use of new innovations. Sometimes, due to illness, households can lose labour, but older age is more likely to negatively impact on adoption (Bucci et al., 2019).

Gender was found to positively influence use of compost manure. The majority of households were male-headed implying that men stood a higher chance to make decisions on which Regenerative Agriculture technologies should be used on their farms. The findings resonate with those of Mwaura et al. (2021).This indicates that men were responsible for making major farm/household decisions (Ndeke et al., 2021).Thus households headed by male had higher chances of using compost manure as compared to female-headed households (Usman et al., 2019).This finding is comparable to those of (Ndeke et al., 2021; Sanou et al., 2019; Wekesa et al., 2018) who noted that gender positively affected adoption of new agricultural innovations. In a contrary opinion by (Bessah et al., 2021) , women are most likely to take up new innovations when compared to men to avoid the overarching constraints resulting from extreme weather events that directly affect them than men

Marital status negatively and significantly influenced uptake of cover cropping implying that married farmers had lower chances of practicing cover cropping as compared to single farmers. This can be related to contradicting views from couples towards a new innovation before coming to a consensus. This result corroborates that of Ojo et al., (2021) which pointed out that marital status negatively influenced the adoption of soil water conservation technologies as large families may be resource constrained. The finding, however, contradicts those of Etim and Ndaeyo (2020) who noted that marriage is a means of generating family labour and most women and children participate in farming. Furthermore, marriage increases concern for household welfare and food security therefore, use of new technologies was positively related to marital status.

Table 4: Socioeconomic factors influencing uptake of regenerative agriculture technologies

Variable	Cereal-legume Intercrop	Mulching	Minimum tillage	Cover cropping	Pasture cropping	Crop rotations	Use of compost Manure
	Coeff.	Coeff.	Coeff.	Coeff.	Coeff.	Coeff.	Coeff.
	Std.error.	Std.error.	Std.error.	Std.error.	Std.error.	Std.error.	Std.error.
Age	0.149	0.086	0.272	0.098	0.094	0.198	-0.043
	(0.109)	(0.109)	(0.115)**	(0.123)	(0.108)	(0.207)	(0.108)
Gender	-0.188	-0.039	-0.222	-0.038	-0.184	0.206	0.285
	(0:143)	(0.148)	(0.148)	(0.170)	(0.141)	(0.276)	(0.150)**
Marital status	0.022	0.094	-0.008	-0.907	-0.208	0.173	-0.025
	(0.189)	(0.195)	(0.200)	(0.324)***	(0.183)	(0.327)	(0.199)
Education level	-0.101	-0.024	-0.064	0.033	-0.094	0.038	0.108
	(0.094)**	(0.099)**	(0.096)	(0.117)	(0.093)	(0.178)	(0.102)
Farming experience	0.145	0.033	-0.243	0.003	0.124	0.112	0.063
	(0.081)	(0.070)	(0.092)***	(0.073)	(0.079)	(0.174)	(0.058)
Farm size	-0.083	-0.041	0.096	-0.054	-0.120	0.213	0.114
	(0.037)**	(0.038)	(0.034)***	(0.049)	(0.037)***	(0.108)**	(0.034)***
Main occupation	-0.413	0.112	-0.088	0.035	-0.362	-0.516	0.232
	(0.118)***	(0.116)	(0.119)	(0.135)	(0.112)***	(0.148)***	(0.118)**
Off farm activity	0.030	0.240	0.535	0.159	-0.046	0.024	-0.387
	(0.137)	(0.145)	(0.116)***	(0.137)	(0.122)	(0.231)	(0.157)**
Constant	1.056	0.383	-0.586	-0.230	1.618	0.531	-1.871
	(0.550)	(0.566)	(0.541)	(0.669)	(0.539)	(0.970)	(0.553)***

Likelihood ratio test of Rho_{ij}=0, Chi2 (21) = 158.453, Prob > chi2 = 0.0000, Wald chi2 (63) =154.44, Log likelihood = -1214.314, ***and ** show significance at 1% and 5% level respectively, Number of observations=400.
Coeff. Denotes coefficient and Std.error. Denotes standard error

Level of education influenced uptake of mulching and intercropping cereals and legumes negatively and significantly. This implies that farmers with low formal education had higher chances of intercropping cereal and legume crops and doing mulching as compared to those with better formal education. This may be associated with farming experience the farmer gets over the years, as one possesses sufficient knowledge on various innovations. Generally, education is believed to increase a farmer's awareness and understanding of new agricultural innovations. Muriithi et al. (2021) and Zakaria et al. (2020) argue that some technologies are knowledge intensive and require basic education to facilitate use and adoption. Therefore this finding challenges those of (Muriithi et al., 2021) and other earlier empirical evidences (Tokede et al., 2020; Zakaria et al., 2020) that show a positive association between education level and farmers' decision to adopt new innovations.

Farming experience had a negative association with uptake of minimum tillage, implying that farmers who had practiced farming for many years were less likely to use minimum tillage on their farms. This can be based on how a farmer perceives a new technology (Ikehi et al., 2022). On the other hand, farmers will always opt out of a technology when returns to investment start decreasing. For instance, farmers may drop use of minimum tillage following the negative marginal effect. Farming experience negatively as well as positively influence the likelihood of taking up agricultural innovations (Zakaria et al., 2020).This could be related with trade-offs that come with technological innovations. As farmers gain more experience in farming, they tend to shift from technologies that yield lower returns to those that are likely to give higher returns (Ndeke et al., 2021).

The results show a positive association between the size of the farm and uptake of minimum tillage as well as use of compost manure. This infers that households with larger farms had increased chances of taking up these innovations. Land being a major resource in production, its abundance increases the chances of farmers taking up new agricultural technologies. The findings resonate with those of Teshome and Baye (2018) with high chances of households with larger farms adopting new land management innovations as compared to those with smaller farms. According to Moronge and Nyamweya (2019), farm size influences adoption as large land gives space to experiment and practice of innovations. The findings agree with those of Muriithi et al., (2021) who indicated that farmers with larger farms, had a higher likelihood of adopting intercropping and crop rotation than those with smaller farms. The findings further reveal a negative association between farm size and uptake of cereal-legume intercrop and pasture cropping .The findings agree with those by Llones and Suwanmaneepong (2021) that increasing farm size will more likely increase input usage under conventional production among non-adopters thus reducing chances of adopting new innovations.

Although farming was the main occupation for majority of the respondents, it had a positive association with use of compost manure only and a negative association with cereal legume intercrop, pasture cropping and crop rotation. This meant that household that carry out crop farming as the main occupation were more likely to take up Regenerative Agriculture, especially use of compost manure and less likely to take up the technologies with negative associations. Farmers who practice agriculture in full time are more eager to increase their income through their produce and are therefore ready to invest in new technologies to grasp opportunities (Mottaleb, 2018). Conversely, farmers with off farm occupations generate extra income that they can equally invest in new innovations (Zakaria et al., 2020).

Uptake of minimum tillage was significantly and positively influenced by engagement in off farm activity by the household heads, implying that farmers with off farm occupations were more likely to adopt minimum tillage on their farms. Farmers who engage in off-farm activities are likely to get an extra income they could spend on farm labour and inputs for production. These findings are similar to those of Wambua et al., (2021) that engagement in off-farm activity generates finances that are invested in capital intensive technologies. On the other hand, engagement in off-farm activity influenced use of compost manure negatively. This may result from farmers allocating more time to off farm occupations than agricultural activities. Preparation of compost manure takes a lot of time thus farmers may prefer use of inorganic fertilizers to use of compost manure. According to studies by Kassie (2018) off-farm activities may distract farming activities, thus impacting negatively on technology adoption.

Conclusion and Recommendations

Age, gender, marital status, education level, farming experience, farm size, main occupation and off-farm activity were all vital determinants of technology uptake of regenerative agriculture at the household/farm level. There is need to encourage farmers in dry-lands to use regenerative agriculture technologies on their farms to scale up productivity. The government and other inventors should focus on informing farmers of benefits associated with regenerative Agriculture as well as equipping them with necessary knowledge and skills to increase uptake of Regenerative Agriculture technologies especially in dry areas.

MJN (15%) conceptualization of research, data collection and analysis, and reporting findings

References

Bessah, E., Raji, A. G. O., Taiwo, O. J., Agodzo, S. K., Ololade, O. O., Strapasson, A., & Donkor, E. (2021). Gender-based variations in the perception of climate change impact, vulnerability and adaptation strategies in the Pra River Basin of Ghana. International Journal of Climate Change Strategies and Management, 13(4-5), 435-462. https://doi.org/10.1108/IJCCSM-02-2020-0018

Betts, R. A., Alfieri, L., Bradshaw, C., Caesar, J., Feyen, L., Friedlingstein, P., Gohar, L., Koutroulis, A., Lewis, K., Morfopoulos, C., Papadimitriou, L., Richardson, K. J., Tsanis, I., & Wyser, K. (2018). Changes in climate extremes, fresh water availability and vulnerability to food insecurity projected at 1.5°C and 2°C global warming with a higher-resolution global climate model. Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences, 376(2119). https://doi.org/10.1098/rsta.2016.0452

Bucci, G., Bentivoglio, D., & Finco, A. (2019). Factors affecting ict adoption in agriculture: A case study in italy. Quality - Access to Success, 20(S2), 122-129.

Chan, A. P. C., Darko, A., Olanipekun, A. O., & Ameyaw, E. E. (2018). Critical barriers to green building technologies adoption in developing countries: The case of Ghana. Journal of Cleaner Production, 172, 1067-1079.
https://doi.org/10.1016/j.jclepro.2017.10.235

Etim, N.-A., & Ndaeyo, N. (2020). Adoption of Climate Smart Agricultural Practices by Rice Farmers in Akwa Ibom State, Nigeria. Journal La Lifesci, 1(4), 20-30. https://doi.org/10.37899/journallalifesci.v1i4.203

Gebru, B. M., Wang, S. W., Kim, S. J., & Lee, W. K. (2019). Socio-ecological niche and factors affecting agroforestry practice adoption in different agroecologies of southern Tigray, Ethiopia. Sustainability (Switzerland), 11(13), 1-19. https://doi.org/10.3390/su11133729

Gosnell, H., Gill, N., & Voyer, M. (2019). Transformational adaptation on the farm: Processes of change and persistence in transitions to 'climate-smart' regenerative agriculture. Global Environmental Change, 59. November 2019, 101965 https://doi.org/10.1016/j.gloenvcha.2019.101965

Ikehi, M. E., Ejiofor, T. E., Ifeanyieze, F. O., Nwachukwu, C. U., & Ali, C. C. (2022). Adoption of agricultural innovations by farmers in Enugu State, Nigeria. International Journal of Agricultural Technology, 18(1), 123-140.

Kalungu, J. W., & Leal Filho, W. (2018). Adoption of appropriate technologies among smallholder farmers in Kenya. Climate and Development, 10(1), 84-96. https://doi.org/10.1080/17565529.2016.1182889

Kassie, G. W. (2018). Agroforestry and farm income diversification: synergy or trade-off? The case of Ethiopia. Environmental Systems Research, 6(1). https://doi.org/10.1186/s40068-017-0085-6

Kiboi, M. N., Ngetich, K. F., Fliessbach, A., Muriuki, A., & Mugendi, D. N. (2019). Soil fertility inputs and tillage influence on maize crop performance and soil water content in the Central Highlands of Kenya. Agricultural Water Management, 217, 316-331 https://doi.org/10.1016/j.agwat.2019.03.014

Kom, Z., Nethengwe, N. S., Mpandeli, N. S., & Chikoore, H. (2022). Determinants of small-scale farmers' choice and adaptive strategies in response to climatic shocks in Vhembe District, South Africa. GeoJournal, 87(2), 677-700. https://doi.org/10.1007/s10708-020-10272-7 https://doi.org/10.1007/s10708-020-10272-7

LaCanne, C. E., & Lundgren, J. G. (2018). Regenerative agriculture: Merging farming and natural resource conservation profitably. PeerJ, 2018(2). https://doi.org/10.7717/peerj.4428

Lai, Z., Chen, M., & Liu, T. (2020). Changes in and prospects for cultivated land use since the reform and opening up in China. Land Use Policy, 97. https://doi.org/10.1016/j.landusepol.2020.104781

Lal, R. (2020). Regenerative agriculture for food and climate. In Journal of Soil and Water Conservation (Vol. 75, Issue 5, pp. 123A-124A). Soil and Water Conservation Society. https://doi.org/10.2489/jswc.2020.0620A

Llones, C., & Suwanmaneepong, S. (2021). Influence of perceived risks in farmer's decision towards sustainable farm practices, Evidence from Northern Thailand. International Journal of Agricultural Technology, 17(6), 2143-2154.

Mottaleb, K. A. (2018). Perception and adoption of a new agricultural technology: Evidence from a developing country. Technology in Society, 55(July), 126-135. https://doi.org/10.1016/j.techsoc.2018.07.007

Muriithi, L. N., Charles, O., Hezron, M., Bernard, G., Gatumo, G. N., & Kizito, K. (2021). Adoption Determinants of Adapted Climate Smart Agriculture Technologies Among Smallholder Farmers in Machakos, Makueni, and Kitui Counties of Kenya. Journal of Agricultural Extension 25(2) 75-85
https://dx.doi.org/10.4314/jae.v25i2.7

Muthee, A. I., Gichimu, B. M., & Nthakanio, P. N. (2019). Analysis of Banana production practices and constraints in Embu county, Kenya. Asian Journal of Agriculture and Rural Development, 9(1), 123-132. https://doi.org/10.18488/journal.1005/2019.9.1/1005.1.123.132

Mwaura, G. G., Kiboi, M. N., Bett, E. K., Mugwe, J. N., Muriuki, A., Nicolay, G., & Ngetich, F. K. (2021). Adoption Intensity of Selected Organic-Based Soil Fertility Management Technologies in the Central Highlands of Kenya. Frontiers in Sustainable Food Systems, 4(March). https://doi.org/10.3389/fsufs.2020.570190 https://doi.org/10.3389/fsufs.2020.570190

Ndeke, A. M., Mugwe, J. N., Mogaka, H., Nyabuga, G., Kiboi, M., Ngetich, F., Mucheru-Muna, M., Sijali, I., & Mugendi, D. (2021). Gender-specific determinants of Zai technology use intensity for improved soil water management in the drylands of Upper Eastern Kenya. Heliyon, 7(6). https://doi.org/10.1016/j.heliyon.2021.e07217 https://doi.org/10.1016/j.heliyon.2021.e07217

Newton, P., Civita, N., Frankel-Goldwater, L., Bartel, K., & Johns, C. (2020). What Is Regenerative Agriculture? A Review of Scholar and Practitioner Definitions Based on Processes and Outcomes. In Frontiers in Sustainable Food Systems (Vol. 4). Frontiers Media S.A. https://doi.org/10.3389/fsufs.2020.577723

Ojo, T. O., Baiyegunhi, L. J. S., Adetoro, A. A., & Ogundeji, A. A. (2021). Adoption of soil and water conservation technology and its effect on the productivity of smallholder rice farmers in Southwest Nigeria. Heliyon, 7(3), e06433. https://doi.org/10.1016/j.heliyon.2021.e06433

Okello, D. O., Feleke, S., Gathungu, E., Owuor, G., & Ayuya, O. I. (2020). Effect of ICT tools attributes in accessing technical, market and financial information among youth dairy agripreneurs in Tanzania. Cogent Food and Agriculture, 6(1). https://doi.org/10.1080/23311932.2020.1817287

Pozza, L. E., & Field, D. J. (2020). The science of Soil Security and Food Security. Soil Security, 1, 100002. https://doi.org/10.1016/j.soisec.2020.100002

Sanou, L., Savadogo, P., Ezebilo, E. E., & Thiombiano, A. (2019). Drivers of farmers' decisions to adopt agroforestry: Evidence from the Sudanian savanna zone, Burkina Faso. Renewable Agriculture and Food Systems, 34(2), 116-133. https://doi.org/10.1017/S1742170517000369

Schreefel, L., Schulte, R. P. O., de Boer, I. J. M., Schrijver, A. P., & van Zanten, H. H. E. (2020). Regenerative agriculture - the soil is the base. Global Food Security, 26. https://doi.org/10.1016/j.gfs.2020.100404

Senyolo, M. P., Long, T. B., Blok, V., & Omta, O. (2018). How the characteristics of innovations impact their adoption: An exploration of climate-smart agricultural innovations in South Africa. Journal of Cleaner Production, 172, 3825-3840. https://doi.org/10.1016/j.jclepro.2017.06.019

Taherdoost, H. (2018). A review of technology acceptance and adoption models and theories. Procedia Manufacturing, 22, 960-967. https://doi.org/10.1016/j.promfg.2018.03.137

Tokede, A. M., Banjo, A. A., Ahmad, A. O., Fatoki, O. A., & Akanni, O. F. (2020). Farmers' knowledge and attitude towards the adoption of agroforestry practices in Akinyele Local Government Area, Ibadan, Nigeria. Journal of Applied Sciences and Environmental Management, 24(10), 1775-1780. https://doi.org/10.4314/jasem.v24i10.10

Usman, U. M. Z., Ahmad, M. N., & Zakaria, N. H. (2019). The determinants of adoption of cloud-based ERP of Nigerian's SMEs manufacturing sector using TOE framework and DOI theory. International Journal of Enterprise Information Systems, 15(3), 27-43. https://doi.org/10.4018/IJEIS.2019070102 https://doi.org/10.4018/IJEIS.2019070102

Wahba, M., Labib, F., & Zaghloul, A. (2019). Impact of the Global Climate Change on Land Degradation in Egypt. International Journal of Environmental Pollution and Environmental Modelling, 2(2), 48-61. https://ijepem.com/article/view/volume-2-issue-2-article-1

Wambua, D. M., Gichimu, B. M., & Ndirangu, S. N. (2021). Smallholder Coffee Productivity as Affected by Socioeconomic Factors and Technology Adoption. International Journal of Agronomy, 2021. https://doi.org/10.1155/2021/8852371
https://doi.org/10.1155/2021/8852371

Wekesa, B. M., Ayuya, O. I., & Lagat, J. K. (2018). Effect of climate-smart agricultural practices on household food security in smallholder production systems: Micro-level evidence from Kenya. Agriculture and Food Security, 7(1). https://doi.org/10.1186/s40066-018-0230-0
https://doi.org/10.1186/s40066-018-0230-0

Worku, A. A. (2019). Factors affecting diffusion and adoption of agricultural innovations among farmers in Ethiopia case study of Ormia regional state Westsern Sewa. International Journal of Agricultural Extension, 7(2), 137-147.
https://doi.org/10.33687/ijae.007.02.2864

Zakaria, A., Alhassan, S. I., Kuwornu, J. K. M., Azumah, S. B., & Derkyi, M. A. A. (2020). Factors Influencing the Adoption of Climate-Smart Agricultural Technologies Among Rice Farmers in Northern Ghana. Earth Systems and Environment, 4(1), 257-271.https://doi.org/10.1007/s41748-020-00146-w