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Factors affecting the adoption of drip irrigation technology among smallholder farmers in Tanzania: A case of Arumeru district, Arushan

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Abstract
Government and development agencies enthusiastically promote drip irrigation technology in a bid to save water and improve food security. Yet most farmers stop using drip irrigation technology as soon as the projects ends. This paper assessed factors affecting adoption of drip irrigation technology among smallholder farmers in Arumeru district of Arusha region, northern Tanzania. The study used structured questionnaire and focus group discussion on a randomly obtained sample of 120 smallholders. Results show that female smallholders adopted drip more than their male counterparts. Also, high income and education levels determined adoption of drip irrigation technology in the area. Similarly, smallholders growing multiple crops were less likely to adopt drip irrigation technology than those growing single or few crops. This paper therefore, recommends that more efforts be directed to strengthen women groupings since they have proved to enable them access cutting edge farming technology. Also, improving education levels among smallholders could further improve farmers' lot in rural areas as increased their chance of adopting technology.

Keywords: drip irrigation, adoption, smallholder farmers

Introduction
Agriculture is by far the largest consumer of the earths available freshwater. About 70% of "blue water" withdrawals from watercourses and groundwater are for agricultural usage, three times more than 50 years ago (WWAP, 2014) [43]. By 2050, the global water demand of agriculture is estimated to increase by a further 19% due to irrigational needs. Approximately 40% of the world's food is currently cultivated in artificially irrigated areas (Garg, e*t al*, 2017) [12]. Global water demand is largely influenced by population growth, urbanization, food and energy security policies, and macro-economic processes such as trade globalization, changing diets and increasing consumption. By 2050, global water demand is projected to increase by 55%, mainly due to growing demands from manufacturing, thermal electricity generation and domestic use (UN-WWDR, 2014) [41]. In Tanzania particularly there has been rise of conflicts recently due to demand of water between different groups of users e.g. livestock keepers and crop cultivators. Some well-known water authors such as Sandra Postel (1998, 1999, and 2001) [27-29] and Peter Gleick (2003) [14] have questioned the sustainability of the current system if it is not transformed in a significant way. Sandra (2001) [32] has proposed that a large-scale shift towards higher productivity, decentralized drip irrigation would be the way forward to increase water productivity and make water use sustainable. In Tanzania there are several NGOs and private companies which promote drip irrigation technology for example World Vision Tanzania, Tanzania Horticulture Association (TAHA), Irrico, Balton Tanzania, and Wade Rain focusing on increasing farmers' income through enhancing on farm productivity by adopting the use of drip irrigation technology. Despite all efforts and the global water decreasing threat smallholder farmers have been reluctant in adopting this technology. This paper therefore, investigated the relationships between selected factors (age, sex, education, and proximity to water source, income, types of crops and farmers experience) among smallholders in Arumeru District of Arusha in Northern Tanzania.

Methods
This study was conducted in Arumeru district in Arusha Region of Northern Tanzania. A sample of 120 smallholder farmers were randomly selected from a population of 49,292 and interviewed using structured questionnaires. Also, five focus group discussions were also held. Descriptive and inferential statistics tools were used to analyze the collected data. Cross tabulation and correlation analysis were computed to determine the relationship of dependent and independent variables and to compare and identify the difference between variables and forecast outcomes.

Results and Discussion
Sex and adoption of smallholder adoption of drip irrigation technology
This study sought to determine whether sex influenced adoption of drip irrigation. Results show out of 39 females interviewed 15 (38.5%) were using drip irrigation while out of 81 men interviewed only 11 (13.6) were using drip irrigation. This result is contrary to many previous studies such as Tumbo *et al.* (2014) [39] who reported that men usually have more power to adopt technology than women because they

have relatively more resources and own land. The higher levels of women who adopted drip irrigation in Arumeru District could be because of NGOs activities in the district which for many years promoted women smallholders' farmers. Upadhyay (2005) [42] noted that in disseminating drip technology many organizations prefer to work with formal and informal groups because it is easier to reach large population. Women in Arumeru district were more likely from economic groupings than men. In this regard, women managed to have higher access to drip technology than men.

Relationship between age and adoption of smallholder adoption of drip irrigation technology

The relationship between age and adoption of drip irrigation in Arumeru district was investigated. Results found that smallholders aged from 36 and above adopted drip irrigation more than other age categories. This result is contrary Cao (2008) [3] who found that probability of adopting the technology was higher among older farmers than younger ones because younger farmers had fewer resources compared to young ones. Normally, the young people who engages in agriculture in Tanzania do not own land, rather they rent it. In this regard, it is difficult for them to install expensive farming technology on a rented land.

Relationship between income and adoption of smallholder adoption of drip irrigation technology

The relationship between income and adoption of drip irrigation was investigated in Arumeru district. Results show that 21 (87.5%) who had income of Tanzanian Shillings 3 million and above, out of the 24 smallholders' farmers interviewed adopted drip irrigation technology. This suggests that income have a positive impact on the adoption drip irrigation among smallholders. This result is similar to Cao, *et al.* (2008) [3] who found that higher family income implies the ability to invest in adoption and to bear the risk associated with it.

Education level and adoption of smallholder adoption of drip irrigation technology

Relationship between education levels and adoption of drip irrigation technology in Arumeru district. Results found that there is a significant relationship ($P \leq 0.01$) between the level of education and the adoption of drip irrigation technology. Farmers with secondary education and more adopted compared drip irrigation than their counterparts. This finding is different from Feng-Min Li (2008) [11] who observed that education level of farmers does not have the expected positive impact on the adoption of the technology.

Table 1: Correlation between socio-economic factors and the use of drip irrigation technology

		Annual income	Age	# of productive people	Sex	Education level
Use of drip irrigation	Pearson Correlation	.275**	-.041	-.086	.283**	.266**

** Correlation is significant at the 0.01 level

Types of crops and the adoption of drip irrigation technology

Types of crops was analyzed whether they affected adoption of drip irrigation technology. This study found that there is a negative correlation between the type of crops and the adoption rate of drip irrigation (significant at $P<0.01$). This suggests that farmers who specialize in single or few crops are more likely to adopt technology than those who do not specialize. In this case, farmers who cultivate horticultural crops adopted drip irrigation more as compared to farmers who cultivated both cereal and horticulture. The reason might be that horticulture are of high value compared to cereal crops and drip irrigation is cost effective if used in high value crops. In the US, Tumbo (2001) [38] found that drip irrigation is currently used on 5 percent of irrigated crops, principally for high value crops in areas where water availability is limited.

Table 2: Correlation between the use of drip irrigation and farm characteristics

		Types of crops cultivated
Use of drip irrigation to irrigate crops	Pearson Correlation Sig(2-tailed)	-.262**

** Correlation is significant at the 0.01 level

Conclusions and recommendations

This paper concludes that women groupings, high income and education and farming specialization contributes to the adoption of technology. It is therefore recommended that governments and organizations promoting rural development should pay attention to the aforementioned factors as they play a critical role in the adoption of technology. Also, more efforts be directed to strengthen women groupings since they have proved to enable them access cutting edge farming technology. Similarly, improving education levels among smallholders could further improve farmers' lot in rural areas as increased their chance of adopting technology.

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