# CHARACTERIZING DETERMINANTS OF THE UPTAKE OF INTEGRATED SOIL FERTILITY MANAGEMENT TECHNOLOGIES IN HETEROGENEOUS SMALLHOLDER FARMS IN THE SUB-HUMID TROPICS

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## Introduction

Rapid population growth, environmental sustainability and achieving the Sustainable Development Goals (SDGs) remain the three most crucial three-tier cross-cutting issues confronting governments across the globe

The rapid population growth culminates in serious food security challenges and, a threat to environmental and SDGs sustainability

Food scarcity in SSA is attributed to stagnation in the production of staple food crops because of the socioeconomic attributes affecting food regimes in the region

Also, persistent low soil fertility and climate change are the primary biophysical root causes of this meager crop production. Low soil fertility has a strong link, directly or indirectly, with environmental sustainability and all the SDGs save SDG 17. Intervention measures to improve soil fertility is thus, of importance in the region

ISFM has strong but unfulfilled potential to remedy the dwindling soil fertility. However, its uptake is barely 44% in the Central Highlands of Kenya. We therefore sought to assess determinants of ISFM uptake by smallholder farmers in the region

## Objective

The objective was to assess the determinants of clustered ISFM uptake by smallholder farmers and sources of soil fertility management information in the Central Highlands of Kenya

## Methodology

### Study Area

❖ We carried out the study in Tharaka-Nithi and Murang'a Counties, Central Highlands of Kenya.

❖ Tharaka-Nithi is situated on the Eastern slopes of Mt. Kenya and rests at 1,500 m above sea level. It receives between 600-1200 mm rainfall annually

❖ Murang'a lies at 1,520-2,280 m above sea level and receives an annual average rainfall ranging between 900 to 1,400 mm

❖ Rainfall pattern in the two areas is bimodal. Short rains coming in October to December and long rains fall from March to June

❖ Crop-livestock farming system is practised on approximately 2 ha and 1.5 ha, per household in Tharaka-Nithi and Murang'a, respectively

❖ The staple food crop is maize (*Zea mays*L.) which is often intercropped with beans (*Phaseolus vulgaris*)

❖ Main cash crops include; avocado (*Persea americana*), coffee (*Coffea arabica*), banana (*Musa spp*.), and tea (*Camelliasinensis*)

### Experimental design

❖ We conducted a cross-sectional survey using a detailed interview schedule to collect primary data on farmers' demographic information, farm characteristics, and ISFM technology characteristics

❖ Sampling frameworks for the two sites were obtained from the respective Ministry of Agriculture extension officers residing and operating in the Counties

❖ From the sampling frames, 300 and 296 respondents from Tharaka-Nithi and Murang'a, respectively, were randomly selected following a simple random sampling technique

❖ The household survey was conducted just before the planting season commenced, a period when the farmers make important farming decisions

### Data analysis

❖ We employed Wald's hierarchical clustering method to identify the most common ISFM technologies used by farmers in the two study sites

❖ We used an ordered probit model in Statistical Package for Social Sciences (SPSS) software version 21 to define the latent variable for ISFM technologies' frequency function (T*)

## Results

➢ The perception of soil fertility had a positive correlation with the uptake of most ISFM clusters (Table 1). Our analysis revealed variance in the relationship between ISFM clusters and determinants of their respective uptake (Table 2)

➢ Estimates of household head (HHH) biophysical, market and resource endowment factors differed in magnitude and direction (either positive or negative) with which they related with ISFM clusters uptake

➢ Results showed that smallholder farmers from the region obtain soil fertility information from varied sources (Figure 1 a and b)

Table 1: Perception of soil fertility status as a determinant of ISFM uptake in Tharaka-Nithi and Murang'a Counties.

| Soil fertility status: | Tharaka-Nithi | | | | | | Murang'a | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $ISFM_{class1}$ | | $ISFM_{class2}$ | | $ISFM_{class3}$ | | $ISFM_{class1}$ | | $ISFM_{class2}$ | | $ISFM_{class3}$ | |
| | Coef. | p>[z] | Coef. | p>[z] | Coef. | p>[z] | Coef. | p>[z] | Coef. | p>[z] | Coef. | p>[z] |
| A minor problem | 0.10 | 0.76 | -0.14 | 0.70 | 0.42 | 0.51 | 0.01 | 0.92 | 0.50 | 0.20 | 0.11 | 0.74 |
| A major problem | 1.09 | 0.30 | 0.36 | 0.51 | 0.24 | 0.62 | 5.75 | **0.02** | -0.08 | 0.88 | 0.01 | 0.91 |
| Very good at farm scale | 0.14 | 0.71 | 1.64 | 0.38 | 1.93 | 0.17 | 0.41 | 0.52 | 0.12 | 0.93 | 0.43 | 0.51 |
| Is good at farm scale | 0.27 | 0.60 | 1.19 | 0.76 | 4.27 | **0.04** | 1.35 | 0.25 | 0.21 | 0.72 | 1.16 | 0.28 |
| Is bad at farm scale | 0.01 | 0.91 | 1.21 | 0.25 | 0.59 | 0.44 | 2.53 | 0.11 | 0.47 | 0.87 | 2.62 | 0.11 |
| Is very bad at farm scale | 6.29 | **0.01** | 0.51 | **0.00** | 2.03 | 0.15 | 0.37 | 0.55 | 1.03 | 0.33 | 0.21 | 0.97 |

**Tharaka–Nithi County**
$ISFM_{class1}$ = Animal manure + anti-erosion + inorganic fertilizer + crop rotation + legume intercrop;
$ISFM_{class2}$ = Compost + *Tithonia diversifolia* + minimum tillage + agroforestry + crop residue retention;
$ISFM_{class3}$ = Green manure.

**Murang'a County**
$ISFM_{class1}$= Agroforestry + green manure + minimum tillage + crop residue retention + crop rotation;
$ISFM_{class2}$ = Animal manure + inorganic fertilizer + anti-erosion + legume intercrop;
$ISFM_{class3}$ = Compost + *Tithonia diversifolia*.

Table 2: Demographic and biophysical determinants of ISFM technologies uptake in Tharaka-Nithi and Murang'a and Counties

| Variables | Tharaka-Nithi | | | | | | Murang'a | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $ISFM_{class1}$ | | $ISFM_{class2}$ | | $ISFM_{class3}$ | | $ISFM_{class1}$ | | $ISFM_{class2}$ | | $ISFM_{class3}$ | |
| | Coef. | P > [z] | Coef. | P > [z] | Coef. | P > [z] | Coef. | P > [z] | Coef. | P > [z] | Coef. | P > [z] |
| Cooperatives member (0= No; 1 = Yes) | 0.66 | **<0.01** | -0.04 | 0.87 | 0.08 | 0.79 | 0.13 | 0.62 | 1.37 | **<0.01** | 0.12 | 0.61 |
| Farmer group member (0= No; 1 = Yes) | 0.29 | 0.16 | -0.01 | 0.97 | -0.25 | 0.43 | -0.10 | 0.69 | 0.02 | 0.92 | -0.10 | 0.64 |
| Religious group member (0= No; 1 = Yes) | 0.39 | **0.03** | 0.45 | **0.02** | 0.17 | 0.51 | 0.39 | 0.09 | -0.13 | 0.63 | 0.22 | 0.33 |
| Saccos member (0= No; 1 = Yes) | 0.55 | **<0.01** | -0.22 | 0.22 | -0.01 | 0.98 | 0.08 | 0.75 | 0.08 | 0.75 | -0.19 | 0.44 |
| Women group member (0= No; 1 = Yes) | 0.16 | 0.39 | -0.23 | 0.20 | 0.02 | 0.94 | 0.25 | 0.21 | 0.15 | 0.48 | -0.15 | 0.44 |
| Youth group member (0= No; 1 = Yes) | -0.08 | 0.89 | -0.63 | 0.23 | 0.20 | 0.76 | 0.09 | 0.89 | -0.30 | 0.58 | 0.59 | 0.25 |
| Farming decision-maker (0= No; 1 = Yes) | 0.17 | 0.08 | 0.03 | 0.80 | -0.11 | 0.42 | 0.14 | 0.22 | 0.03 | 0.81 | 0.03 | 0.79 |
| Farming experience (0= No; 1 = Yes) | -0.29 | **0.03** | 0.04 | 0.76 | -0.04 | 0.83 | -0.02 | 0.90 | 0.00 | 0.99 | 0.02 | 0.87 |
| Gender of HHH (0= No; 1 = Yes) | -0.58 | **<0.01** | -0.28 | 0.14 | -0.29 | 0.28 | -0.03 | 0.91 | 0.15 | 0.47 | -0.30 | 0.12 |
| Level of education (0= No; 1 = Yes) | -0.29 | **0.01** | 0.06 | 0.59 | 0.10 | 0.49 | -0.06 | 0.65 | 0.02 | 0.88 | -0.06 | 0.60 |
| Age of HH (continuous) | -0.05 | 0.66 | 0.01 | 0.97 | 0.16 | 0.36 | -0.27 | 0.07 | -0.30 | **0.02** | -0.07 | 0.58 |
| Adequate food (0= No; 1 = Yes) | -0.85 | 0.61 | -0.16 | 0.88 | 17.36 | 1.00 | 0.62 | 1.00 | -23.33 | 1.00 | -41.56 | 1.00 |
| Change in SF over time (0= No; 1 = Yes) | -0.88 | 0.10 | -0.13 | 0.81 | -5.80 | 1.00 | 1.42 | 1.00 | -5.28 | 1.00 | -6.81 | 1.00 |
| Confidence to invest in land (0= No; 1 = Yes) | 3.28 | 0.35 | 0.94 | 0.47 | -16.90 | 1.00 | 7.53 | 1.00 | -28.93 | 1.00 | -44.47 | 1.00 |
| Info on resources availability (0= No; 1 = Yes) | 2.48 | **0.05** | -2.31 | 0.06 | -16.75 | 1.00 | 13.96 | 1.00 | -24.41 | 1.00 | -70.37 | 1.00 |
| Is soil fertility problem (0= No; 1 = Yes) | -1.25 | 0.31 | 1.08 | 0.30 | 3.97 | 1.00 | 0.54 | 1.00 | -10.30 | 1.00 | -25.23 | 1.00 |
| Length of food shortage (continuous) | 2.48 | 0.26 | 4.40 | 0.07 | 1.58 | 1.00 | -10.39 | 1.00 | 47.44 | 1.00 | 62.91 | 1.00 |
| Perception of SF (0 = Not a problem; 1 = A problem) | -0.15 | 0.55 | -0.75 | 0.12 | 7.44 | 1.00 | -5.06 | 1.00 | 1.29 | 1.00 | 4.65 | 1.00 |
| Rating SF (categorical) | -1.83 | 0.20 | -0.28 | 0.89 | -17.58 | 1.00 | 1.87 | 1.00 | 12.67 | 1.00 | 15.73 | 1.00 |

Table 2 *continued*

| Variables | Tharaka-Nithi | | | | | | Murang'a | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $ISFM_{class1}$ | | $ISFM_{class2}$ | | $ISFM_{class3}$ | | $ISFM_{class1}$ | | $ISFM_{class2}$ | | $ISFM_{class3}$ | |
| | Coef. | P > [z] | Coef. | P > [z] | Coef. | P > [z] | Coef. | P > [z] | Coef. | P > [z] | Coef. | P > [z] |
| Land renting length (continuous) | 0.43 | 0.25 | 0.55 | 0.39 | -7.10 | 1.00 | 3.63 | 1.00 | -1.53 | 1.00 | -12.14 | 1.00 |
| Access to loan (0=No; 1 = Yes) | -0.15 | 0.63 | 0.58 | 0.10 | (omitted) | | 0.03 | 0.94 | 0.23 | 0.52 | 0.31 | 0.36 |
| Distance to agrodealer in km (continuous) | -0.03 | 0.26 | -0.02 | 0.44 | 0.06 | **0.02** | -0.05 | 0.22 | 0.10 | 0.09 | 0.03 | 0.26 |
| Distance buyer in km (continuous) | -0.02 | 0.57 | 0.04 | 0.15 | -0.07 | 0.08 | 0.08 | **0.03** | 0.05 | 0.32 | 0.04 | 0.21 |
| Distance tarmac road in km (continuous) | -0.01 | 0.76 | -0.03 | 0.18 | 0.01 | 0.80 | 0.04 | **0.05** | -0.04 | **0.05** | -0.03 | 0.29 |
| Access to animal power (0=No; 1 = Yes) | -0.19 | 0.46 | -0.18 | 0.49 | -0.20 | 0.61 | 4.57 | **<0.01** | 0.09 | 0.90 | 4.25 | **<0.01** |
| Access to hand hoe (0=No; 1 = Yes) | -5.25 | 0.98 | 5.00 | 0.99 | -2.25 | 0.76 | -9.26 | 0.99 | -1.73 | **0.04** | -8.62 | 0.99 |
| HH adult inside labor (continuous) | 0.06 | 0.51 | 0.03 | 0.69 | -0.03 | 0.80 | 0.02 | 0.82 | -0.09 | 0.26 | 0.03 | 0.71 |
| HH adult outside labor (continuous) | -0.01 | 0.84 | 0.00 | 1.00 | 0.19 | **0.03** | -0.08 | 0.24 | 0.09 | 0.18 | 0.07 | 0.19 |
| Amount of off-farm income (continuous) | -0.27 | **<0.01** | 0.01 | 0.86 | 0.10 | 0.39 | 0.02 | 0.78 | 0.02 | 0.78 | -0.01 | 0.94 |
| Land size in acres (continuous) | -0.28 | 0.23 | 0.17 | 0.47 | -0.29 | 0.45 | -0.58 | 0.22 | 0.44 | 0.25 | 0.29 | 0.39 |
| Land under cultivation (continuous) | -0.04 | 0.91 | -0.04 | 0.89 | 0.40 | 0.38 | 0.40 | 0.46 | -0.59 | 0.18 | -0.53 | 0.2 |
| Radio (0=No; 1 = Yes) | 0.50 | 0.11 | 0.75 | **0.01** | -0.37 | 0.33 | 0.10 | 0.80 | -0.52 | 0.18 | -0.31 | 0.35 |
| TV (0=No; 1 = Yes) | -0.17 | 0.42 | 0.30 | 0.17 | 0.14 | 0.64 | 0.07 | 0.78 | 0.53 | **0.02** | -0.40 | 0.08 |
| Vehicle (0=No; 1 = Yes) | 0.10 | 0.81 | -0.40 | 0.34 | 0.62 | 0.22 | 0.58 | 0.09 | -0.23 | 0.51 | 0.36 | 0.28 |
| Wheelbarrow (0=No; 1 = Yes) | 0.63 | **<0.01** | 0.05 | 0.80 | -0.43 | 0.15 | 0.12 | 0.62 | 0.20 | 0.39 | 0.26 | 0.26 |
| Total livestock tropical unit (continuous) | -0.08 | 0.15 | 0.09 | 0.15 | -0.08 | 0.44 | -0.15 | 0.16 | 0.14 | 0.19 | 0.01 | 0.94 |

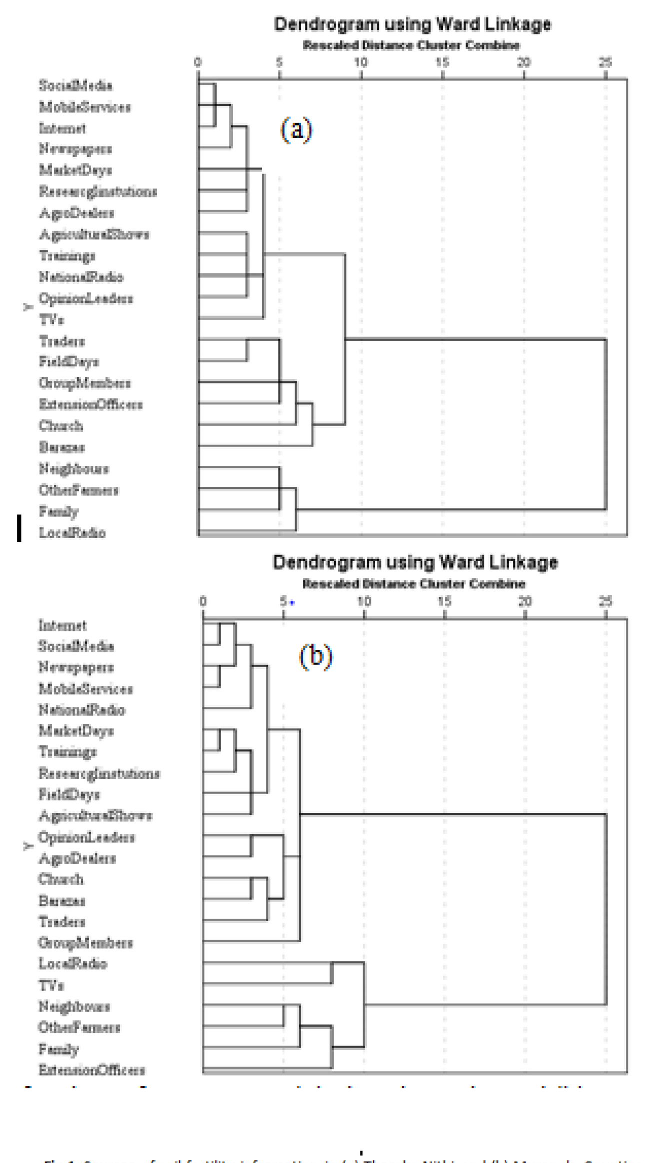


Fig.1: Sources of soil fertility information in (a) Tharaka-Nithi and (b) Murang'a Counties.

**Summary of key findings**

- There are indications of transition to more ISFM practices was found
- Combined minimum tillage and agroforestry substituted use of inorganic fertilizers
- Uptake of ISFM is significantly affected by socioeconomic and biophysical factors
- Perception of soil fertility status influence uptake of various ISFM sets
- Communication channels are vital in ISFM uptake

## Conclusion and Recommendation

ISFM clusters are indications that smallholder farmers in the Central Highlands of Kenya are transitioning to higher levels of ISFM. The uptake of ISFM technologies in the region was influenced by socio-economic, bio-physical determinants, and farmers' perception of soil fertility status. We recommend institutional and policy support to scale-up the uptake of ISFM technologies

## Reference

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