ADOPTION AND UTILIZATION OF ZAI PITS FOR IMPROVED FARM PRODUCTIVITY IN THARAKA-NITHI COUNTY, KENYA

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ABSTRACT
Smallholder farmers in low midland zones of Tharaka-Nithi County are facing challenges in improving agricultural productivity and livelihoods. Low crop yields due to low erratic rainfall, high evapotranspiration, and deteriorating soil health in smallholder farmers' fields have led to a quest for sustainable production practices with greater resource use efficiency. To alleviate these challenges, impact of zai pits was assessed in terms of factors that influence adoption in Tharaka-Nithi County, located in low midland zones of eastern Kenya. Interview schedules were used to elicit information from 290 farmers. A descriptive statistical analysis approach was used to analyse data. There was significant relationship between farmers who had been visited by an agricultural officer and adoption ((χ^2=6.019, P=0.05), where a higher percentage of farmers who had adopted had been visited by non-governmental extension agents. A significant difference existed between the average farm size of adopters and non-adopters (t=2.7, df=285, P=0.05). There is need to re-evaluate the role that socio-economic variables and farm characteristics contribute in adoption of Zai pits as a water harvesting technology.
Keywords: *Low erratic rainfall, Non-government extension agents, Socio-economic factors, Water harvesting*

INTRODUCTION
The present food insecurity and projected population growth in Sub-Saharan Africa (SSA) demand change from low yielding farming systems towards greater production and sustainability (Rockström et al., 2002; Cai and Rosegrant, 2003; Kauffman et al., 2003), particularly in semi-arid tropics where food security is threatened by frequent droughts, dry spells (Steiner et al., 2003) and infertile soils (Sanchez, 2002). Approximately 82% of Kenya landmass is characterised as arid and semi-arid (Abbass, 2009). The threat of increasing dry spell occurrences (Rockström, 2003; Enfors and Gordon, 2007) suggest an urgent need to change from the traditional cultivation practices in sub-Saharan Africa to more efficient and robust approaches which promote soil and water conservation (Ngigi et al., 2007). Soil fertility management research and outreach programs have been conducted in the SSA countries by several institutions, generating several knowledge-intensive technologies that have proven themselves successful for managing soil fertility (Bekunda et al.2010). However, according to Woomer, (2007) few ''modern'' soil management technologies have been adopted by the smallholder farmers, partly because of their high cost relative to crop price, and economic returns to farming have remained low (Woomer, 2007). While promoting water harvesting technologies as one of the feasible options for improving agricultural productivity in semiarid environments, there is need to understand the factors that influence their adoption.

MATERIALS AND METHODS

The study was conducted in Tharaka-Nithi County in Eastern Kenya. Tharaka-Nthi County borders Meru County to the North and Northeast, Kitui County to the East and Southeast, Embu County to the South and Southwest and occupies an area of 2,638.8 km^2. It lies in the Lower Midland 4 and 5 (LM 4 and 5) and Inner Lowland 5 (IL 5) agro-ecological zones (Jaetzold et al., 2006). Temperatures range from a minimum of 11°C to a maximum of 25.9°C and rainfall ranges between 200 mm and 800 mm per annum. The predominant soils are the highly weathered and leached acid infertile soils- ferrasols (Jaetzold et al., 2006). The area experiences a bi-modal pattern of rainfall.The main source of livelihood for the Tharaka people revolves around marginal farming and livestock rearing which are greatly affected by long spells of drought, which at times lead to total crop failure and massive loss of livestock (Jaetzold et al., 2006).

Structured interview schedule, was used to generate from 291 respondents. To facilitate the data collection process together with the researcher, seven enumerators were recruited based on their education level in addition to their ability to communicate the local "Kitharaka".

Data analysis

Data was analyzed using statistical package (SPSS version 16) and presented quantitatively using different statistical methods such as percentage, frequency, tabulation, Chi-square test (for dummy /discrete variables) and (t-test for continuous variables). The description was made using mean, minimum as well as maximum values, percentage and standard deviations.

RESULTS AND DISCUSSIONS

The study was conducted in Tharaka Central and Tharaka South in Tharaka Nithi County. The males composed 76.6% while female farmers composed 32.4%. About 51.9% of the repondents were non- adopters while 48.1% were adopters.Most (63.8%) of the farmers had attained primary education. Out of the 31 farmers who had attained tertiary education, 20 of them were non-adopters. About 14.7% had no formal education. A higher percentage (85.2%) of farmers were involved in farming as an occupation while only 6.7% were in business (Table 1).

Table 1: Social demographic characteristics of adopters and non-adopters

Sub-Counties	Non-Adopters	Adopters	
Tharaka Central	10(6.6)	13(9.3)	23(7.9)
Tharaka South	141(93.4)	127(90.7)	268(92.1)
Total	151(100)	140(100)	291(100)
Gender			
Male	115(76.2)	108(77.1)	223(76.6)
Female	36(23.8)	32(22.9)	68(32.4)
	151(100)	140(100)	291(100)
Level of education			
No Education	22(15.9)	17(13.4)	39(14.7)
Primary Education	84(60.9)	85(66.9)	169(63.8)
Secondary Education	12(8.7)	14(11.0)	26(9.8)
Tertiary Education	20(14.5)	11(8.7)	31(11.7)
	138(100)	127(100)	265(100)
OccupationHH			
Farming	124(83.2)	118(87.4)	242(85.2)
Business	7(4.7)	9(6.7)	16(5.6)
Employed	18(12.1)	8(5.9)	26(9.2)
	149(100)	135(100)	284(100)

Majority (60.1%) of the farmers had attained 1-5 times non- formal trainings on agricultural practices. There was a significant relationship (χ^2=31.339 , df=3, P=0.001) between attendance of non formal trainings and adoption where a higher percentage of those who had attended more than 10 trainings were adopters (Table 2). On the other hand 36.7% of the non-adopters had never attended any non- formal trainings which is an indication that non-formal trainings have a significant training on adoption of zai pits in the region. Similar studies denoted signficant and positive association between training and adoption of water harvesting technologies (Kihara, 2002).

The results from cross tubulations showed that membership in groups and associations had a significant relationship with adoption (χ^2=31.339,df=1, P=0.005). The rationale is that a farmer belonging to an association or a group is most likely able to access information from other farmers on the benefits of zai pits. Some non-governmental organization such as Catholic Diocess of Meru have been promoting water harvesting techiques in Tharaka Nithi using cash for asset model.The external support given to the farmers by the NGOs had a significant and positive (χ^2=31.339,df=1, P=0.005) effect on the adoption of Zai since a higher pecentage of the adopters were beneficiaries as compared to the non-adopters.

There was a positive significant relationship between adoption and steepness of the land (χ^2=7.912, df=1, P=0.003) where a higher percentage (64.7%) of the farmers who were adopters reported that their land was slopy (Table 2). The steepness or flatness of a plot affects the use of rainwater harvesting technologies. This is because zai pits are associated with collection and storage of runoff water for later use.

Farmer adoption of zai pits was also influenced by access to information.The χ^2 analysis showed a significant association between visits by non-government extension and adoption (χ^2=6.02,df=1, X=0.05) (Table 2). This is in line with research finding by Melaku (2005) whofound a positive and significant association of extension service and adoption of rain water harvesting technology. In another study by Marsh et al. (2000) extension as a source of information has shown to influence adoption of agricultural technologies.

Table 2: Case summary showing results of dummy explanatory varibles that affect adoption of zai pits

Variables	Adoption		Total	Chi-Square Tests
Non-Formal trainings	Non-Adopters	Adopters	Total	
None	55(36.7)	22(15.9)	77(26.7)	χ^2=31.339 , df=3, P=0.001)
1-5 times	87(58.0)	86(62.30	173(60.1)	
6-10 times	8(5.3)	14(10.1)	22(7.6)	
More than 10 times	0(0)	16(11.6)	16(5.6)	
Total	150(100)	138(100)	288(100)	
Member of Association/ farmer group	Non-Adopters	Adopters	Total	Chi-Square Tests
No	28(18.7)	10(7.1)	38(13.1)	χ^2=31.339
Yes	122(81.3)	130(92.9)	252(86.9)	df=1 P=0.005
Total	150(100.0)	140(100)	290(100)	
Beneficiary of NGO	Non-Adopters	Adopters	Total	Chi-Square Tests
No	75(49.7	31(22.6	106(36.8)	χ^2=23.285
Yes	76(50.3)	106(77.3)	182(63.2)	df=1, x=0.001
Total	151(100)	137(100)	288(100)	
Land slopy	Non-Adopters	Adopters	Total	Chi-Square Tests
No	78(51.70)	49(35.3)	127(43.8)	χ^2=7.912
Yes	73(48.3)	90(64.7)	163(56.2)	df=1, X=0.003
Total	151(100)	139(100)	290(100)	
Visited NGO Worker	Non-Adopters	Adopters	Total	Chi-Square Tests
No	137(54.8)	113(45.2)	250(100)	
Yes	14(34.14)	27(65.85)	41(100)	χ2=6.02
Total	151(51.9)	140(48.1)	291(100)	df=1, X=0.05

Most of the farmers(76.3%) who have adopted zai pits got the information from the non-government extension agents. About 10.8% and 7.2% of the farmers got the information from government extension agent and other farmers respectively while 5.8% used their own experience (Figure 1).This is in line with the cross tubulation done on the same study which showed a positive significant relationship between visit by non-government extension agents and adoption. However it disagrees with the findings of Kimaru-Muchai et al.,(2013) who reported that most of farmers receive information on intergrated soil fertility management practices from other farmers.

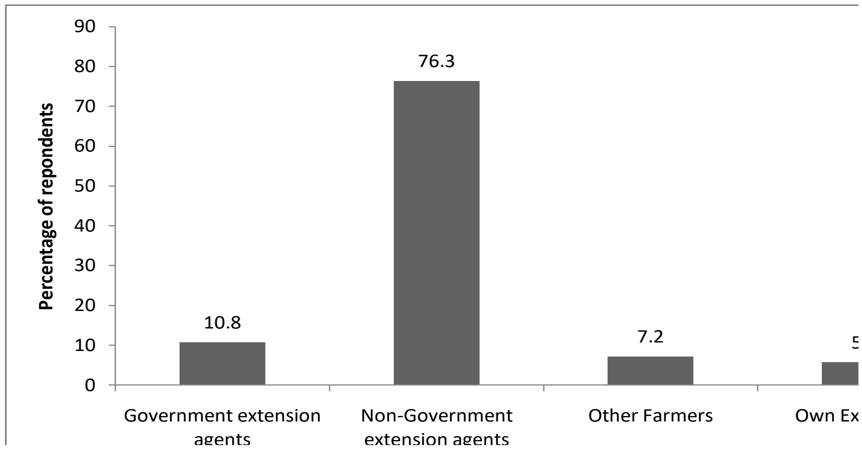

Figure 1: Source of information on zai pits

Among the farmers who have adopted zai pits, 95% use animal manure as a soil fertility ammendement. Only 2.1% of the farmers combine animal manure plus fertilizer as input to zai pits. About 6.4% reported that they do not use any input at all on zai pits (Table 3). According to Liniger et al. (2011) combining soil fertility ammendments with soil and water conservatgion is more suitable. A combination of manure application with zai pits in Burkina Faso resulted in a more than two fold grain yield compared with that without manure (FatondJi et al., 2006).

Table 3: Combination of zai pits and soil fertility improvements

	Practice Zai and ISFM		Total
ZaiPits+ISFM	No	Yes	
Zai pits +animal manure	7(5)	133(95.0)	140
Zai pits+green manure	116(82.9)	24(17.1)	140
Zai pits + fertilizer	134(95.7)	6(4.3)	140
Zai pits +Animal manure +Fertilizers	137(97.9)	3(2.1)	140
Zai pits +vegetation +Ferilizers	136(97.1)	4(2.9)	140
Zai pits +Animal manure +vegetation	101(72.1)	39(27.9)	140
Zai pits alone	131(93.6)	9(6.4)	140
Total	762(77.8)	218(22.2)	980

The average age of the non adopters was 46.3 years while the average age of the non adopters was 44.7 years. The result of the t-test showed there was a significant difference (t=2.707, P=0.007) between house hold size of the adopters (6.06) and the non adopters (5.34). In addition there was also significant difference (t=2.707, P=0.007) of household members working on the farm among the adopters and the non adopter. This implies that adopters have more labour sources compared to the non- adopters. The number of groups a farmer belonged also influenced the adoption of zai pits in that a significant difference existed between the adopters and the non adopters at less than1% probablity level (-4.835). The implication is that majority of the adopters had joined many groups as compared to their counterpart. The total farm size for the adopters was higher (6.81) while for non adopters was 5.45, hence a significant difference exist at less than 5% probablity level (-2.237) (Table 4). This agrees with research findings that Buyinza et al.(2008) who reported that farmers who had bigger farm size were likely to adopt rain water harvesting techniniques.

There was a significant difference at (t=2.594, P=0.01) on ownership of cattle as the average number of cows owned by adopters (2.3) was higher compared to the non adopters(1.7).At the same time a significant difference was experinced on the number of goats owned by the adopters(5.67) and the non adopters(4.04) at less than 5% probablity level (t=-2.26) (Table 4). This implied that the adopters had more livestock resources than the adopters even though there was no significant difference in ownership of sheep, donkeys and hens. The findings agree with the study of Musaba (2010) who reported positive association between herd size and technology adoption.

Table 4: Case summary showing results of continous varibles that affect adoption of zai pits

	Adoption	N	Mean	Std. Deviation	t	df	Sig. (2-tailed)
AgeHH	Non-Adopters	148	44.77	14.5172			
	Adopters	132	46.30	12.0729	-0.964	276.681	0.336
YearsFarmingExperience	Non-Adopters	150	20.19	12.6196			
	Adopters	139	22.50	13.3321	-1.514	282.146	0.131
HouseholdSize	Non-Adopters	146	5.34	2.0787			
	Adopters	136	6.06	2.3844	-2.707	268.514	0.007
HouseMembersWorking	Non-Adopters	123	3.02	1.6791			
	Adopters	138	3.60	1.8105	-2.709	258.583	0.007
Number of Groups	Non-Adopters	147	1.66	1.1010			
	Adopters	135	2.37	1.3424	-4.835	259.729	0.001
Total Farm Size	Non-Adopters	147	5.45	5.3914			
	Adopters	140	6.81	4.8378	-2.237	284.005	0.026
Cattle	Non-Adopters	151	1.34	1.6887			
	Adopters	140	1.95	2.2706	-2.594	255.787	0.01
Goats	Non-Adopters	151	4.04	6.0728			
	Adopters	140	5.67	6.2184	-2.262	286.163	0.024

DISCUSSION AND CONCLUSION

Agricultural investments, especially in the semi-arid environments are risky. Hence, most farmers are risk averse and reluctant to invest in new technologies that would improve agricultural production and livelihoods (Ngigi et al., 2005). According to Pannell et al. (2006), adoption is principally influenced by the characteristics and circumstances of the farmer, and the characteristics of the practice, especially its relative advantage over existing practices and landholder's ability to trial the practice. Farmers adopt an innovation if they expect that the practice will help them achieve their goals, which may include economic, social and environmental goals (Ngigi et al., 2005).

The findings of this study suggests that number of non- formal trainings, beneficiaries of NGOs, membership of group ,steepness of land and visits by non-governmental extension agents play an important role in adoption of zai pits. Other factors such as farm size, number of cows and goats owned by the farmer and number of groups a farmer belonged also played a significant role in adoption and utilization of zai pits. In regards to these findings farmers should be encouraged to join farmer groups or association and attend non- formal training on agricultural practices. In addition, both non-government extension agents and government extension agents should be encouraged to visit the farmers and have more interaction with them in dissemination of benefits of zai pits.

Most farmers in Tharaka Nithi have learnt the art of combining zai pits with manure as a soil fertility amendment. However they should be encouraged to use other technologies such compost, organic fertilizers and green manure in addition to animal manure. At the same time it is essential to scale up both water harvesting technologies combined with soil fertility management practices. Organic materials such as compost and manure need only be added to the planting holes instead of spreading them over the entire field area. The improved efficiency makes it easier for farmers to obtain and apply the fertility inputs needed to maintain productive soils.

REFERENCES

Abbass, A.M. 2009. Drought in Kenya and National Development. Arid Lands Resource Management Project. Special Programmes Office of the President. Nairobi, Kenya.

Bekunda, M., Sanginga, N. and Woomer, P.L. 2010. Restoring Soil Fertility in Sub-Sahara Africa. Advances in Agronomy, 108:183-236

Buyinza, M., and Wambede, N. 2008. Extension for agroforestry technology adoption: mixed intercropping of crotolaria (*Crotolaria grahamiana*) and maize (*Zea mays* L.) in Kabale district, Uganda. Environmental Research Journal 2(3):131-137.

Cai, X., and Rosegrant, M.W. 2003. World water productivity: Current situation and future options. In Water productivity in agriculture: Limits and opportunities for improvement. J.W. Kijne, R. Barker, and D. Molden (Eds.). Wallingford, UK and Cambridge, MA: CABI Publication, 163-179.

Enfors, E. and Gordon, L. 2007. Analyzing resilience in dryland agro-ecosystems. A case study of the Makanya catchment in Tanzania over the past 50 years. Land Degra- dation and Dement, 18:680–696.

Fatondji, D., Martius, C., Bielders, C., Vlek, P., Bationo, A. and Gérard, B. 2006. Effect of planting technique and amendment type on pearl millet yield, nutrient uptake, and water use on degraded land in Niger. Nutr. Cycl. Agroecosyst. 76:203–217.

Jaetzold, R., Schmidt, H., Hornet, Z.B. and Shisanya, C.A., 2006. Farm Management Handbook of Kenya. Natural Conditions and Farm Information. 2nd Edition. Vol.11/ C. Eastern Province. Ministry of Agriculture/GTZ, Nairobi, Kenya.

Kauffman, J.H., Mantel, S., Ringersma, J., Dijkshoom, J.A., van Lynden, G.W.J. and Dent, D.L., 2003. Making better use of green water under rain-fed agriculture in sub- Saharan Africa, p. 103-108. *In*: Proceedings of the symposium and workshop on water conservation technologies for sustainable dryland agriculture in Sub-Saharan Africa (WCT). Held at Bloem Spa Lodge and Conference Centre, Bloemfontein, South Africa 8-11th April 2003.

Kihara, F.I. 2002. Evaluation or rainwater harvesting systems in *Laikipia* District, Kenya. GHARP case study report. In Ngigi (2003) Rainwater Harvesting for Improved Food Security; Promising Technologies in the Greater Horn of Africa. GHARP, KRA, Nairobi, Kenya, 2002.

Kimaru-Muchai, S.W., Mucheru-Muna M., Mugwe J.N., Mairura F S and Mugendi D.N. 2013. Communication channels used in dissemination of soil fertility management practices in the Central Highlands of Kenya. In: Vanlauwe B, Asten P and Guy Blomme, G (Eds.). Agro-Ecological Intensification of Agricultural Systems in the African Highlands Chapter 4:283-307.

Liniger, H.P., Mekdaschi Studer, R., Hauert, C. and Gurtner, M. 2011. Sustainable Land Management in Practice: Guidelines and Best Practices for Sub-Saharan Africa, TerrAfrica, WOCAT, and FAO, Rome.

Marsh, S.P., Pannell, D.J. and Lindner R. K. 2000. The impact of agricultural extension on and diffusion of lupins as a new crop in Western Australia. Australian Journal of Experimental Agriculture 40:571-583.

Melaku, G. 2005. Adoption and profitability of Kenyan Top Bar Hive Bee Keeping Technology: A study in Ambasel Woreda. M.Sc. Thesis Alemaya Universty, Ethiopia.

Musaba, E.C. 2010. Analysis of factors influencing adoption of cattle management technologies by communal farmes in Northern Namibia. Livestock Research for Rural Development 22(6).

Ngigi N S. 2003. Rainwater harvesting for improved food security: Promising technologies in the greater horn of Africa. GHARP, KRA, Nairobi, Kenya.

Ngigi, S.N., Savenije, H.H.G. and Gichuki, F.N. 2007. Land use changes and hydrological impacts related to up-scaling of rainwater harvesting and management in upper Ewaso Ng'iro river basin, Kenya. Land Use Policy, 24:129–140.

Pannell, D.J., Marshall, G.R., Barr, N., Curtis, A., Vanclay, F. and Wilkinson, R. 2006. Understanding and promoting adoption of conservation technologies by rural landholders. Australian Journal of Experimental Agriculture, 46:1407–1424.

Rockström, J. 2003. Resilience building and water demand management for drought mitigation. Physics and Chemistry of the Earth, 28:869–877.

Sanchez, P.A. 2002. Ecology: Soil fertility and hunger in Africa. Science 295:2019–2020.

Steiner, K.G. 2002. Producing in harmony with nature through conservation tillage. African Conservation Tillage Network. Information series number 1.

Woomer, P.L. 2007. Costs and returns to soil fertility management options in Western Kenya, p. 877–885. *In*: Advances in Integrated Soil Fertility Management in Sub Saharan Africa: Challenges and Opportunities. A. Bationo, B. S. Waswa, J. Kihara, and J. Kimetu (Eds.). Springer, Dordrecht.