INITIATIVE ON Agroecology

Assessment of existing and preferred agroecological soil, water, and integrated pest management practices in the Makueni and Kiambu Agroecological Living Landscapes, Kenya

Anne Kuria, Peter Bolo, Winnie Ntinyari, Levi Orero, Beatrice Adoyo, Hezekiah Korir, Nicholas Syano, Esther Kagai, and Lisa E. Fuchs

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The purpose of this Contextualization Report is threefold: first, to characterize the location of the Agroecological Living Landscape (ALL) as well as its environmental, social, and economic context; second, to understand the data and information currently available in the ALL; and third, to characterize how and to what extent agroecological principles are already being employed in the ALL.

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The CGIAR Initiative Transformational Agroecology across Food, Land, and Water Systems develops and scales agroecological innovations with small-scale farmers and other food system actors in seven low- and middle-income countries. It is one of 32 initiatives of CGIAR, a global research partnership for a food-secure future, dedicated to transforming food, land, and water systems in a climate crisis.

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3 International Institute of Tropical Agriculture (IITA)

4 Drylands Natural Resources Centre (DNRC)

5 Community Sustainable Agriculture and Healthy Environmental Program (CSHEP)

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ACKNOWLEDGEMENTS

This study was conducted jointly with partner and host organizations and farmers. We are grateful for the support, team effort, and commitment of all persons involved.

We thank our partners from the *Drylands Natural Resource Centre* (DNRC) in Mbumbuni market, Makueni County, and specifically CEO and founder Nicholas Syano, for the overwhelming guidance and support. We also thank DNRC staff members Juliet Murugi, Nelly Jaluo, Jackson Mwanthi, and Theresia Mutua who actively participated in data collection.

DNRC is a locally registered non-government organisation (NGO) whose primary goal is to promote sustainable development of resources of the drylands regions of Kenya in order to bring about improved livelihoods of the marginalized communities and people living there. The organization equips subsistence farmers in drylands to restore their degraded lands and address the challenges of deforestation, falling agricultural yields, failing livelihood, water scarcity, loss of traditional knowledge and climate variability through permaculture and agroecological best practices. DNRC's vision is to see "Sustainable and resilient communities in the drylands", while its mission is "To promote sustainable development in the drylands of Kenya in order to bring about improved livelihoods of the marginalized communities living there by sharing the best practices and delivering effective program related and not limited to agroforestry, agroecology, and permaculture and culture regeneration". DNRC's core activities and programs include a dryland tree nursery, community training and outreach, rainwater harvesting, green charcoal production, agroecological food production, culture regeneration, poultry production, permaculture and agroecology short courses trainings, traditional food promotion, eco-building/cob building, traditional log beehive production and keeping, agroecology and permaculture student apprenticeship, mentorship and volunteership. DNRC is currently working with 800 plus households (about 4,800 people) and twelve schools (about 3,750 pupils) in the drylands of Kenya, and specifically Makueni County.

We thank our partners from the *Community Sustainable Agriculture Healthy Environmental Program* (CSHEP) in Ndeiya, Kiambu County, and specifically director and founder Esther Kagai, for her invaluable support to our team throughout the planning and implementation of the study. We also thank her staff members Sylvia Njonjo, Leah Wanjiru, and Catherine Wambui Irungu, who actively supported data collection.

CSHEP is a registered community-based organization (CBO) focused on training small-scale farmers on agroecological and organic practices, especially women in Kajiado north, the Ndeiya areas of Kiambu County, and peri-urban areas southwest of Nairobi city. CSHEP's aim is to support farmers to improve their soils, increase food production for food safety and security, and safeguard the environment. This also helps to uplift the lives of women, their families and for the schoolchildren to secure skills on food production. CSHEP mainly engage by training and facilitating access to information by the farmers, initiating gardening projects where a variety of safe food crops are grown using sustainable practices. CSHEP also organize for small-scale farmer's organic certification through the Participatory Guarantee System (PGS), which contributes to the formation of small farmers' markets that support income generation.

We thank our partners from the *Participatory Ecological Land Use Management* (PELUM- Kenya) team, and specifically Patrick Ngunjiri Kihoro, Zonal coordinator for Lower Eastern and Coast zone, for taking part in the data collection exercise in both agroecological living landscapes (ALLs).

Participatory Ecological Land Use Management (PELUM) Association is a network of Civil Society Organizations / NGOs working with Small-scale farmers in East, Central, and Southern Africa. The Association membership has grown from 25 pioneer members (in 1995) to over 280 members. PELUM Kenya is the Kenyan country chapter of the PELUM Association and has a membership of 57 Member Organizations. Both DNRC and CSHEP are registered members. PELUM Kenya network promotes agroecological principles and practices through the following approaches: advocacy and policy influence, networking, capacity development, information, and knowledge sharing. The various agroecological practices promoted include organic agriculture, sustainable agriculture, regenerative agriculture, agroforestry, permaculture, conservation agriculture, biodynamic agriculture, family farming, and bio-intensive agriculture. All PELUM Kenya Member Organizations do not promote GMOs or the use of synthetic agricultural inputs.

We are grateful to Michael Sakha, a PhD student from the Kenyatta University, attached to IITA, for supporting data collection.

We are greatly indebted to farmers from both Kiambu and Makueni ALLs for their invaluable information and willingness to share their knowledge with our team, which has made this joint assessment a success. A list of farmers who participated in the study can be found at the end of this report.

Chapter 1: Introduction and Methodology

1.1 Background and rationale of the joint assessment

The CGIAR Initiative on Agroecology (or Agroecology Initiative) is a collaborative partnership of eight CGIAR entities, as well as CIFOR-ICRAF, and the French research institute CIRAD under the Agroecology Transformative Partnership Platform (TPP) project. The initiative is funded by the CGIAR System Council and its current first phase (2022-2024) implemented in nine countries, comprising six in Africa, two in Asia, and one in the Americas. The primary goal of the Agroecology Initiative is to promote the application of contextually appropriate agroecological principles by farmers and communities in various contexts, with support from other food system actors.

The Agroecology Initiative operates through so-called agroecological living landscapes (ALLs) in each country. The ALLs are geographically bound landscapes in which smallholder farmers, agroecology practitioners, researchers, and other development actors are engaged to identify, test and promote agroecological innovations across sectors and scales.

In Kenya, the Agroecology Initiative team led by CIFOR-ICRAF, and involving teams from the Alliance of Bioversity International and CIAT, as well as IITA and WorldFish, has fostered the emergence of two ALLs: one in Kiambu, and another in Makueni County. The Agroecology Initiative's interaction and engagement with the ALLs is organised via central points referred to as 'ALLs host centres': (1) the Community Sustainable Agriculture and Healthy Environment Program (CSHEP) in Ndeiya, Kiambu County, which focuses on organic agriculture; (2) the Drylands Natural Resource Centre (DNRC) in Mbumbuni, Makueni County, focusing on permaculture. The ALL host centres represent and provide a physical space where FSAs can meet, interact, and co-create knowledge.

This assessment and report are part of the work conducted by work package 1 (WP1), which focuses on the establishment and engagement of the ALLs, as well as on-farm agroecological innovations. The report presents the results of a joint assessment of existing and preferred agroecological practices in three focus areas: soil management, water management and integrated pest management (IPM) in two ALLs of Makueni and Kiambu Counties.

The assessment was conducted in February 2023 and aimed at characterising the farming systems, capturing innovative practices that are being implemented in the ALLs, alongside farmers' experiences and evaluations of these practices, and understanding farmers' interests and aspirations for the future.

1.2 Research objectives

The specific objectives of the assessment were the following:

1. To identify farm and household characteristics of farmers living in the Makueni and Kiambu ALLs.
2. To document all the existing agroecological farming practices in the two ALLs in the targeted three focus areas: soil management, water management, and integrated pest management.
3. To understand the context, including identifying the strengths and weaknesses (barriers, gaps, and costs) of the agricultural practices that farmers are currently implementing.

4. To assess the soil, water, and integrated pest management practices that farmers would prefer to implement in the future.

1.3 Sampling strategy

A total of 80 farmers (i.e., 40 farmers from each ALL) were interviewed in this joint assessment study. Because of the diversity and heterogeneous nature of the study areas, stratified random sampling was applied in order to arrive at a sample that is representative of the biophysical and socioeconomic context and characteristics of the entire population. This in return allows for generalizability and promotes the external validity of the study as well as avoiding research biases. Stratified random sampling was carried out with the help of the ALL host centres using a multi-stage approach using the following five key factors: program and non-program farmers (referring to whether or not they had previously been trained by the ALL host centres), geography (villages), gender, age, and land size. In Kiambu ALL, 27 farmers who had previously been trained by Community Sustainable Agriculture and Healthy Environment (CSHEP) and 13 non-CSHEP farmers were interviewed. In Makueni ALL, 10 non-DNRC (Drylands Natural Resources Centre) farmers were selected, whereas 30 were affiliated with the DNRC program.

In Kiambu ALL, farmers were sampled from nine villages in Ndeiya sub-county and ward: Gitutha, Makutano, Nderu, Boma, Gatarakwa, Kameria, Mirithu, Michofo, and Kiawanda. In Makueni ALL, farmers were sampled from Mbooni East sub-county, with villages drawn from two wards. From Kiteta Kisau ward, 14 villages were sampled: Kivani, Maiyuni, Chome, Lungu, Kalimbi, Kiumoni, Ndumbo, Kimandi, Kyekaa, Maandau, Utwaa, Ivumbu, Ngai, and Itakani. In Waiya Usalala ward, two villages, namely Kithendu and Usalala, were selected.

Furthermore, the practices being implemented in the host organizations for the respective ALLs, namely, CSHEP in Kiambu ALL and DNRC in Makueni ALL, were evaluated.

1.4 Data collection

Data were collected in February 2023 using semi-structured questionnaires, with both open- and closed-ended questions. Socio-demographic and farm system characterising questions were mostly close-ended, while the practice assessment and evaluation questions combined closed- and open-ended questions. The latter provided farmers with an opportunity to express themselves freely, which allowed to team to capture more detailed contextual information. Training and pre-testing were conducted the ALL host centres. The questionnaires were administered jointly by a team comprising researchers from ICRAF, the Alliance of Bioversity and CIAT, IITA, and the ALL host centres.

Data collected involved understanding the general farm and farmer characterization; the various soil, water, and IPM practices (options) that farmers are implementing; and the context in which the options are being implemented, including which practice-specific raw materials are locally available, the sources of knowledge about the practices, farmers' knowledge and understanding of the scientific mechanisms of the practices, contextual factors, strengths and challenges, costs, labor, persons responsible for managing the practices, and crops that are grown alongside the practices. Crops captured explicitly in this study were annual crops such as maize and beans and biennial crops such as vegetables. Perennial tree-crop production, including the production of fruits as a tree-crop, was not systematically assessed in this study. However, farmers mentioned whether they practiced agroforestry or not.

1.5 Classification of various soil management, water management, and IPM practices

Table 1 provides an overview of the different soil management, water management, and IPM practices that exist and are being implemented in various locations in East Africa. This list is non-exhaustive, and contains both agroecological and non-agroecological practices. The team used this classification to guide their observations on the ground.

Table 1: Complementary classification of all relevant soil, water, and integrated pest management practices

Soil management practices	Water management practices	Integrated pest management practices
Cultural methods No-till farming; cover cropping; crop rotation; intercropping; integration with deep- & shallow-rooted plants; conservation/reduced/minimum tillage; mixed farming (crop-livestock); composting; manure application; mulching; afforestation of degraded lands; planting erosion-tolerant crops; using organic fertilizer; using vegetative strips; practicing agroforestry. Alley cropping; strip cropping; incorporation of organic matter/residues; selecting soil-conserving crops; planting vegetation on slopes; using green manures; seed saving; biofertilizer; organic matter addition; awareness campaigns on soil management practices. **Structural methods** Collection and disposal of runoff; construction of check dams; gabions; terraces; zai pits; terracing; contour ploughing; implementation of runoff control measures; construction of sediment basins/traps; soil moisture monitoring; soil water conservation. **Chemical methods** Liming; inorganic fertilizer application; application of biochar; use of soil conditioners; use of reduced- or low-toxicity pesticides; soil analysis; soil salinity management.	**Green water management** Recycling; mulching; drip irrigation; using gray water and/or surface runoff for irrigation; ditches/zai pits/terraces/ gabions; raised beds, vertical gardens; soil conservation; adoption of drought-tolerant crops; using hybrid seed varieties with improved water use efficiency; using water-saving irrigation systems such as drip or sprinkler; crop rotation; terracing; using drought-tolerant crops; using drought-tolerant plants in agroforestry systems; planting early-maturing crops; water use monitoring; surface water management; adoption of precision agriculture; reforestation and afforestation; promotion of conservation agriculture; awareness campaigns on water conservation; implementation of water-saving technologies. **Water harvesting** Rainwater harvesting; maintenance of water storage structures; use of rainwater for livestock Cisterns/wells/boreholes; water storage tanks; infiltration basins; construction of water retention ponds; interception ditches.	**Biological methods** Biopesticides; use of natural predators; using beneficial nematodes to control pests in soil; using beneficial insects (e.g., wasps to lay eggs on pests); using pheromone traps; proper identification of pests and diseases; monitoring pest populations; integrating livestock (e.g., poultry, cattle, etc.) into cropping systems to control pests; encouraging natural enemy populations. **Chemical methods** Using low-risk pesticides; plant-based concoctions; microbial-based insecticides; chemical pesticides; fumigants; herbicides to control weeds; fungicides; rodenticides to control rodents. **Mechanical/physical methods** Hand picking; using trap crops; installing physical barriers (e.g., mesh covers); flooding fields to drown pests; physical removal. **Cultural methods** Push-pull technique; pruning; burning; shading to prevent damage by birds; attracting and trapping insects (yellow sticky traps); proper drying and storage; mulching; crop rotation; row covers; companion planting; planting pest- and disease-resistant crops; proper irrigation; proper sanitation and ventilation; selecting appropriate planting dates; diversifying crops; properly disposing of plant debris; proper spacing; weeding; intercropping.

1.6 Data analysis

The data collected were first cleaned, which involved removing outliers, fixing spelling errors, removing duplicates, and cross-checking for errors and inconsistencies that were corrected. The data were then coded through either assigning numerical codes or reclassifying answers to open-ended questions into fewer general categories in order to allow for statistical analysis. The data were then analysed descriptively using cross-tabulations and mean comparisons, sums, and frequencies and were presented in tables, graphs, charts, and figures.

Chapter 2: Results on-farm and household characteristics of Makueni and Kiambu ALLs

2.1 Socioeconomic characteristics of Kiambu and Makueni ALL households

The assessment used questionnaires to survey 80 respondents from both Makueni (40) and Kiambu (40) ALLs. Table 2 presents the detailed characteristics of the ALL farms and households in the two ALLs.

Table 2: Socioeconomic characteristics of ALL farms and households

Characteristic[1]	Kiambu ALL n = 40[1]	Makueni ALL n = 40[1]	Overall n = 80[1]
Farm size (ha)	0.84 ± 0.76	1.73 ± 1.44	1.29 ± 1.23
Age	56 ± 15	56 ± 13	56 ± 14
Gender			
Females	29 (72%)	31 (78%)	60 (75%)
Males	11 (28%)	9 (22%)	20 (25%)
Family type			
Female-headed household	12 (30%)	10 (25%)	22 (28%)
Male-headed household	28 (70%)	30 (75%)	58 (72%)
Family size	4.77 ± 1.83	5.78 ± 1.85	5.28 ± 1.89
Level of education			
None	1 (2.6%)	1 (2.5%)	2 (2.6%)
Primary	15 (39%)	22 (55%)	37 (47%)
Secondary	20 (53%)	14 (35%)	34 (44%)
Tertiary	2 (5.3%)	3 (7.5%)	5 (6.4%)

1 Data are presented as number (percentage); mean ± standard deviation unless otherwise indicated.

In both the Makueni and Kiambu ALLs, farming was the primary income source. Table 3 gives details on the farming activities and dominant crops grown in the two ALLs. Farm-produced food sustained households for approximately 8.2 ± 4.0 months in Kiambu and for 6.6 ± 3.7 months in Makueni. Maize and beans were the predominant crops, with high cultivation rates in both ALLs (86% and 80%, respectively). In Kiambu, other common crops grown included potatoes and vegetables. In Makueni, respondents also commonly cultivated cowpeas, pigeon pea. Some degree of natural farming (72%) and agroforestry (98%) were prevalent in Makueni, while 85% of respondents in Kiambu indicated engaging in both natural farming and agroforestry. Silviculture, agrisilviculture, agrosilvopastoral, and silvopastoral systems were dominant, and included tree species such as mango, grevillea, moringa, eucalyptus, and other fruit trees.

Table 3: Farming activities and dominant crops grown in the ALLs

Characteristic[1]	Kiambu ALL n = 40[1]	Makueni ALL n = 40[1]	Overall n = 80[1]
Farming is main income source (Yes)	37 (92%)	40 (100%)	77 (96%)
Number of months when food was sufficient	8.2 ± 4.0	6.6 ± 3.7	7.4 ± 3.9
Main crops grown			
Maize	30 (75%)	39 (98%)	69 (86%)
Beans	28 (70%)	36 (90%)	64 (80%)
Vegetables	26 (65%)	1 (2.5%)	27 (34%)
Potatoes	26 (65%)	2 (5.0%)	28 (35%)
Cowpeas	0 (0%)	30 (75%)	30 (38%)
Pigeon peas	0 (0%)	25 (62%)	25 (31%)
Do you practice any kind of natural farming?	34 (85%)	29 (72%)	63 (79%)
Do you practice any form of agroforestry?	33 (85%)	39 (98%)	72 (91%)

1 Data are presented as number (percentage); mean ± standard deviation unless otherwise indicated.

2.2 Farmers' perceptions on soil quality and guiding soil- and plant-based indicators for describing soil quality in Makueni and Kiambu ALLs

Overall, respondents across the two ALLs perceived their soils as being of medium quality (i.e., 51 respondents; 65%), and these constituted 51% of the respondents in Makueni ALL and 78% in Kiambu ALL (Table 4). The most commonly used soil-based indicators across the ALLs by farmers to classify soil quality were soil color, texture, moisture, organic matter, soil fauna, ease of ploughing, infiltration rate, manure (input) dependency, and erosion potential. Out of these soil-based indicators, soil color and organic matter were the most commonly used indicators to classify soil quality in both the Makueni and Kiambu ALLs. The most commonly used crop-based indicators of soil quality were crop yield, crop vigor, indicator plants, and growth rate of crops.

Table 4: Farmers' perceptions on soil quality and guiding soil- and plant-based indicators for describing soil quality in Makueni and Kiambu ALLs

Characteristic[1]	Kiambu ALL n = 40[1]	Makueni ALL n = 40[1]	Overall n = 80[1]
Respondents' soil quality perception (description)			
High quality	4 (10%)	8 (21%)	12 (15%)
Medium quality	31 (78%)	20 (51%)	51 (65%)
Low quality	4 (10%)	11 (28%)	15 (19%)
Not aware	1 (2.5%)	0 (0%)	1 (1.3%)
Soil-based indicators used for soil quality description			
Soil color	8 (20%)	12 (30%)	20 (25%)
Soil texture	7 (18%)	7 (18%)	14 (18%)
Soil organic matter	5 (12%)	2 (5.0%)	7 (8.8%)
Infiltration rate	1 (2.5%)	4 (10%)	5 (6.2%)
Soil fauna	3 (7.5%)	1 (2.5%)	4 (5.0%)
Soil moisture	2 (5.0%)	1 (2.5%)	3 (3.8%)
Dependence on fertility inputs	0 (0%)	3 (7.5%)	3 (3.8%)
Erosion potential	0 (0%)	3 (7.5%)	3 (3.8%)
Ease of ploughing	2 (5.0%)	0 (0%)	2 (2.5%)
Crop-based indicators used for describing soil quality			
Crop yield	14 (35%)	9 (22%)	23 (29%)
Crop vigor	11 (28%)	4 (10%)	15 (19%)
Indicator plants	3 (7.5%)	10 (25%)	13 (16%)
Growth rate	1 (2.5%)	9 (22%)	10 (12%)
Crop residue	0 (0%)	3 (7.5%)	3 (3.8%)
Crop color	2 (5.0%)	1 (2.5%)	3 (3.8%)
Crop performance	0 (0%)	2 (5.0%)	2 (2.5%)
Germination rate	1 (2.5%)	0 (0%)	1 (1.3%)

1 Data are presented as numbers (percentage), unless otherwise indicated.

In Kiambu ALL, the respondents mostly used crop yield (35%), crop vigor (28%), indicator plants (7.5%), and crop color (5.0%) to classify soil quality. However, in Makueni ALL, the respondents mostly used indicator plants (25%), crop yield (22%), crop growth rate (22%), and crop vigor (10%) as the four most commonly used indicators to classify soil quality.

2.3 Farmers' perceptions on effects of climate change on farms and yields of main crops in Makueni and Kiambu ALLs

In both the Makueni ALL and Kiambu ALL, all respondents reported experiencing climate and yield changes in their main crops over the past 5–10 years. The two most common climate-related changes identified by the respondents were drought/low rainfall (52 respondents; 65%) and poor yield (29 respondents; 36%). In Kiambu ALL, drought/low rainfall was mentioned by 68% of the respondents and poor yield was mentioned by 38%. In Makueni ALL, 62% of the respondents identified drought/low rainfall, while 35% cited poor yield as the main effect of climate change. Additionally, farmers in both ALLs mentioned other climate-related changes such as increased pest incidences, stunted plant growth, and dying trees. One respondent (2.5%) in Kiambu ALL also highlighted the occurrence of erratic rainfall experienced on the farm. Overall, a higher percentage of farmers (82–92%) reported decreased crop yield as the primary impact of climate change, primarily attributed to drought/inadequate rainfall (68–72%) in both ALLs (Table 5).

Table 5: Farmers' perceptions on the effects of climate change on farms and yields of main crops in the two ALLs in the past 5-10 years.

Characteristic[1]	Kiambu ALL n = 40[1]	Makueni ALL n = 40[1]	Overall n = 80[1]
How climate affected farm in the past 5 to 10 years (free text answers)			
Low rainfall/drought	27 (68%)	25 (62%)	52 (65%)
Poor yield	15 (38%)	14 (35%)	29 (36%)
Late/irregular onset of rain	3 (7.5%)	1 (2.5%)	4 (5.0%)
Stunted crop growth	2 (5.0%)	1 (2.5%)	3 (3.8%)
High temperatures	2 (5.0%)	0 (0%)	2 (2.5%)
Less crop diversity	0 (0%)	2 (5.0%)	2 (2.5%)
Less feed causing animal deaths	0 (0%)	1 (2.5%)	1 (1.3%)
Decreased income	1 (2.5%)	0 (0%)	1 (1.3%)
Increase of pests	1 (2.5%)	0 (0%)	1 (1.3%)
How climate change has affected yield in the past 5 to 10 years			
Decreased yield	33 (82%)	37 (92%)	70 (88%)
Don't know	3 (7.5%)	1 (2.5%)	4 (5.0%)
Fluctuating yield	2 (5.0%)	1 (2.5%)	3 (3.8%)
Increased yield	2 (5.0%)	1 (2.5%)	3 (3.8%)
Possible reasons/causes for the observed changes in yield			
Drought/inadequate rainfall	29 (72%)	27 (68%)	56 (70%)
Poor soil quality	2 (5.0%)	1 (2.5%)	3 (3.8%)
High temperatures	2 (5.0%)	0 (0%)	2 (2.5%)
Kiambu (CSHEP) interventions	1 (2.5%)	0 (0%)	1 (1.3%)
Organic farming	1 (2.5%)	0 (0%)	1 (1.3%)
Improper farm practices	0 (0%)	1 (2.5%)	1 (1.3%)
Poor seed quality	1 (2.5%)	0 (0%)	1 (1.3%)

1 Data are presented as numbers (percentage), unless otherwise indicated.

Anne Kuria/CIFOR-ICRAF

Chapter 3: Options: The existing soil, water, and integrated pest management practices in Makueni and Kiambu ALLs

3.1 Soil management practices in Kiambu and Makueni ALLs

Overall, a total of 16 soil management practices were encountered on farms in both ALLs, with 16 in Kiambu ALL and 9 in Makueni ALL (Table 6). The most common practices encountered in Kiambu ALL were compost manure (63%), farmyard manure (60%), crop rotation (33%), intercropping (30%), mulching (25%), and terraces (20%) for the farms visited.

In Makueni ALL, the most common soil management practices as found on the farms visited were farmyard manure (63%), compost manure (43%), agroforestry (40%), terraces (33%), intercropping (30%), and crop rotation (25%).

Table 6: All soil management practices encountered in Kiambu and Makueni ALLs

Practice	Kiambu n = 40	Makueni n = 40	Total n = 80	Overall %
Farmyard manure	24 (60%)	25 (62.5%)	49	61
Compost manure	25 (62.5%)	17 (42.5%)	42	53
Intercropping	12 (30%)	12 (30%)	24	30
Crop rotation	13 (32.5%)	10 (25%)	23	29
Agroforestry	7 (17.5%)	16 (40%)	23	29
Terraces	8 (20%)	13 (32.5%)	21	26
Mulching	10 (25%)	6 (15%)	16	20
Cover crops	6 (15%)	3 (7.5%)	9	11
Biogas sludge	7 (17.5%)	0 (0%)	7	9

Practice	Kiambu n = 40	Makueni n = 40	Total n = 80	Overall %
Raised beds	5 (12.5%)	0 (0%)	5	6
Double digging	4 (10%)	1 (2.5%)	5	6
Zai pits	4 (10%)	0 (0%)	4	5
Sunken beds	3 (7.5%)	0 (0%)	3	4
Hugo culture	2 (5%)	0 (0%)	2	3
Timely planting/cultivation	1 (2.5%)	0 (0%)	1	1
Fallow	1 (2.5%)	0 (0%)	1	1

3.2 Water management practices in Kiambu and Makueni ALLs

Overall, a total of 16 water management practices were encountered. Thirteen of these were encountered in Kiambu ALL and 10 in Makueni ALL (Table 7). In Kiambu ALL, the water management practices mostly encountered on the farms sampled were mulching (35%), multistorey kitchen gardens (30%), and water recycling (30%). The main practices in Makueni ALL were water harvesting/storage tanks (35%), terraces (33%), and zai pits (18%).

Table 7: All water management practices encountered in Kiambu and Makueni ALLs

Practice	Kiambu ALL n = 40	Makueni ALL n = 40	Total n = 80	Overall %
Terraces	7 (17.5%)	13 (32.5%)	20	25
Water recycling	12 (30%)	4 (10%)	16	20
Mulching	14 (35%)	1 (2.5%)	15	19
Water harvesting/storage tanks	0(0%)	14 (35%)	14	18
Multistorey kitchen gardens	12 (30%)	1 (2.5%)	13	16
Zai pits	5 (12.5%)	7 (17.5%)	12	15
Water retention ditches	5 (12.5%)	0 (0%)	5	6
Earth dam	1 (2.5%)	3 (7.5%)	4	5
Sunken beds	3 (7.5%)	1 (2.5%)	4	5
Raised beds	3 (7.5%)	0 (0%)	3	4
Agroforestry	0 (0%)	2 (5%)	2	3
Drip irrigation	2 (5%)	0 (0%)	2	3
Water pans/ponds	2 (5%)	0 (0%)	2	3
Boreholes	0 (0%)	1 (2.5%)	1	1
Cover crops	1 (2.5%)	0 (0%)	1	1
Drought-tolerant crops	1 (2.5%)	0 (0%)	1	1

3.3 Integrated pest management practices in Kiambu and Makueni ALLs

Overall, a total of seven IPM practices were encountered on the farms visited in both ALLs. Eight practices were encountered in Kiambu ALL but only three in Makueni ALL (Table 8).

In Kiambu ALL, plant-based biopesticides were encountered on 88% of the farms, followed by the use of repellent crops (25%), crop rotation (15%), and intercropping (15%). In Makueni ALL, plant-based biopesticides were the most commonly encountered IPM practice (38%). Repellent crops and intercropping were encountered on only 3% of the farms sampled.

Table 8: All IPM management practices encountered in Kiambu and Makueni ALLs

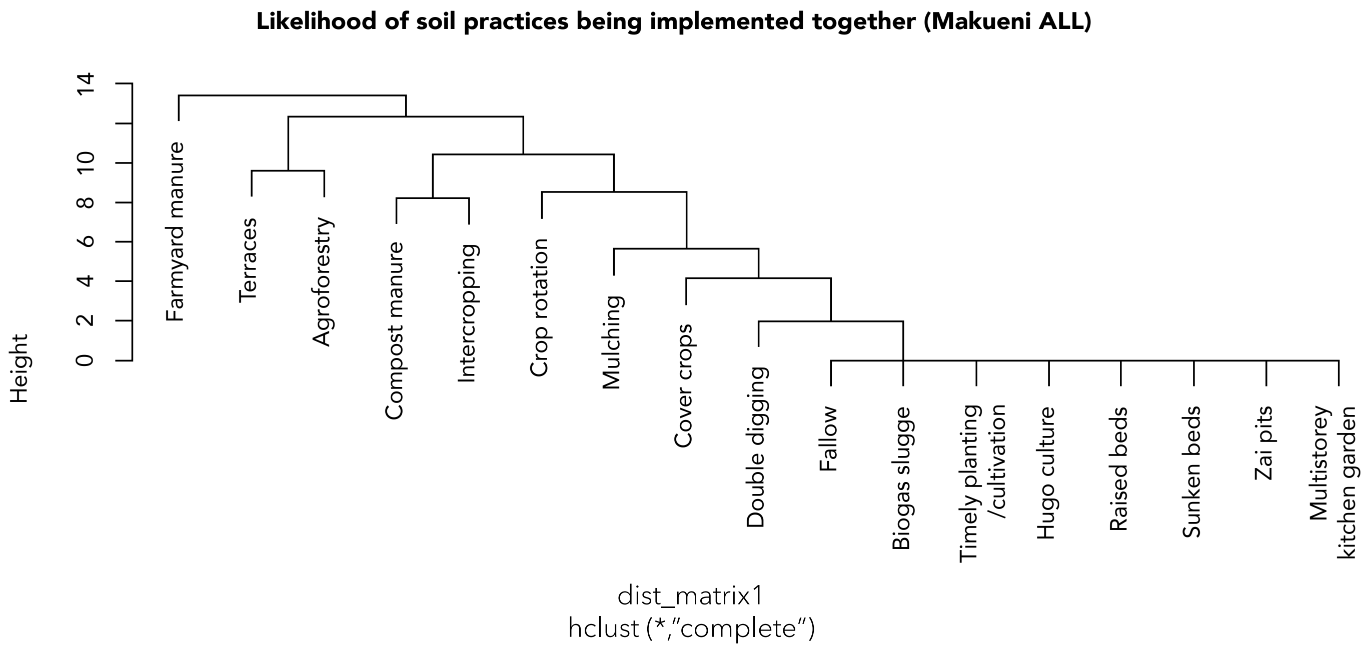
IPM practice	Kiambu ALL n = 40	Makueni ALL n = 40	Total n = 80	Overall %
Plant-based biopesticides	35 (88%)	15 (38%)	50	63
Repellent crops	10 (25%)	1 (2.5%)	11	14
Crop rotation	6 (15%)	0 (0%)	6	8
Intercropping	6 (15%)	1 (2.5%)	7	9
Natural predators	3 (7.5%)	0 (0%)	3	4
Ash-based biopesticides	2 (5%)	0 (0%)	2	3
Traps	2 (5%)	0 (0%)	2	3
Soap	1 (2.5%)	0 (0%)	1	1

3.4 Co-implementation likelihood of soil, water, and IPM practices

In addition to certain practices exhibiting multipurpose characteristics, a further analysis combining the two ALLs revealed that certain practices were likely to be implemented in conjunction with each other. In terms of soil management, the practices most likely to be co-implemented in Makueni ALL were terraces and agroforestry, compost manure and intercropping, as well as zai pits, sunken beds, and multistorey kitchen gardens, among others (Figure 1).

Figure 1: Dendrogram illustrating the likelihood of soil management practices being implemented together in Makueni ALL

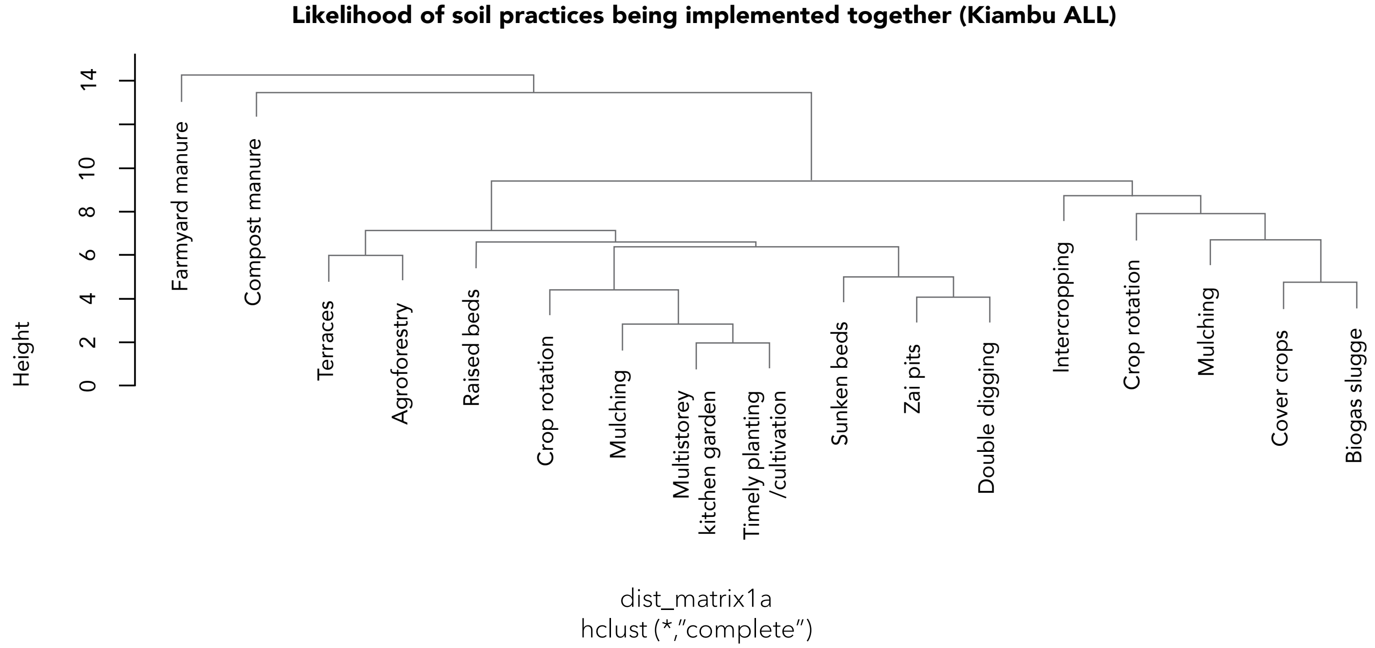
(The dendrogram is based on hierarchical clustering analysis using a correlation distance metric. The height of the branches represents the level of similarity between soil management practices, with shorter branches indicating a higher likelihood of co-implementation).



Similarly, in Kiambu ALL, the practices that were likely to be co-implemented were sunken beds, zai pits, and double digging; mulching and intercropping; terracing and crop rotation; and farmyard manure and compost manure; among others (Figure 2).

Figure 2: Dendrogram illustrating the likelihood of soil management practices being implemented together in Kiambu ALL

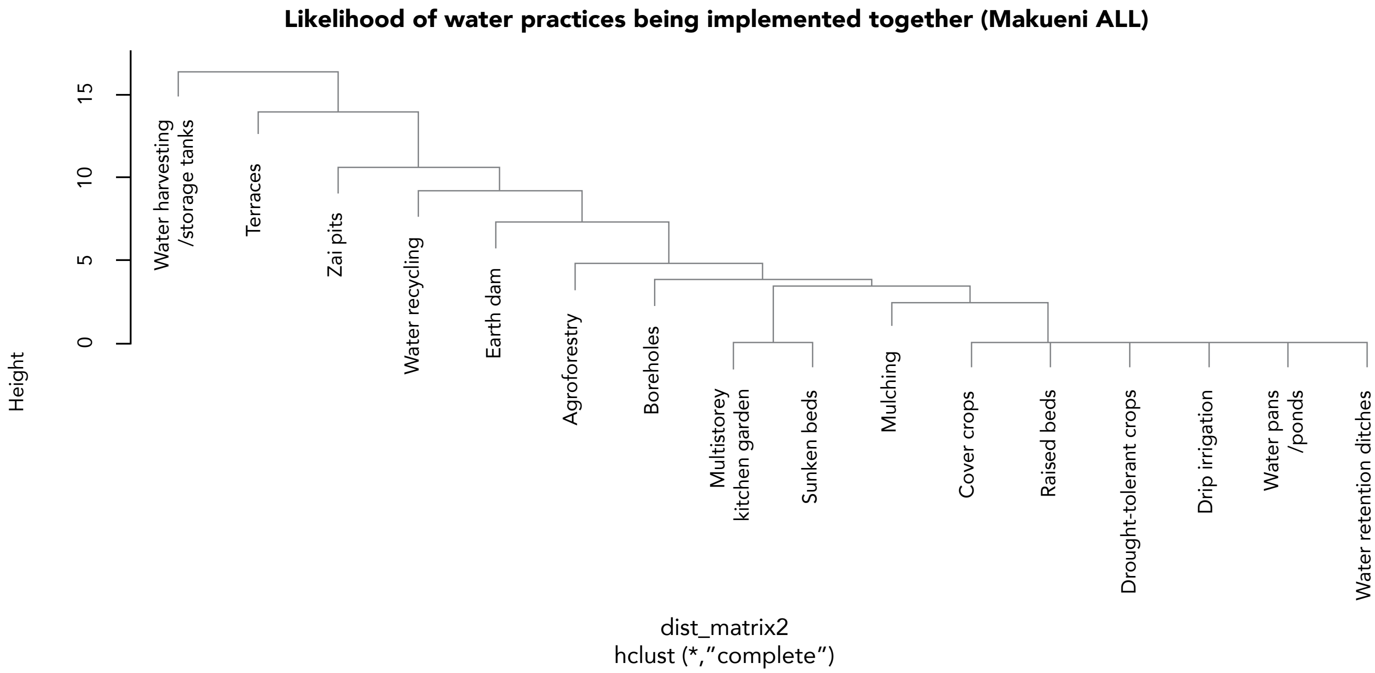
(The dendrogram is based on hierarchical clustering analysis using a correlation distance metric. The height of the branches represents the level of similarity between soil management practices, with shorter branches indicating a higher likelihood of co-implementation).



An examination of water management practices in Makueni ALL indicates that multiple practices are likely to be implemented together. Specifically, cover crops, raised beds, drought-tolerant crops, drip irrigation, water pans, and water retention ditches are expected to be co-implemented. Additionally, multistorey kitchen gardens and sunken beds are identified as the practices most likely to be co-implemented in Makueni ALL (Figure 3).

Figure 3: Dendrogram illustrating the likelihood of water management practices being implemented together in Makueni ALL.

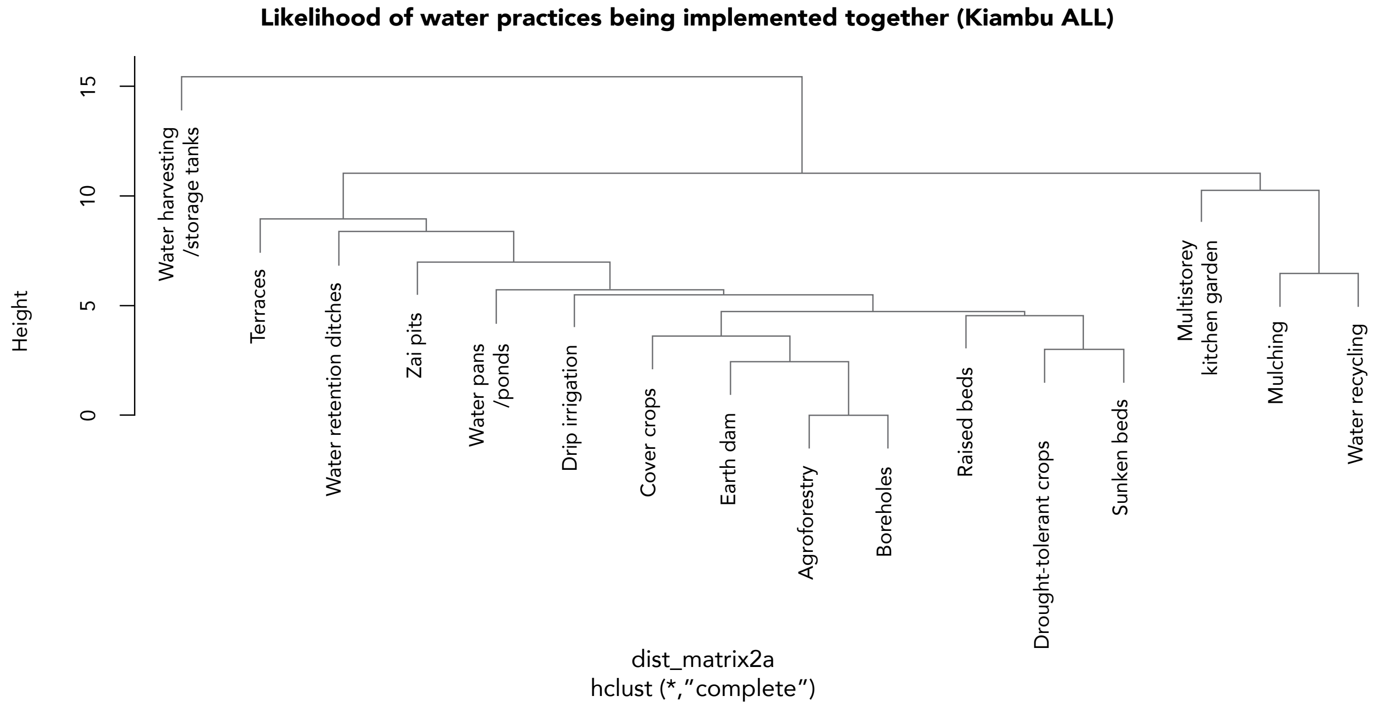
(The dendrogram is based on hierarchical clustering analysis using a correlation distance metric).



As in Makueni ALL, numerous practices exhibit potential to be co-implemented with others in Kiambu ALL. As in Makueni ALL, multistorey kitchen gardens are expected to be implemented in conjunction with sunken beds. Similarly, cover crops, raised beds, drought-tolerant crops, drip irrigation, water ponds, and water retention ditches are likely to be co-implemented (Figure 4).

Figure 4: Dendrogram illustrating the likelihood of water management practices being implemented together in Kiambu ALL

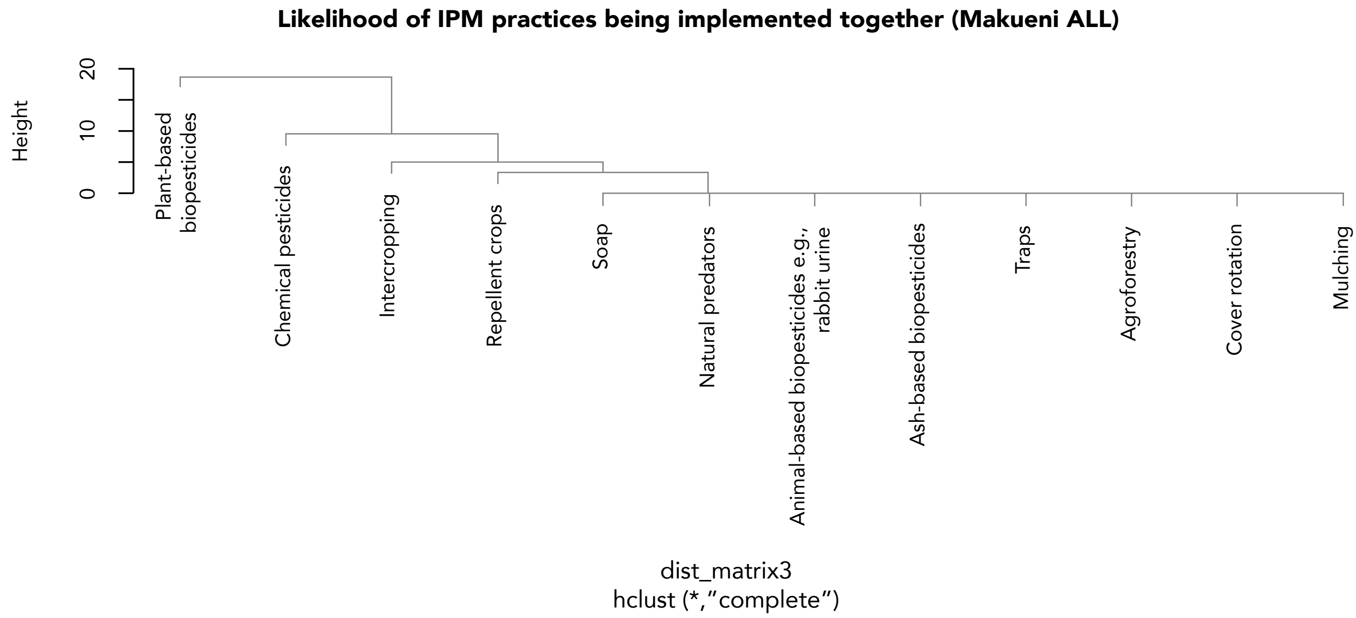
(The dendrogram is based on hierarchical clustering analysis using a correlation distance metric).



Furthermore, traps, natural predators, animal- and plant-based biopesticides, agroforestry, crop rotation, and mulching were identified as the practices most likely to be co-implemented for IPM practices in Makueni ALL (Figure 5).

Figure 5: Dendrogram illustrating the likelihood of integrated pest management practices being implemented together in Makueni ALL

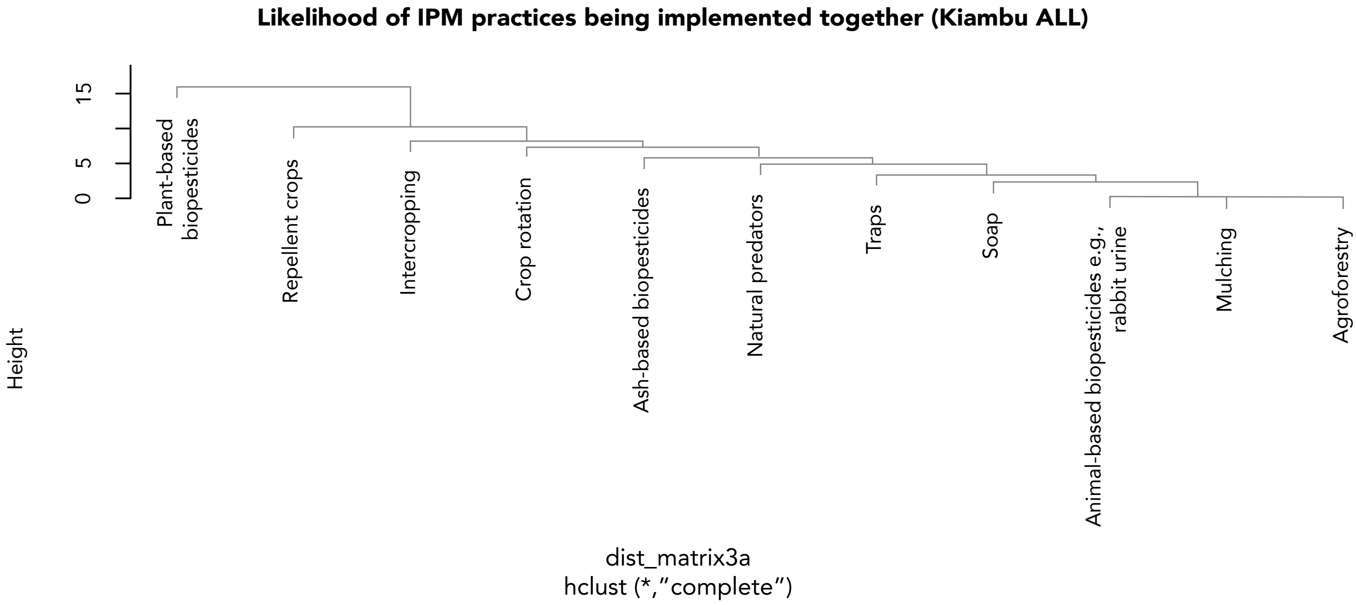
(The dendrogram is based on hierarchical clustering analysis using a correlation distance metric).



In Kiambu ALL, animal-based biopesticides, mulching, and agroforestry; and intercropping and crop rotation were most likely to be co-implemented (Figure 6).

Figure 6: Dendrogram illustrating the likelihood of integrated pest management practices being implemented together in Kiambu ALL.

(The dendrogram is based on hierarchical clustering analysis using a correlation distance metric).

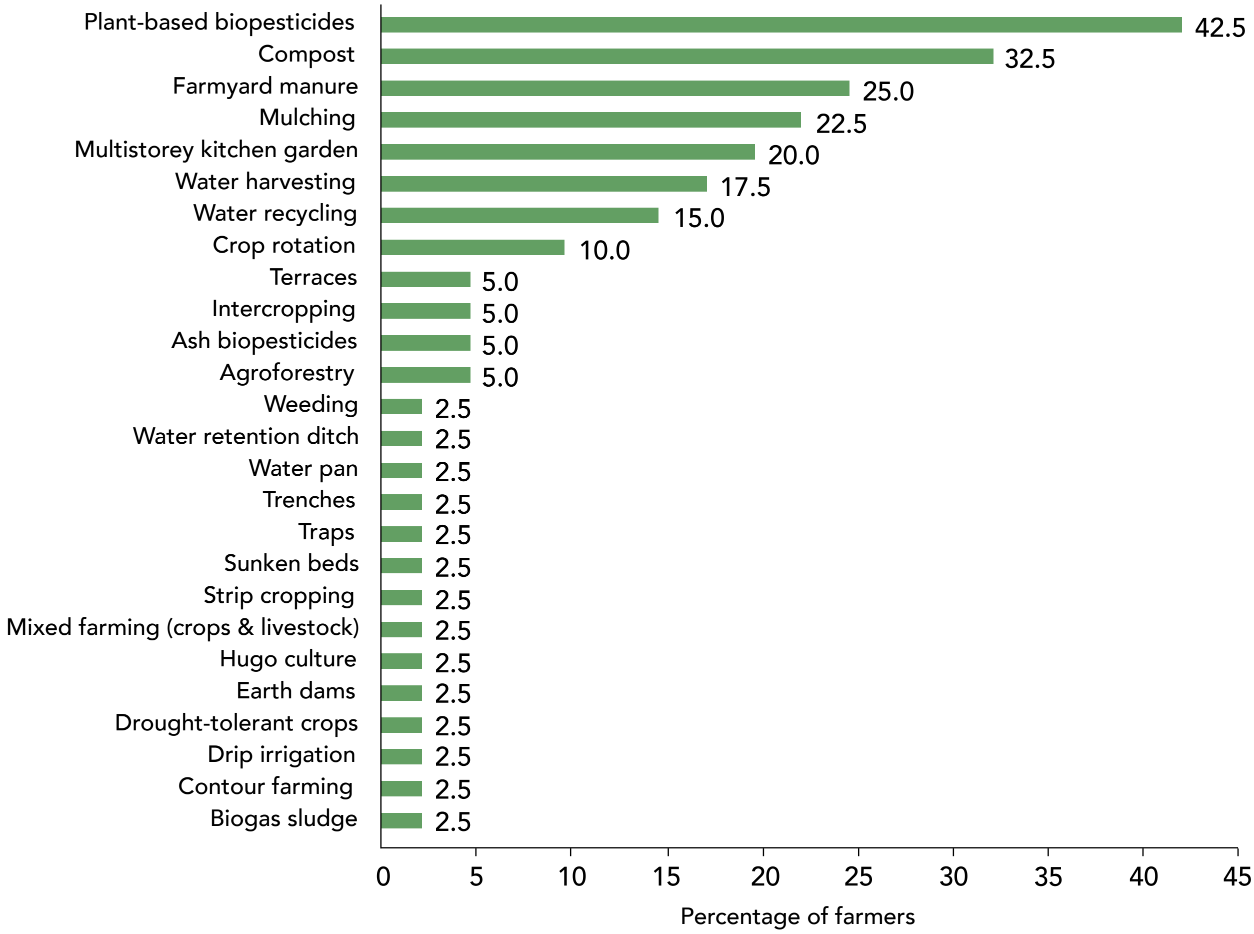


Chapter 4: Context: Performance and evaluation of inventoried soil, water, and IPM practices in the ALLs

4.1 Inventoried soil, water, and IPM practices by farmers in Makueni and Kiambu ALLs

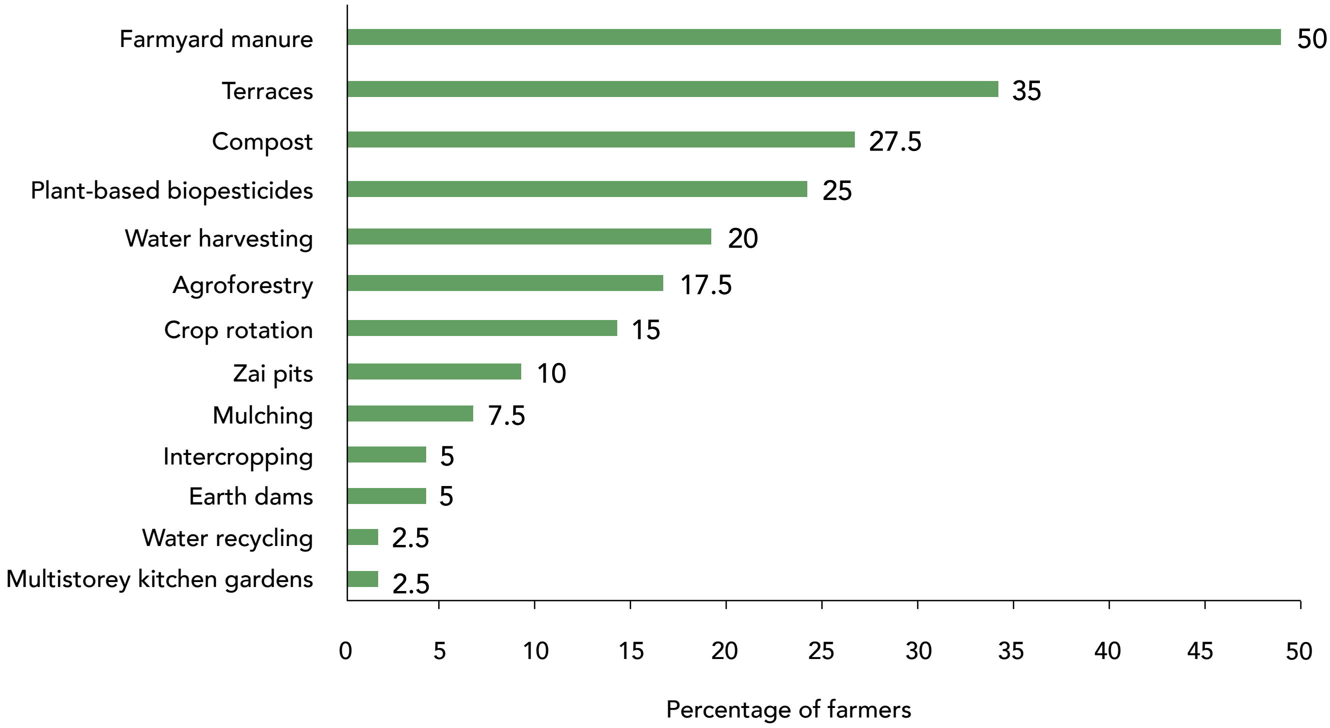
A total of 26 practices were inventoried. A majority of the farmers interviewed in Kiambu ALL inventoried plant-based biopesticides (42.5%), compost manure (32.5%), farmyard manure (25%), mulching (22.5%), and multistorey kitchen gardens (20%), as indicated in Figure 7.

Figure 7: Practices inventoried by farmers in Kiambu ALL



In Makueni ALL, 13 practices were inventoried. Farmers interviewed mainly inventoried farmyard manure (50%), terraces (35%), compost manure (27.5%), plant-based biopesticides (25%), water harvesting (20%), and agroforestry (17.5%) (Figure 8).

Figure 8: Practices inventoried by farmers in Makueni ALL



4.1.1 Crops to which the practices are applied

The types of crops to which the different practices are applied in Kiambu ALL are highlighted in Table 9.

Table 9: Crops to which practices were applied in Kiambu ALL

Type of practice	Local resources used in Kiambu ALL
Agroforestry (n=2)	N/A
Farmyard manure (n=10)	Mainly applied on vegetables, maize, and fruits such as strawberry
Compost (n=13)	Applied to all crops, including vegetables (kale, tomatoes, spinach), maize, beans, and Irish potatoes
Crop rotation (n=4)	Crops mostly were maize, beans, and vegetables
Multistorey kitchen gardens (n=8)	Only vegetables are grown in multistorey gardens
Mulching (n=9)	Mainly practiced on vegetables, but also on maize and beans
Plant-based biopesticides (n=16)	Used to control pests on vegetables
Ash biopesticides (n=3)	Mostly used in maize
Terraces (n=2)	Terraces were used for growing vegetables and leguminous fodder tree species (e.g., *Desmodium* and *Calliandra*)
Water harvesting (n=7)	Harvested water was mainly used for livestock, growing vegetables and fruits, and raising tree seedlings in nurseries
Water recycling (n=6)	Mostly used for growing vegetables
Biogas sludge (n=1)	Applied to all crops
Intercropping (n=2)	Maize was mostly intercropped with beans. Leguminous *Calliandra* spp. were also used for intercropping.
Drought-resistant crops (n=1)	Drought-tolerant crops planted include cassava, pigeon peas, sweet potatoes, and black beans
Earth dams (n=1)	N/A
Hugo culture (n=1)	N/A
Sunken beds (n=1)	Vegetables
Trenches (n=1)	N/A
Traps (n=1)	Mainly practiced on fruit trees and vegetables

Likewise, Table 10 highlights crops to which practices were applied in Makueni ALL.

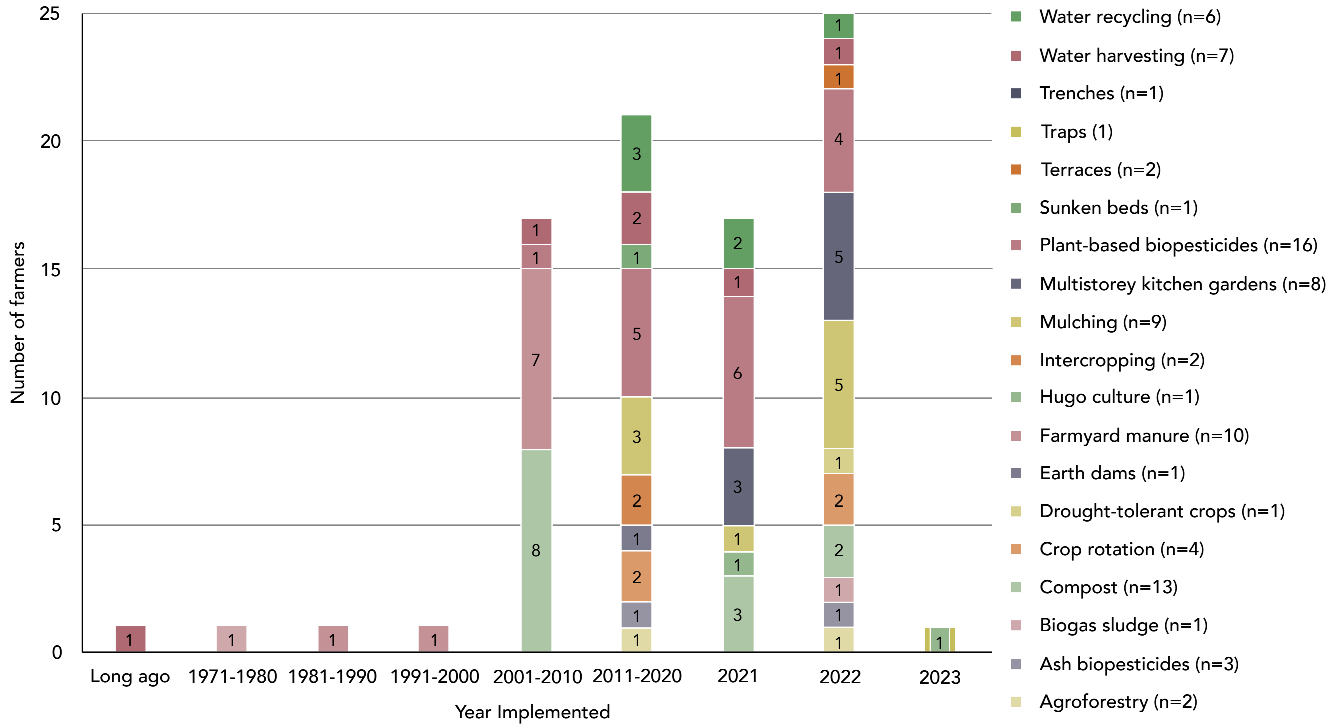
Table 10: Crops to which practices were applied in Makueni ALL

Type of practice	Crops to which the practice was applied in Makueni ALL
Agroforestry (n = 7)	Agroforestry trees were mostly integrated within the cropland and grown together with all crops, including maize, beans, cowpeas, pigeon peas, and sorghum.
Compost (n = 11)	Mainly used to grow a wide range of crops, including maize, black beans, beans, pigeon peas, potatoes, vegetables, and fruit trees.
Crop rotation (n = 6)	Crops mainly rotated were maize, beans, and vegetables.
Earth dams (n = 2)	Used to provide water to bananas, Napier grass, and pumpkins.
Farmyard manure (n = 19)	Mainly used on maize, beans, and vegetables.
Water harvesting (n = 8)	Water harvested was used for growing vegetables, green gram, and maize.
Intercropping (n = 2)	Intercropping was done between cowpeas, pigeon peas, beans, and maize.
Mulching (n = 3)	Mulching was mostly done on maize, beans, pigeon peas, and cowpeas.
Multistorey kitchen gardens (n = 1)	Used for vegetables, maize, and potatoes.
Plant-based biopesticides(n = 10)	Applied on all crops, including fruit trees (oranges, mangoes, avocadoes); for controlling pests on trees such as *Grevillea robusta* and *Senna* spp.; and for vegetables, bananas, maize, beans, cowpeas, and pigeon peas.
Terraces (n = 14)	Used for growing all crops.
Water recycling (n = 1)	Recycled water was also used on all crops.
Zai pits (n = 4)	Used for growing all crops.

4.1.2 Year when the practices were first implemented

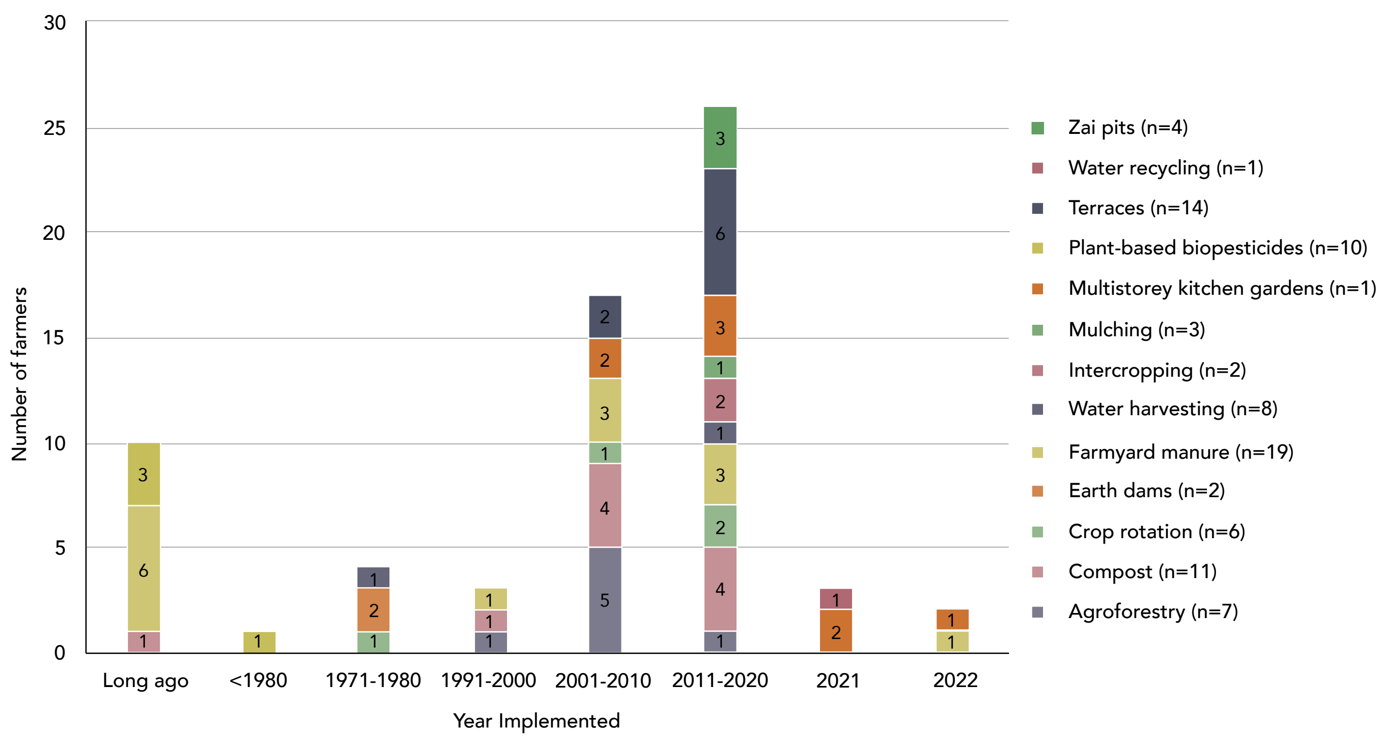
In Kiambu ALL, a majority of the practices were first implemented from 2001 to 2022 (Figure 9). A majority of the farmers implementing FYM and compost first adopted the technology from 2001 to 2010. Plant-based biopesticides were implemented from 2011 to 2022. Multistorey kitchen gardens are a relatively new practice implemented in 2021 and 2022.

Figure 9: Year when the practices were first implemented in Kiambu ALL



In Makueni ALL, a majority of the practices were first implemented from 2001 to 2020 (Figure 10). A majority of the farmers first practiced agroforestry and composting from 2001 to 2010. Practices first implemented from 2011 to 2020 were zai pits, mulching, and multistorey kitchen gardens. However, the use of FYM manure and terraces was not a new concept but had been practiced from a long time ago by a majority of the farmers.

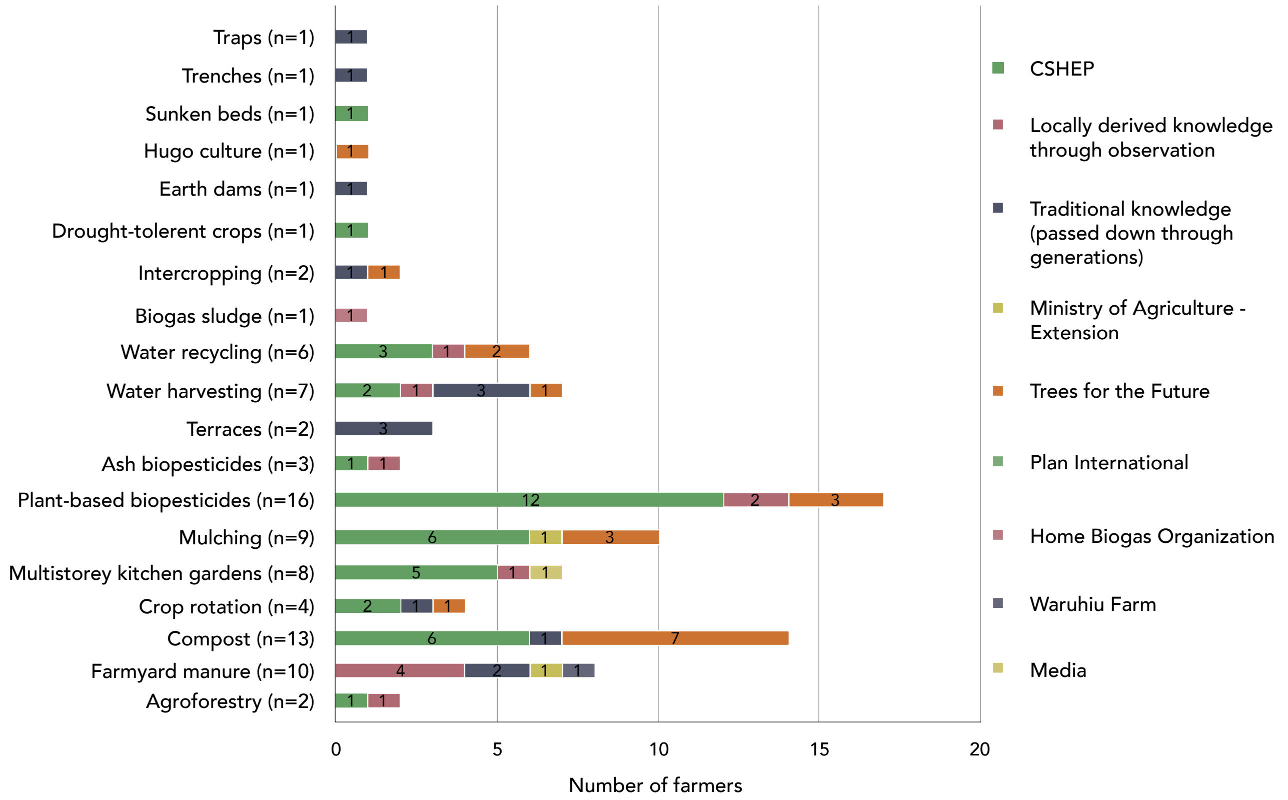
Figure 10: Year when the practices were first implemented in the Makueni ALL



4.1.3 Practices learned from whom or where

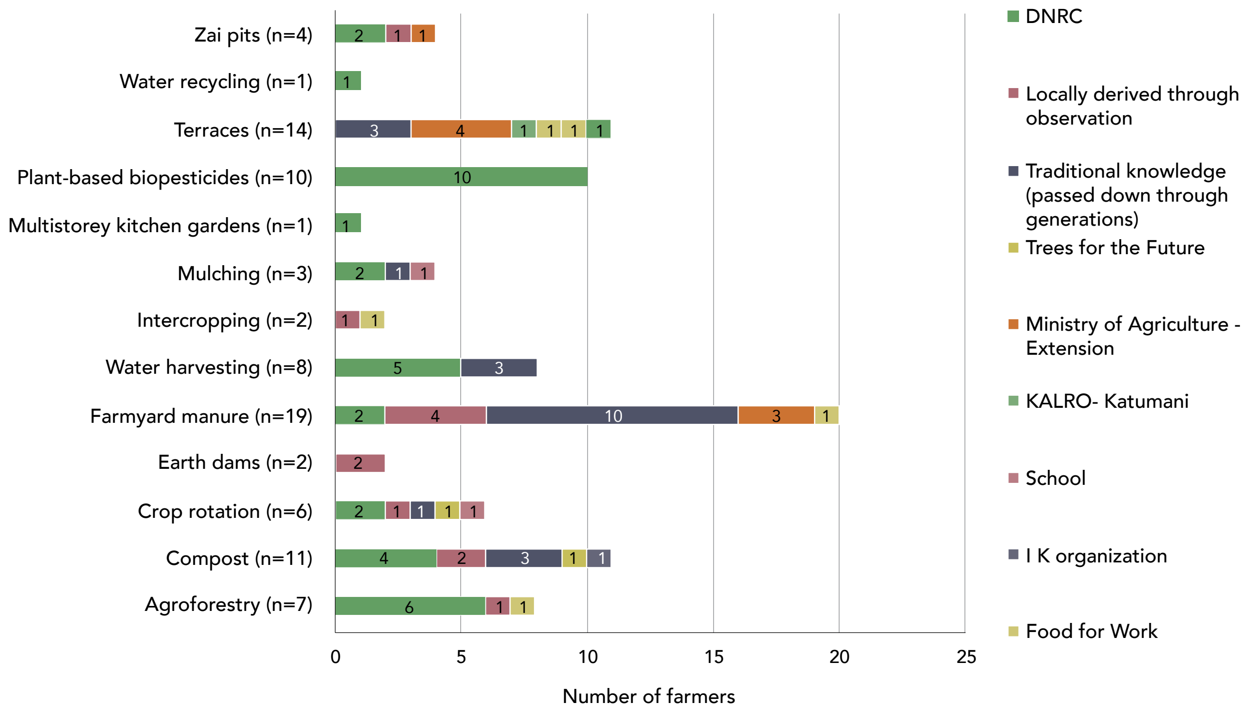
In Kiambu ALL, farmers learned about the practices from seven sources, with CSHEP, locally derived knowledge through observation, and traditional knowledge passed down from one generation to another being the three main sources (Figure 11). Practices mainly learned through CSHEP were plant-based biopesticides, mulching, multistorey kitchen gardens, compost, water recycling, and crop rotation. Practices mainly learned through traditional knowledge were terraces and water harvesting, while that learned mainly through local observation was farmyard manure.

Figure 11: Sources from where the practices were learned in Kiambu ALL



In Makueni ALL, farmers learned about the practices from eight sources, with DNRC, traditional knowledge passed down from one generation to another, and locally derived knowledge through observation being the three main sources (Figure 12). Practices mainly learned through DNRC were plant-based biopesticides, agroforestry, water harvesting, compost, and water recycling. Practices mainly learned through traditional knowledge were FYM and terraces, while those learned mainly through observation were FYM and earth dams.

Figure 12: Sources from where the practices were learned in Makueni ALL



4.1.4 Which locally available resources do you use for the specific practice?

In Kiambu ALL, 91% of the farmers indicated that they used local resources, while 9% indicated that they did not. Table 11 shows the local resources used per practice.

Table 11: Locally available materials that are used for/by practices in Kiambu ALL

Type of practice	Local resources used in Kiambu ALL
Agroforestry (n=2)	Tree seedlings sourced from local nurseries
Farmyard manure (n=10)	Dung from cows, goats, poultry
Compost (n=13)	Green and dry tree litter/ leaves, egg shells, banana stem, charcoal dust, crop residues, ash, kitchen waste, top soil, farmyard manure, grass, crushed bones, water
Crop rotation (n=4)	Crops from local seeds
Multistorey kitchen gardens (n=8)	Manure, compost, grass, soil, gunny bags, liners, tanks
Mulching (n=9)	Tree leaves, *Grevillea robusta* leaves, grass (dry, nappier), weeds after weeding, crop residue (maize stalks), hay, silage
Plant-based biopesticides (n=16)	Plant parts: *Tithonia diversifolia*, Mexican marigold, Sodom apple (*Solanum incanum*), *Tephrosia*, garlic, aloe vera, ash, rabbit urine, Neem (*Azadirachta indica*)
Ash biopesticides (n=3)	Firewood, water
Terraces (n=2)	Jembes, spades
Water harvesting (n=7)	Water gutters
Water recycling (n=6)	Kitchen water, old drums/ basins/ buckets, ash
Biogas sludge (n=1)	Manure, water
Intercropping (n=2)	Local seed varieties
Drought-resistant crops (n=1)	Local seed varieties
Earth dams (n=1)	None
Hugo culture (n=1)	Banana leaves, banana stalks, compost, soil, water
Sunken beds (n=1)	Green leaves, e.g., *Tithonia*, compost and top soil
Trenches (n=1)	Jembes, spades
Traps (n=1)	None

In Makueni ALL, 84% of the farmers indicated that they used local resources, while 16% indicated that they did not. Table 12 shows the local resources used per practice.

Table 12: Locally available materials that are used for/by practices in Makueni ALL

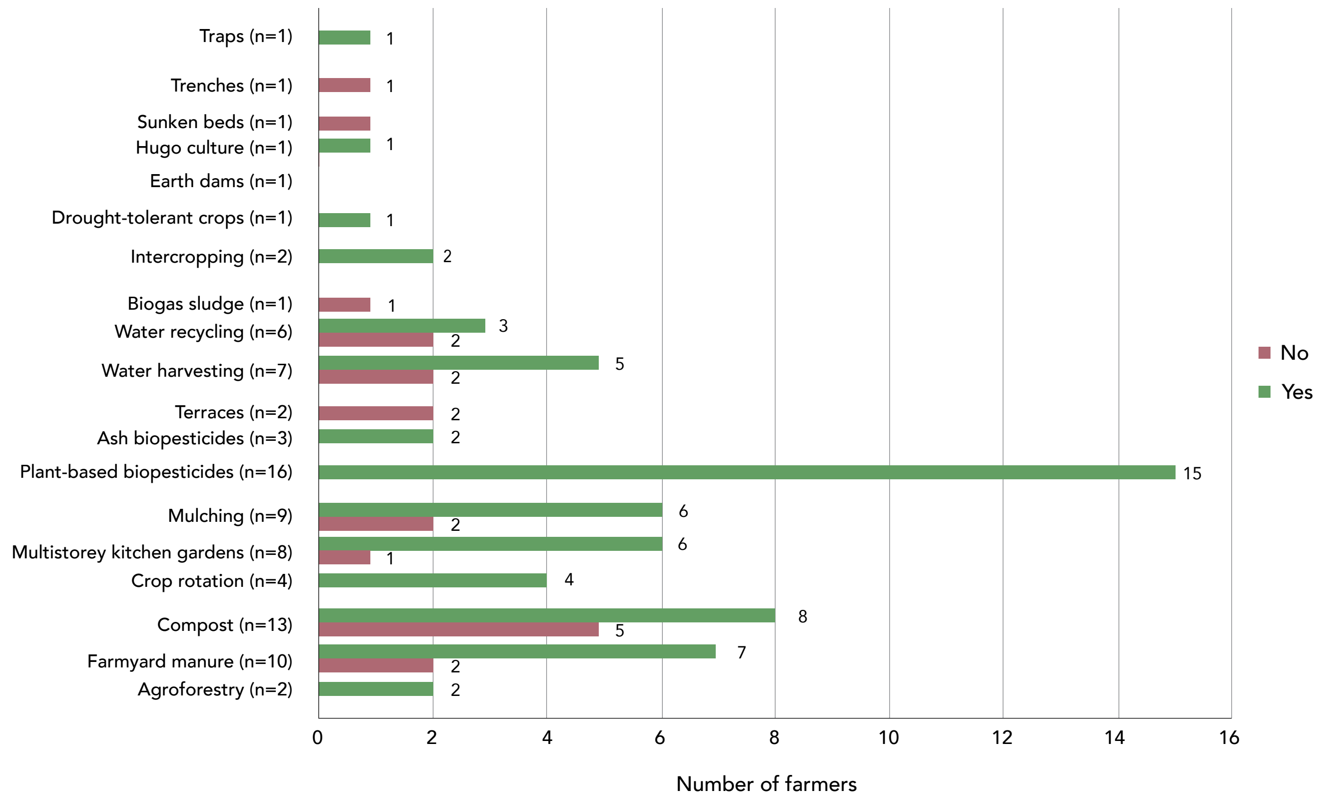
Type of practice	Local resources used in Makueni ALL
Agroforestry (n=7)	Seedlings, manure, working tools, e.g., jembe, panga
Compost (n=11)	Fodder remains, litter, ash, farmyard manure, mulberry leaves, maize stalks, ash, egg shells, *Lantana* camara leaves, *Tithonia* leaves, water, top soil, green and dry matter
Crop rotation (n=6)	Seeds, manure, local labor
Earth dams (n=2)	Working equipment (jembe, spade, fork, wheelbarrow), timber, sandy soil
Farmyard manure (n=19)	Cow, goat, and poultry dung, crop residues (beans, peas, cow peas, maize), grass, fodder remains, ash, local labor
Water harvesting (n=8)	Sisal leaves and jericans used as gutters for collecting water
Intercropping (n=2)	Local seed varieties
Mulching (n=3)	Tree leaves, e.g., *Grevillea robusta*, grass

Type of practice	Local resources used in Makueni ALL
Multistorey kitchen gardens (n=1)	Manure (chicken waste), fence and branches,jembe,spades
Plant-based biopesticides (n=10)	Plant parts (sodom apple, neem, pepper, mexican marigold, onions, *Muthulu*, local labor
Terraces (n=14)	Jembe, Spade, Labor
Water recycling (n=1)	Ash and water (ash purifies water), (soap)
Zai pits (n=4)	Jembe, spade, seeds

4.1.5 Does the practice decrease/substitute the use of synthetic inputs?

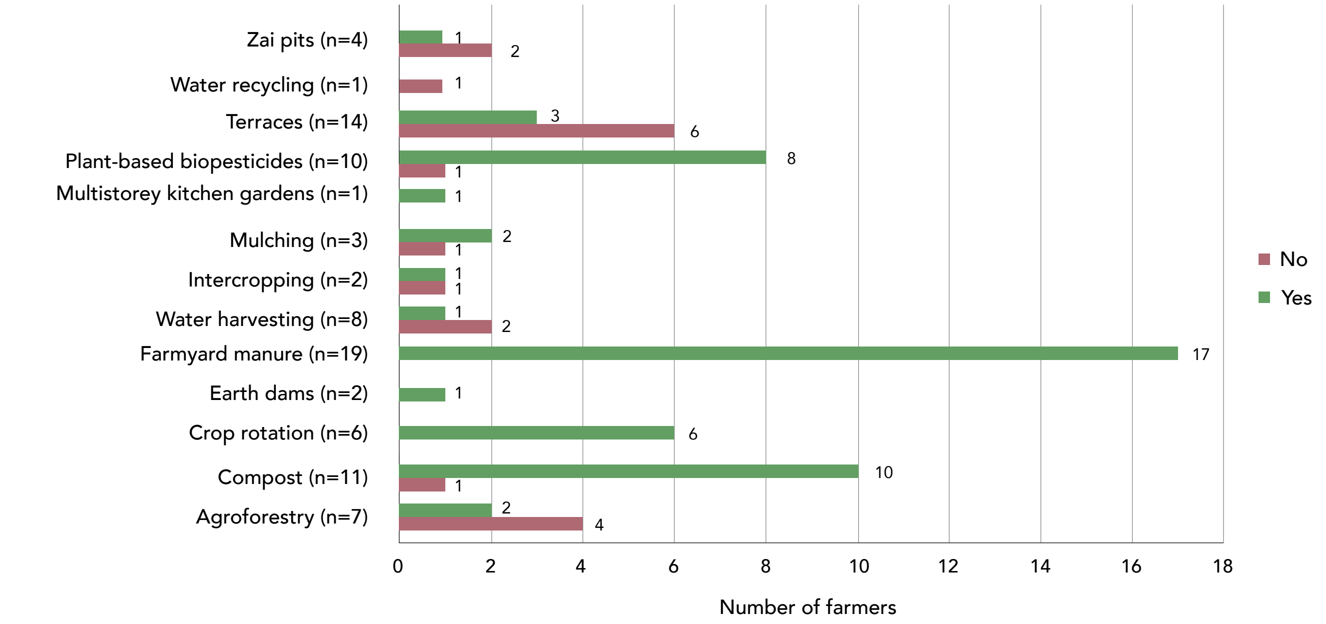
In Kiambu ALL, practices that were viewed as decreasing or substituting the use of synthetic inputs were plant-based biopesticides, ash-based biopesticides, farmyard manure, compost, and multistorey kitchen gardens (Figure 13). Structural practices such as terraces, sunken beds, and trenches were not associated with synthetic input reduction or substitution. The following practices were viewed as substituting the use of inorganic fertilizer: agroforestry, compost, crop rotation, drought-tolerant crops, Farmyard manure, mulching, and multistorey kitchen gardens. Practices that substituted the use of inorganic pesticides were agroforestry, crop rotation, drought-tolerant crops, intercropping, multistorey kitchen gardens, plant-based biopesticides, traps, and water recycling. A practice that substituted the use of herbicides was mulching.

Figure 13: Does the practice decrease/substitute the use of inorganic inputs in Kiambu ALL?



In Makueni ALL, practices that were viewed as decreasing or substituting the use of synthetic inputs were Farmyard manure, plant-based biopesticides, compost, and crop rotation (Figure 14). However, structural practices such as terraces, zai pits, as well as water harvesting and agroforestry were not associated with synthetic input reduction or substitution. The following practices were viewed as substituting the use of inorganic fertilizer: agroforestry, compost, crop rotation, drought-tolerant crops, Farmyard manure, mulching, and plant-based biopesticides. Practices that substituted the use of inorganic pesticides were crop rotation and plant-based biopesticides. A practice that substituted the use of herbicides was mulching. Water recycling substituted the use of water-purifying chemicals.

Figure 14: Does the practice decrease/substitute the use of inorganic inputs in Makueni ALL?



4.1.6 Does the practice interact with other inputs?

In Kiambu ALL, a majority of the practices, including plant-based biopesticides, multistorey kitchen gardens, crop rotation, agroforestry, mulching, intercropping, drought-tolerant crops, and trenches, were viewed as interacting with other inputs. However, water harvesting, biogas sludge, traps, terraces, and ash biopesticides were viewed as not interacting with other inputs (Figure 15).

Figure 15: Does the practice interact with other inputs/treatments in Kiambu ALL?

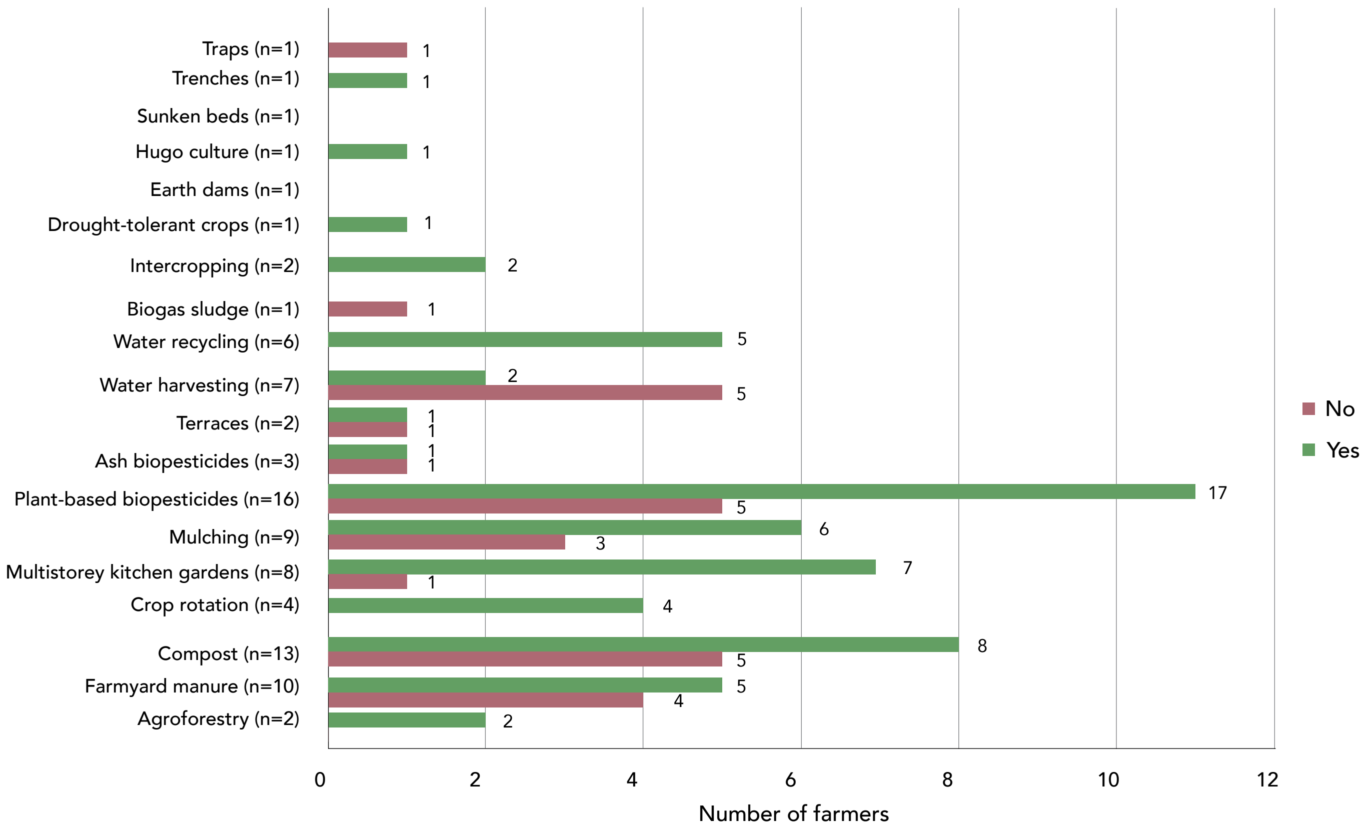


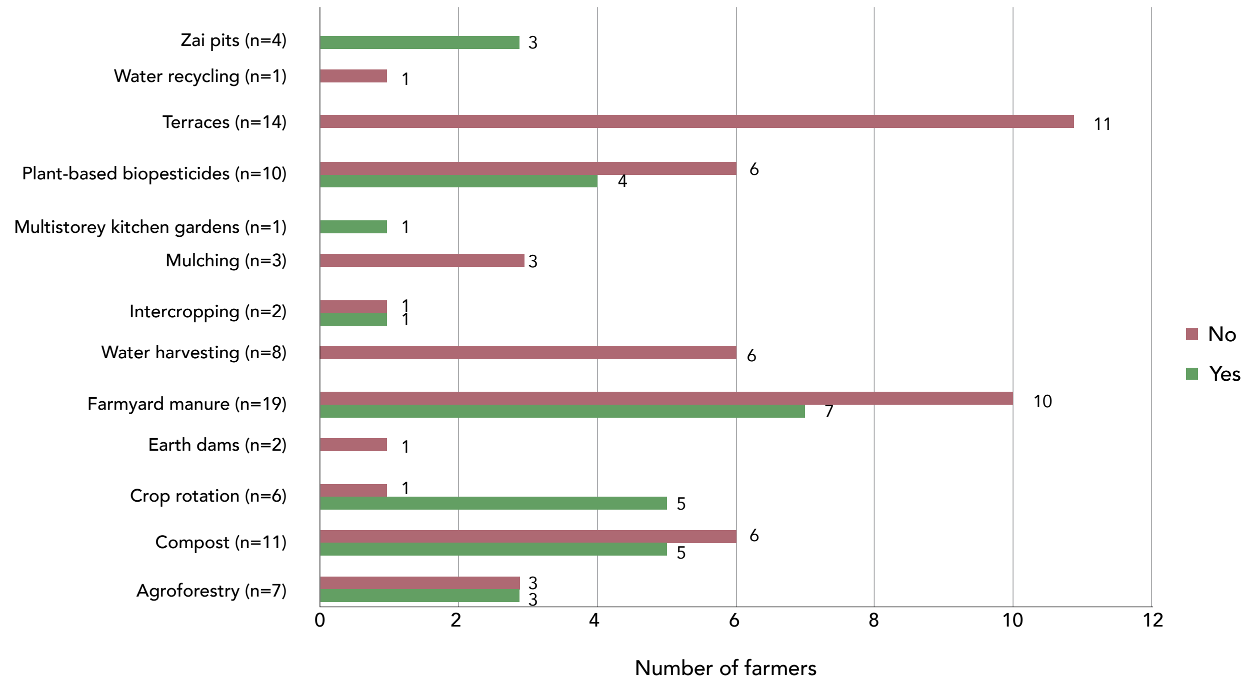
Table 13 highlights the inputs/treatments that farmers viewed as interacting with each practice in Kiambu ALL.

Table 13: Inputs/treatments that practices interact with in Kiambu ALL

Type of practice	Inputs/treatments interacting with the practices in Kiambu ALL
Agroforestry	Manure, compost
Ash biopesticides (n = 3)	Pepper
Biogas sludge (n = 1)	N/A
Compost (n = 13)	Charcoal dust, animal manure, ash, water, plant litter, farmyard manure
Crop rotation (n = 4)	Compost manure, FYM, ash, plant-based biopesticides
Drought-tolerant crops (n = 1)	Organic fertilizer, pesticides
Earth dams (n = 1)	N/A
Farmyard manure (n = 10)	Organic inputs, inorganic fertilizer, ash, plant litter
Hugo culture (n = 1)	Compost
Intercropping (n = 2)	Organic fertilizer, compost
Mulching (n = 9)	Raised beds, compost, organic inputs
Multistorey kitchen gardens (n = 8)	Water, organic fertilizer, foliar fertilizer, pesticides, compost
Plant-based biopesticides (n = 16)	Biological pesticides (e.g., pepper, garlic, *Tithonia*, Mexican marigold)
Sunken beds (n = 1)	N/A
Terraces (n = 2)	Manure, compost, water-harvesting trenches
Traps (n = 1)	N/A
Trenches (n = 1)	N/A
Water harvesting (n = 7)	Organic manure, ash
Water recycling (n = 6)	Organic inputs, water, ash

In contrast, in Makueni ALL, a majority of the practices were viewed as not interacting with other inputs, which include terraces, water harvesting, farmyard manure, compost, mulching, plant-based biopesticides, earth dams, and water recycling (Figure 16). The few practices viewed as interacting with other inputs were zai pits, crop rotation, and multistorey kitchen gardens.

Figure 16: Does the practice interact with other inputs/treatments in Makueni ALL?



Likewise, Table 14 highlights the inputs/treatments that farmers viewed as interacting with each practice in Makueni ALL.

Table 14: Inputs/treatments that practices interact with in Makueni ALL

Type of practice	Inputs/treatments interacting with the practices in Makueni ALL
Agroforestry (n = 7)	Organic manure
Compost (n = 11)	FYM, organic manure, and inputs
Crop rotation (n = 6)	FYM, compost, organic manure
Earth dams (n = 2)	N/A
Farmyard manure (n = 19)	Crop residues, litter, ash
Intercropping (n = 2)	Organic manure
Mulching (n = 3)	N/A
Multistorey kitchen gardens (n = 1)	Organic pesticides
Plant-based biopesticides (n = 10)	Inorganic pesticides, push-pull technology
Terraces (n = 14)	N/A
Water harvesting (n = 8)	N/A
Water recycling (n = 1)	N/A
Zai pits (n = 4)	Mulching

4.2 Awareness of the scientific mechanisms of the practices

Farmers' awareness of the scientific mechanisms of the practices was also sought. The results indicate that, in Kiambu ALL, 50% of the farmers practicing plant-based biopesticides were aware of their scientific mechanisms while 50% were not aware (Figure 17). Practices for which a majority of the farmers had knowledge about the scientific mechanisms were compost, crop rotation, multistorey kitchen gardens, and agroforestry, whereas those practices for which farmers were not aware of their scientific mechanisms were water harvesting, water recycling, intercropping, and traps.

Figure 17: Number of farmers aware of the scientific mechanisms of practices in Kiambu ALL

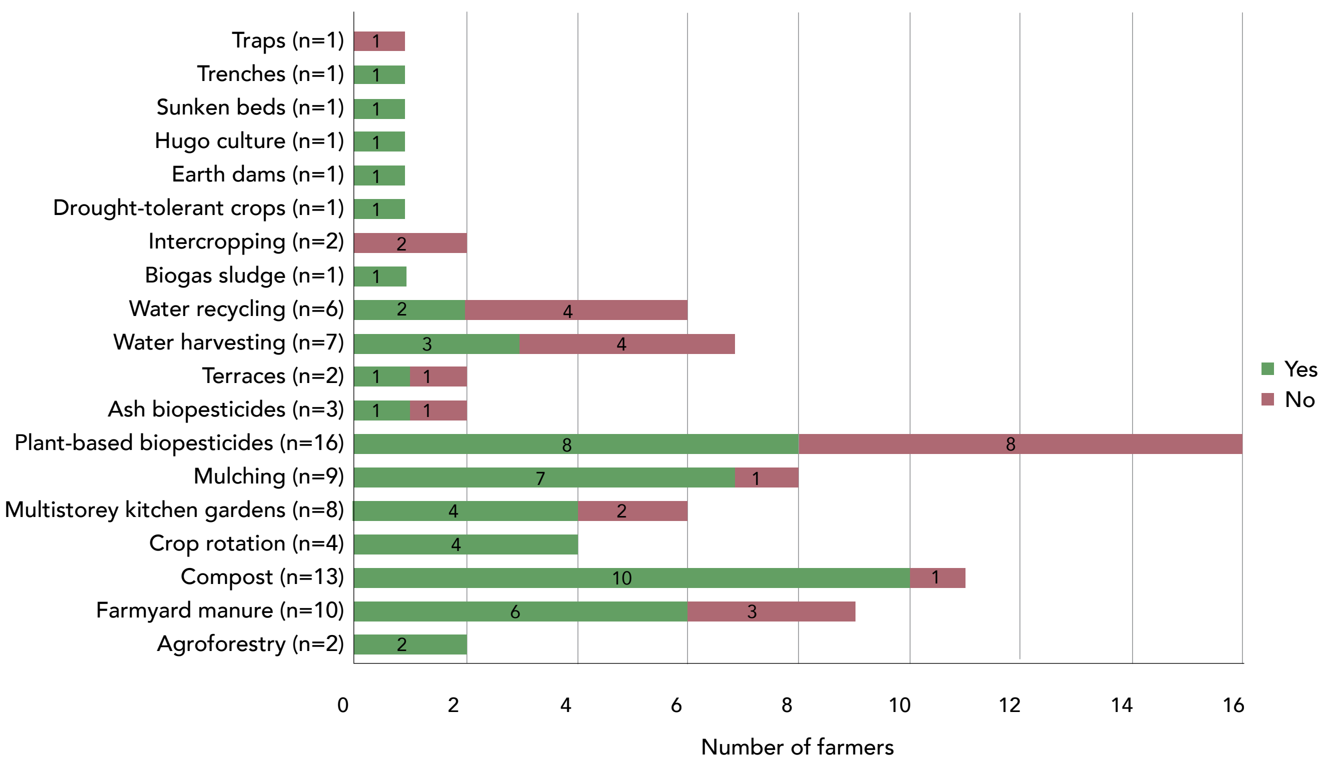


Table 15 outlines farmers' awareness of the scientific mechanisms associated with agroecological practices in Kiambu ALL.

Table 15: Farmers' awareness of the scientific mechanisms of the practices in Kiambu ALL

Type of practice	Scientific mechanism of practices according to farmers in Kiambu ALL
Agroforestry (n=2)	Enhancing rainwater infiltration into the soil and wind break.
Farmyard manure (n=10)	Increases soil fertility by adding nutrients to the soil, it breaks down healthy organic materials that are then made available for the soil. It also reduced pest attacks to crops. However, FYM should be used only after it has matured in order for the nutrients to be available to crops.
Compost (n=13)	Increases soil organic matter, softens the soil thereby enhancing water infiltration, improves soil structure, increases soil fertility and enhances nutrient availability to crops, does not scorch the soil and leads to growing of healthy crops.
Crop rotation (n=4)	Breaks the cycle of pests and diseases and rejuvenates the soil.
Multistorey kitchen gardens (n=8)	Majority of farmers did not know. Helps in water conservation and retention.
Mulching (n=9)	Conserves soil moisture through reducing evaporation, reduces weeds, and reduces pest infestation leading to healthier plants.
Plant-based biopesticides (n=16)	Repells pests - e.g., for some it is the bitterness and for others it is the odour of the concoction repels pests away, while other pests are killed. It is important to know the amount to use.
Ash biopesticides (n=3)	Ash-based biopesticides were perceived as neutralizing the soil PH and protecting plants from pests such as worms.
Terraces (n=2)	Helps in soil conservation by preventing soil erosion, helps in water infiltration to the soil.
Water harvesting (n=7)	Controls water flow and increases water use efficiency in large portions. It requires the correct installation of equipment in order to optimize catching of water.
Water recycling (n=6)	Ash reduces the acidity contained in soap.
Biogas sludge (n=1)	Increases soil fertility.
Intercropping (n=2)	No knowledge of how intercropping works.
Drought-resistant crops (n=1)	Drought-resistant crops such as sweet potatoes are good cover crops, while black beans act as good soil amendment .
Earth dams (n=1)	If well made can use drip irrigation (pump) to minimize water loss.
Hugo culture (n=1)	Increases soil fertility.
Sunken beds (n=1)	The material at the bed breaks the hard pan improves air circulation, improves retention of moisture (leaves, etc.).
Trenches (n=1)	Control soil erosion through reducing the speed of surface runoff.
Traps (n=1)	No knowledge.

In Makueni ALL, practices for which the majority of farmers had knowledge about the scientific mechanisms were terraces, compost, agroforestry, crop rotation, zai pits, mulching, and intercropping (Figure 18). About 50% of the farmers practicing Farmyard manure were aware of its scientific mechanisms, whereas 50% were not aware. A majority of the farmers were not aware of the scientific mechanisms for water harvesting.

Figure 18: Number of farmers aware of the scientific mechanisms of practices in Makueni ALL

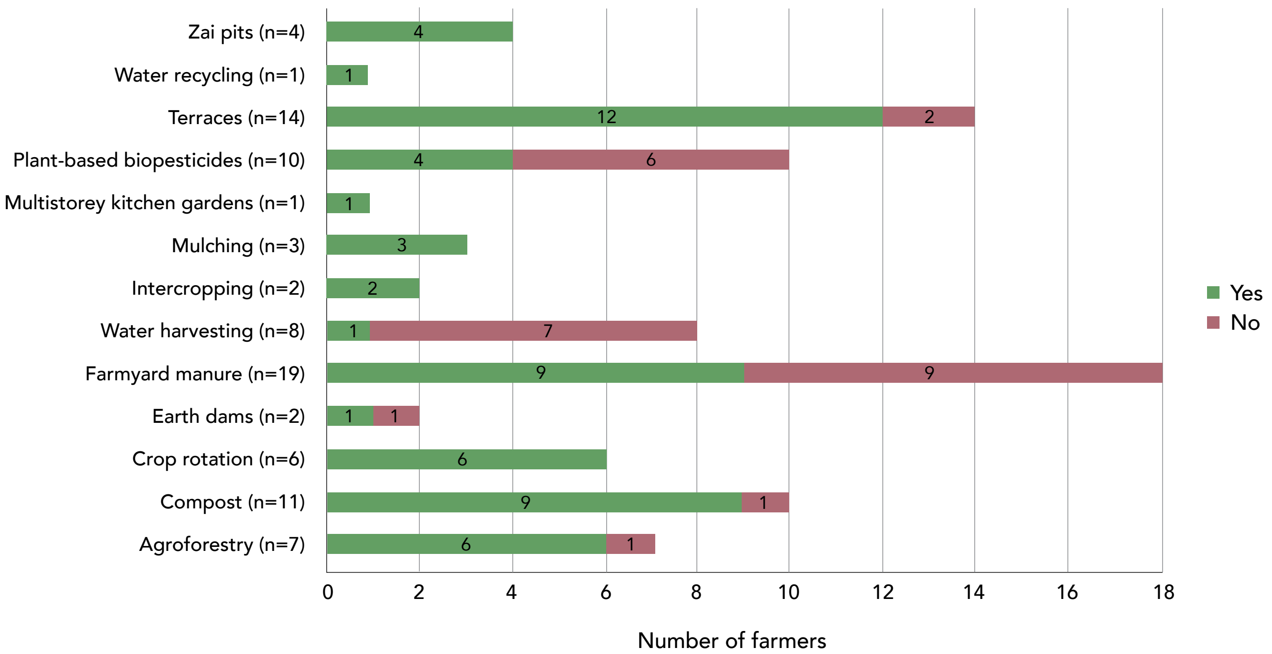


Table 16 outlines farmers' awareness of the scientific mechanisms associated with agroforestry in Makueni ALL.

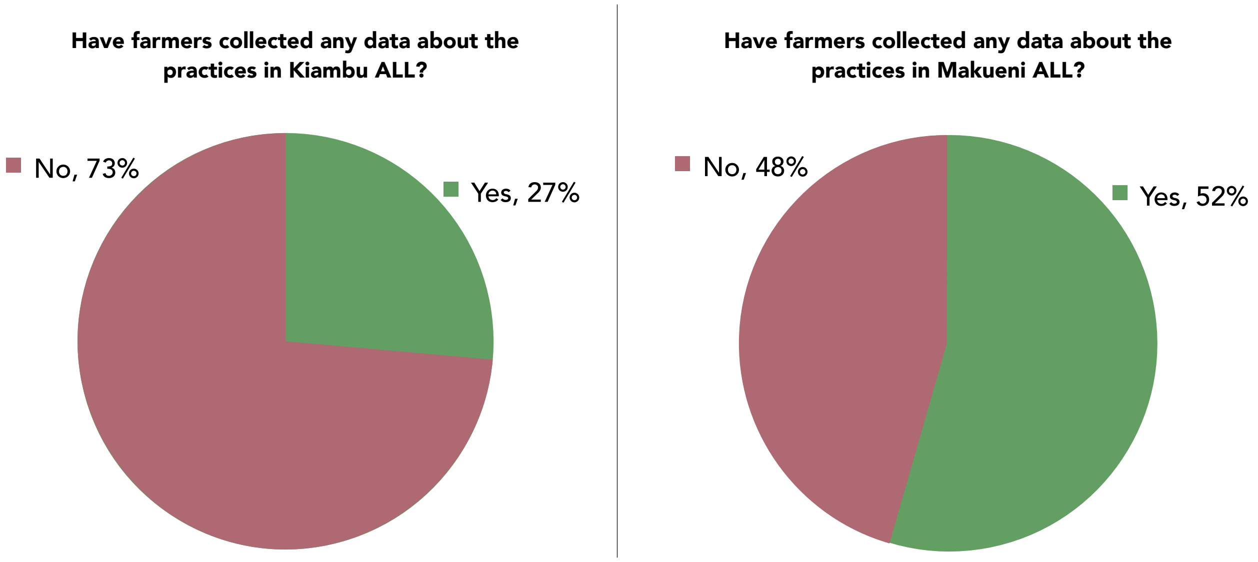
Table 16: Farmers' awareness of the scientific mechanisms of the practices in Makueni ALL

Type of practice	Scientific mechanism of practices according to farmers in Makueni ALL
Agroforestry (n=7)	Purifies the air, provides shade that leads to microclimate regulation, attracts rainfall, soil erosion control, soil fertility improvement, attracts rainfall. Correct spacing is required.
Compost (n=11)	Soil fertility improvement through adding nutrients, retains soil moisture, controls pests. Adding ash and water improves the decomposition process.
Crop rotation (n=6)	Improves soil fertility, soil moisture conservation, pest control.
Earth dams (n=2)	Must have an inlet.
Farmyard manure (n=19)	Soil fertility improvement.
Water harvesting (n=8)	Digging as it is slopping so that soil cannot get into the water, construction of inlet and outlets.
Intercropping (n=2)	Soil fertility improvement, crops planted in rows.
Mulching (n=3)	Soil fertility improvement, water conservation and retention.
Multistorey kitchen gardens (n=1)	Produces nutritious food.
Plant-based biopesticides (n=10)	Kills pests, repels pests, less residual effects (does not remain in food after being applied to crops).
Terraces (n=14)	Slows the speed of surface runoff and reduces soil erosion, enhances water infiltration thus improving soil moisture content. Planting vegetation on the edges prevents soil erosion while planting crops along terraces diversifies food sources. It requires knowlegde on the design and measurements/dimensions.
Water recycling (n=1)	Cleanses water.
Zai pits (n=4)	Intercepts and retains water thus making it available for crop use.

4.3 Have farmers collected any data about the practices?

The main data collection method used by farmers in both ALLs was observation. Figure 19 shows that a majority of farmers in the Kiambu ALL had not collected any form of data about their practices, while a majority of Makueni farmers had.

Figure 19: Percentage of farmers who have collected any data regarding the practices



In Kiambu ALL, farmers collected data on 10 practices: Farmyard manure, compost, multistorey kitchen gardens, plant-based biopesticides, terraces, water harvesting, water recycling, hugo culture, and trenches (Table 17). Crop performance/yield was the main type of data collected as reported for 6 of the 10 practices for which data were collected. No data were reported as having been collected on nine practices: agroforestry, crop rotation, intercropping, ash-based biopesticides, drought-tolerant crops, biogas sludge, earth dams, sunken beds, and traps.

Table 17: Type of data about practices collected by farmers in Kiambu ALL

Type of practice	Data collected by Kiambu ALL farmers
Agroforestry (n = 2)	None.
Farmyard manure (n = 10)	Ability to control pests.
Compost (n = 13)	Uses a thermometer to measure maturity of the compost. Performance of leaves from different tree species such as *Grevillea* and avocadoes, soil quality after compost application, soil fertility, crop performance, and water retention of soil after compost application.
Crop rotation (n = 4)	None.
Multistorey kitchen gardens (n = 8)	Crop yield, water usage, spacing of plants.
Mulching (n = 9)	Water retention rate, weed suppression rate, soil fertility/quality after mulch application.
Plant-based biopesticides (n = 16)	Types of pests, pest incidence, crop performance.
Ash biopesticides (n=3)	None.
Terraces (n = 2)	Crop yield.
Water harvesting (n = 7)	Crop yield.
Water recycling (n = 6)	Purity level of water.
Biogas sludge (n = 1)	None.
Intercropping (n = 2)	None.
Drought-tolerant crops (n = 1)	None.
Earth dams (n = 1)	None.
Hugo culture (n = 1)	Crop yield, plant growth rate.

Type of practice	Data collected by Kiambu ALL farmers
Sunken beds (n = 1)	None.
Trenches (n = 1)	Silt deposition rate.
Traps (n = 1)	None.

Table 18 outlines farmers' feedback on the kind of data they collect from each of the practices in Makueni ALL. Unlike in Kiambu ALL, farmers in Makueni ALL collected data on agroforestry, crop rotation, and intercropping.

Table 18: Type of data about practices collected by farmers in Makueni ALL

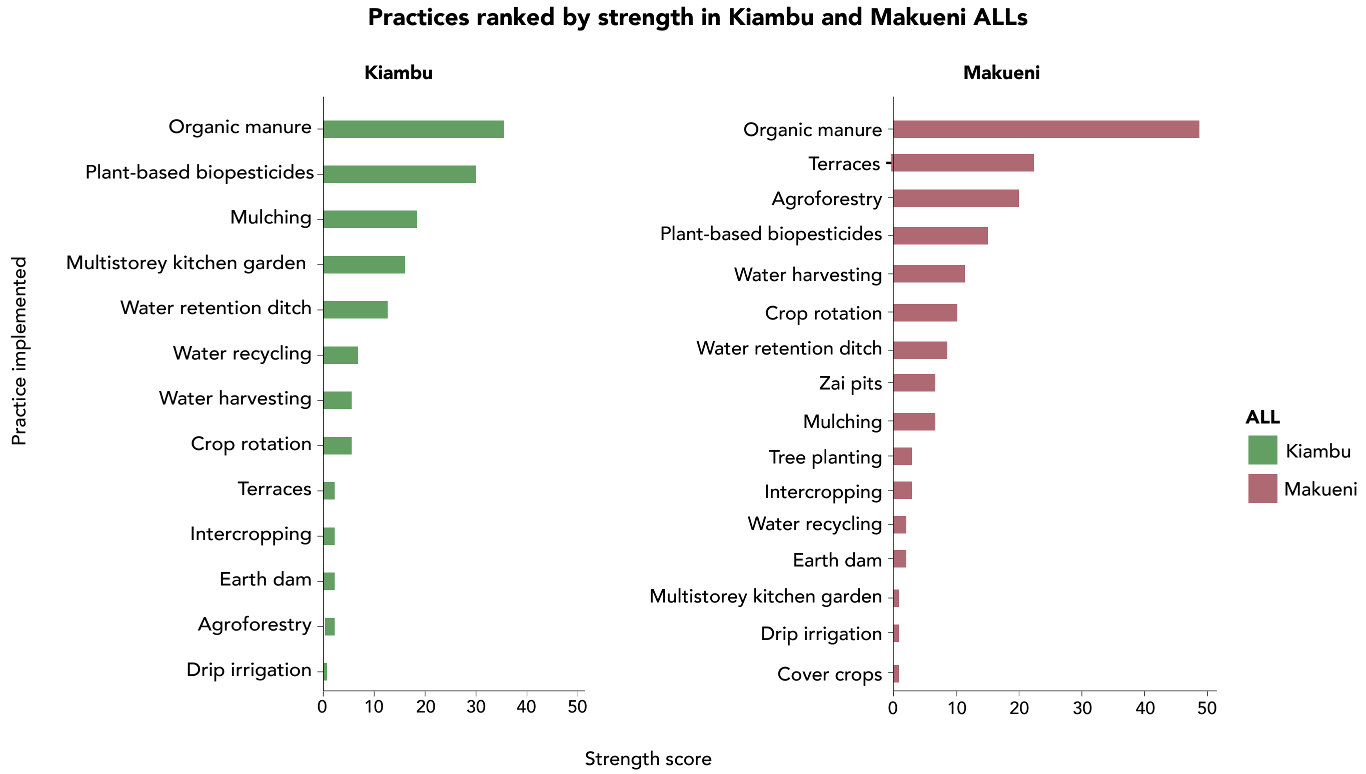
Type of practice	Data collected by Makueni ALL farmers
Agroforestry (n = 7)	Productivity of crops grown near trees, shade amount, air freshness level, soil erosion rate, rainfall amount.
Compost (n = 11)	Decomposition level, crop yield, soil color.
Crop rotation (n = 6)	Crop vigor, crop yield, pest incidence.
Earth dams (n = 2)	N/A.
Farmyard manure (n = 19)	Crop vigor, crop performance/growth rate, crop yield, soil health.
Water harvesting (n = 8)	N/A.
Intercropping (n = 2)	Pest incidence, crop yield.
Mulching (n = 3)	Pest infestation incidence, soil water content.
Multistorey kitchen gardens (n = 1)	N/A.
Plant-based biopesticides (n = 10)	Signs of pest incidence, crop yield.
Terraces (n = 14)	Surface runoff speed, crop yield.
Water recycling (n = 1)	Color of water.
Zai pits (n = 4)	Amount of water intercepted in holes, crop yield.

4.4 Strengths and weaknesses of practices in Makueni and Kiambu ALLs

4.4.1 Cumulative strengths of the inventoried practices

In Figure 20, the cumulative strengths (benefits) of the practices are displayed. Among the inventoried practices, organic manure (farmyard manure and compost) exhibited the highest number of strengths/benefits in both ALLs. Furthermore, in Kiambu ALL, plant-based biopesticides, mulching, and multistorey kitchen gardens received high cumulative benefit scores. Similarly, in Makueni ALL, terraces, agroforestry, and plant-based biopesticides were associated with significant cumulative benefit scores.

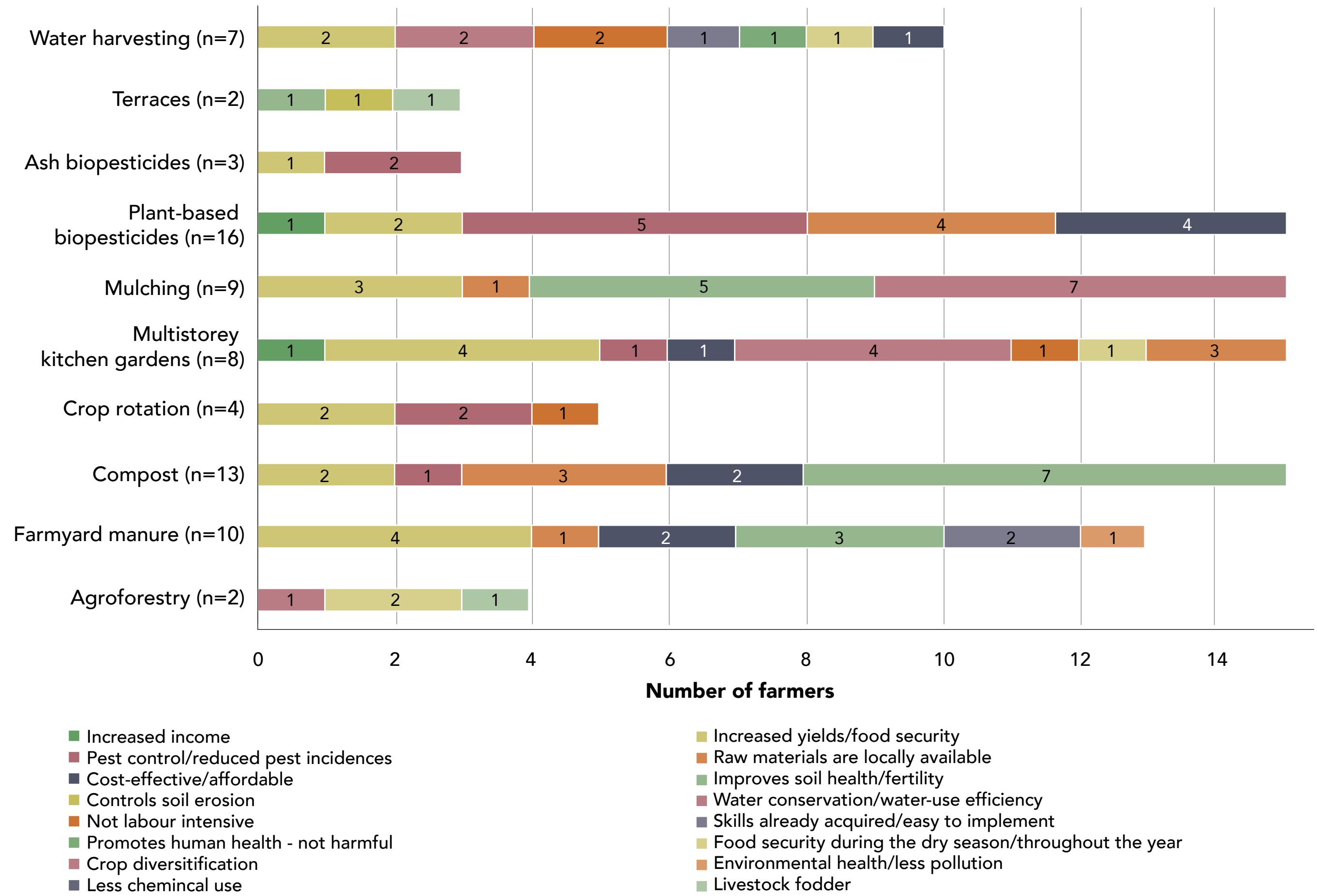
Figure 20: Cumulative strengths of inventoried practices in both ALLs



4.4.2 Strengths and benefits associated with practices in Kiambu ALL

In Kiambu ALL, compost manure was perceived as being beneficial because it improves soil health (54%), leads to soil water conservation, and uses locally available materials (23%), and is cost-effective and leads to increased crop yield (15%) (Figure 21). Farmyard manure was perceived as being beneficial because it leads to increased crop yield (40%), improves soil health (30%), is cost-effective, farmers have already acquired the skills in its preparation and management (20%), farmers use locally available materials, and it is environmentally healthy (10%). Mulching was viewed as being beneficial for soil water conservation (78%), improving soil health and fertility (56%), increasing crop yield (33%), and raw materials being locally available (11%). Multistorey gardens were seen as increasing crop yield and enhancing soil water conservation (50%). The practice also uses less space to grow more crops (38%). It leads to food security throughout the year, is not labor intensive, leads to increased income, and pests are easy to control (13%). Plant-based biopesticides were viewed as beneficial due to being effective in pest control (31%), using locally available materials, and being cost-effective (25%). Some farmers believed they already had the skills in preparation and application of biopesticides (13%) and they also attributed strength to increased crop yield (13%).

Figure 21: Strengths of the inventoried soil, water, and IPM practices in Kiambu ALL



4.4.3 Challenges associated with soil, water, and IPM practices in Kiambu ALL

The practices implemented in Kiambu ALL were constrained by various factors (Figure 22) as follows. Farmers viewed compost production as being labor intensive (31%) and it was affected by water shortage (15%). Farmyard manure was mainly constrained by the shortage of water (40%) and being costly to purchase (10%). Mulching, on the other hand, was mainly constrained by being labor intensive (50%), pest infestation (33%), farmers' lack of knowledge of its preparation and management, drought, and being affected by weather conditions (17%). Multistorey kitchen gardens were mainly constrained by water shortage (50%) and lack of land (13%). Plant-based biopesticides were constrained by weather/temperature (31%), water shortage (19%), not being very effective in pest control (13%), being labor intensive, lack of equipment, and farmers' lack of knowledge on their preparation and application (6%).

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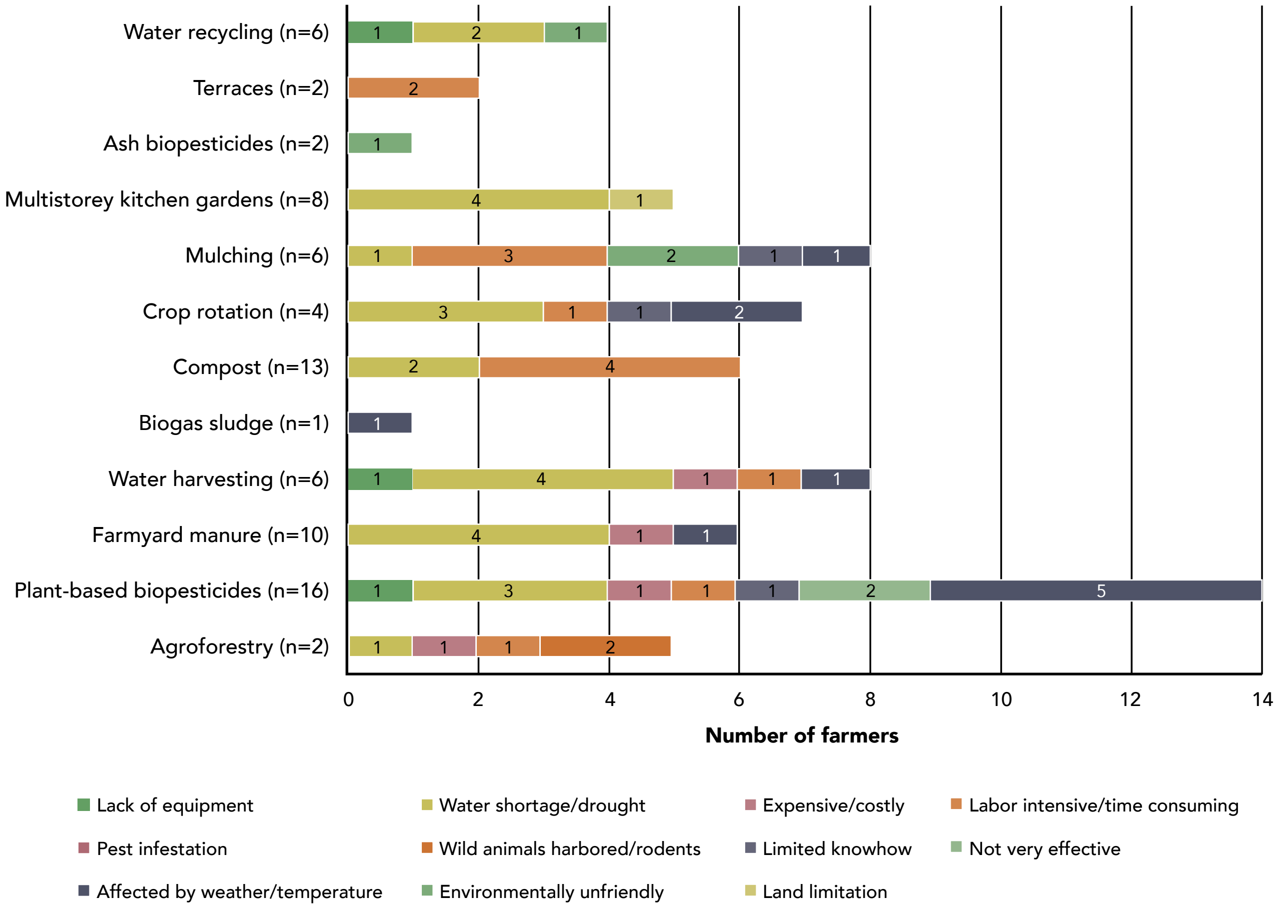
Figure 22: Challenges of the inventoried soil, water, and IPM practices in Kiambu ALL



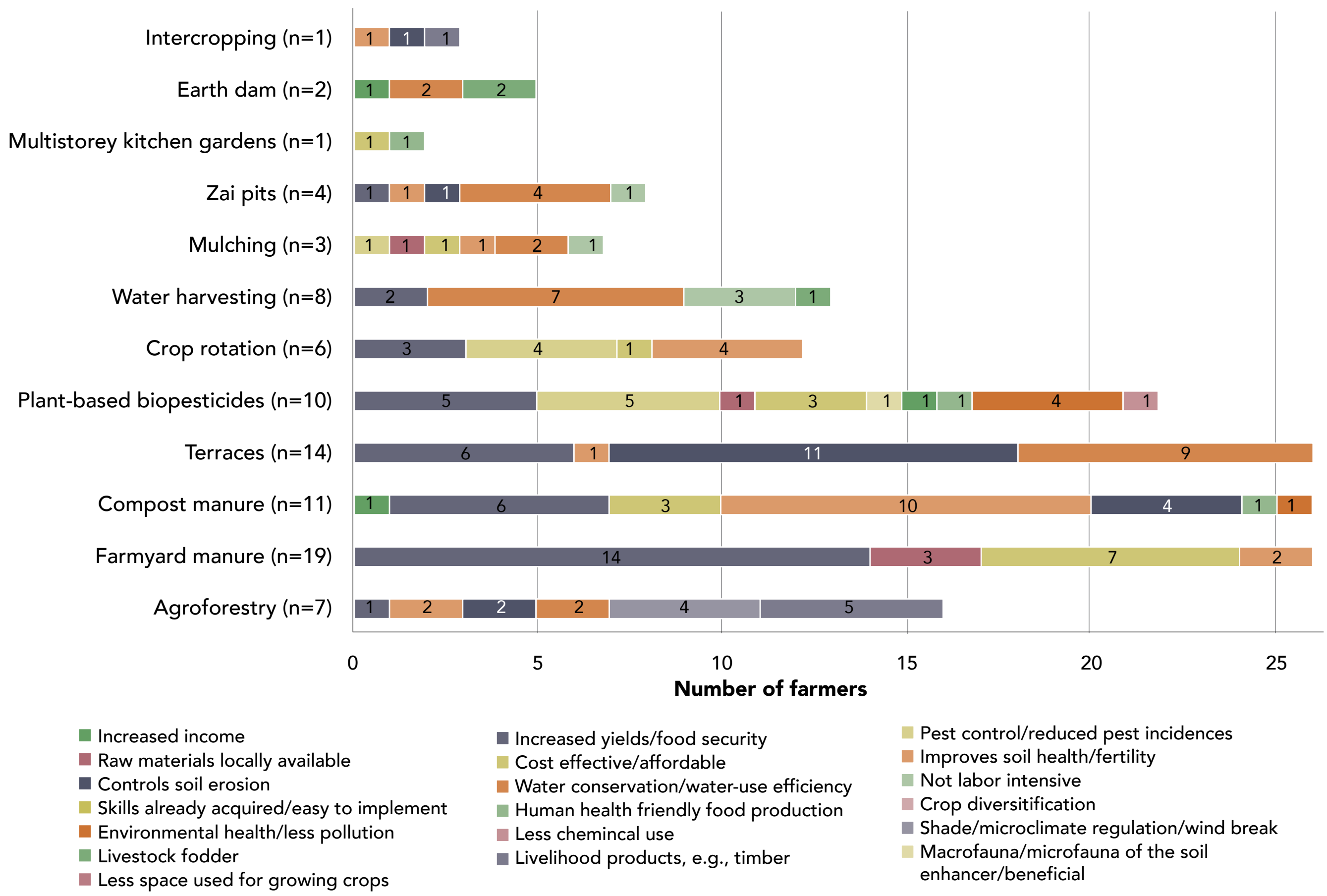
4.4.4 Strengths and benefits associated with practices in Makueni ALL

Figure 23 shows a breakdown of the different strength scores based on various parameters. Various practices were associated with certain strengths. In Makueni ALL, strengths from the practices mentioned by farmers fall under the following core elements of agroecology: integrated natural farming (9), social justice (5), and circular economy (5).

The strengths of the inventoried practices assessed are classified into 19 benefits as presented in Figure 23. Farmyard manure strengths were increasing crop yield (70%), improving soil health (40%), being cost-effective (35%), and being prepared using locally available raw materials (15%). Strengths of terraces were soil erosion control (79%), soil water conservation (64%), and increased crop yield (43%).

On the other hand, compost manure was perceived as improving soil health and fertility (91%), increasing crop yield (55%), improving soil erosion control (36%), and being cost-effective (27%). Plant-based biopesticides were perceived as having numerous benefits, such as effective pest control (50%), increasing crop yield (50%), being environmentally safe and thereby controlling pollution (40%), not being labor intensive, producing food that is safe for human health, cost-effectiveness, and improving soil health (10%). Water harvesting was attributed to have the following strengths: water conservation (88%), not being labor intensive (38%), and leading to increased crop yield (25%). Agroforestry was considered to be able to provide livelihood products such as fruits, timber, firewood, and fodder (71%); shade/micro-climate regulation (59%); and water conservation, soil erosion control, and soil fertility improvement (29%).

Figure 23: Strengths of the inventoried soil, water, and IPM practices in Makueni

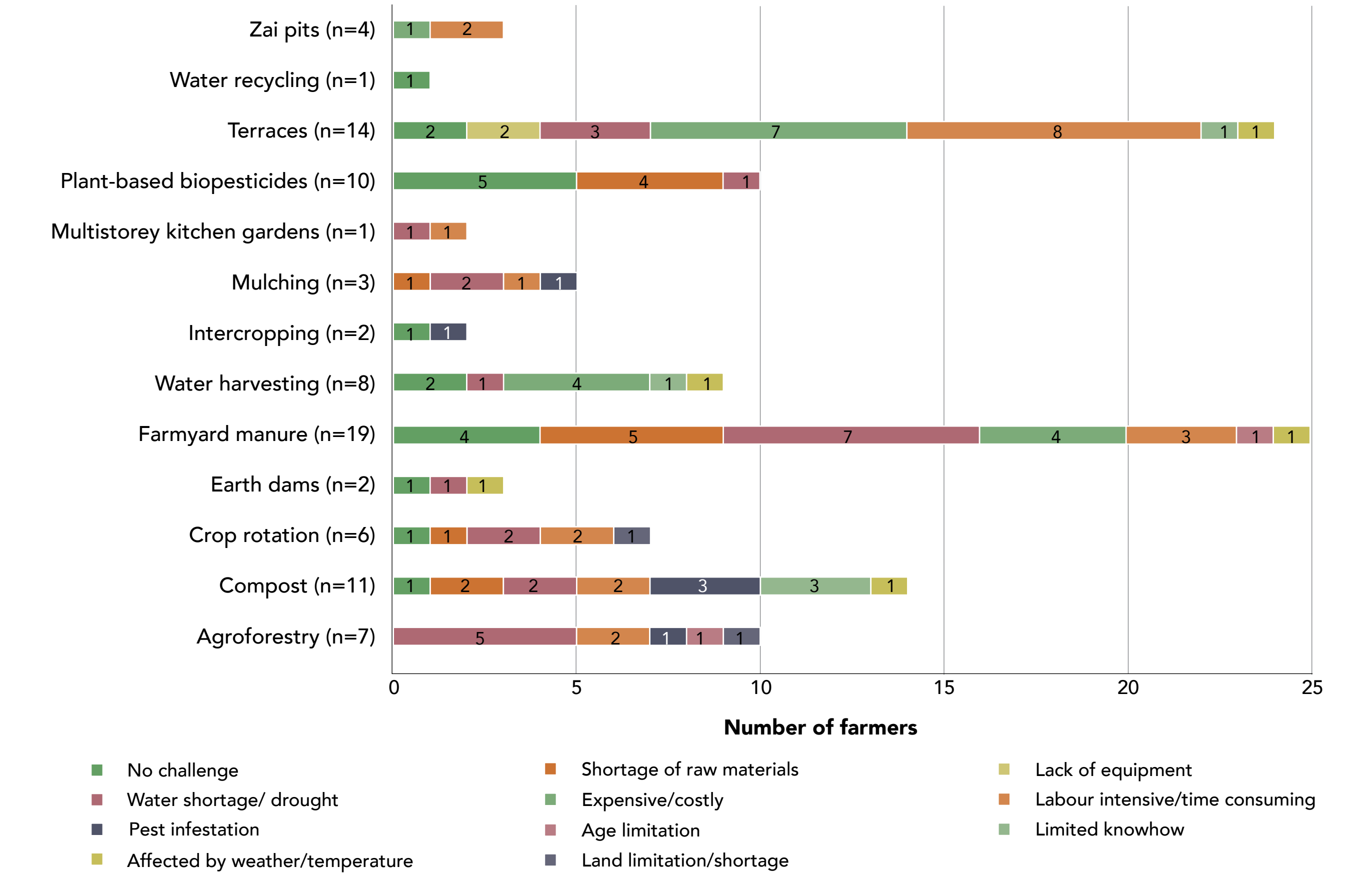


4.4.5 Challenges associated with the soil, water, and IPM practices in Makueni ALL

In Makueni ALL, farmers identified 10 challenges associated with the soil, water, and IPM practices that they are implementing (Figure 24).

The main challenges affecting farmyard manure as reported by farmers were drought (37%), shortage of raw materials (26%), high cost (21%), and perception of being labor intensive (16%). The main challenges affecting terraces were labor intensive nature (57%), cost (50%), water shortage/drought (21%), and lack of equipment (14%). The challenges affecting compost manure included farmers lacking knowledge on how to prepare it (27%), pest infestation on crops to which compost manure is applied (27%), water shortage, shortage of raw materials, and the perception of being labor intensive (18%). Plant-based biopesticides were mainly challenged by the lack of raw materials such as leaves (40%) and water shortage (10%). Water harvesting was perceived as being labor intensive (57%) and costly (50%), while 21% of the farmers mentioned that there was water shortage. Agroforestry was mainly constrained by drought (71%), the perception of being labor intensive (29%), shortage of land, and pest infestation of tree seedlings (14%).

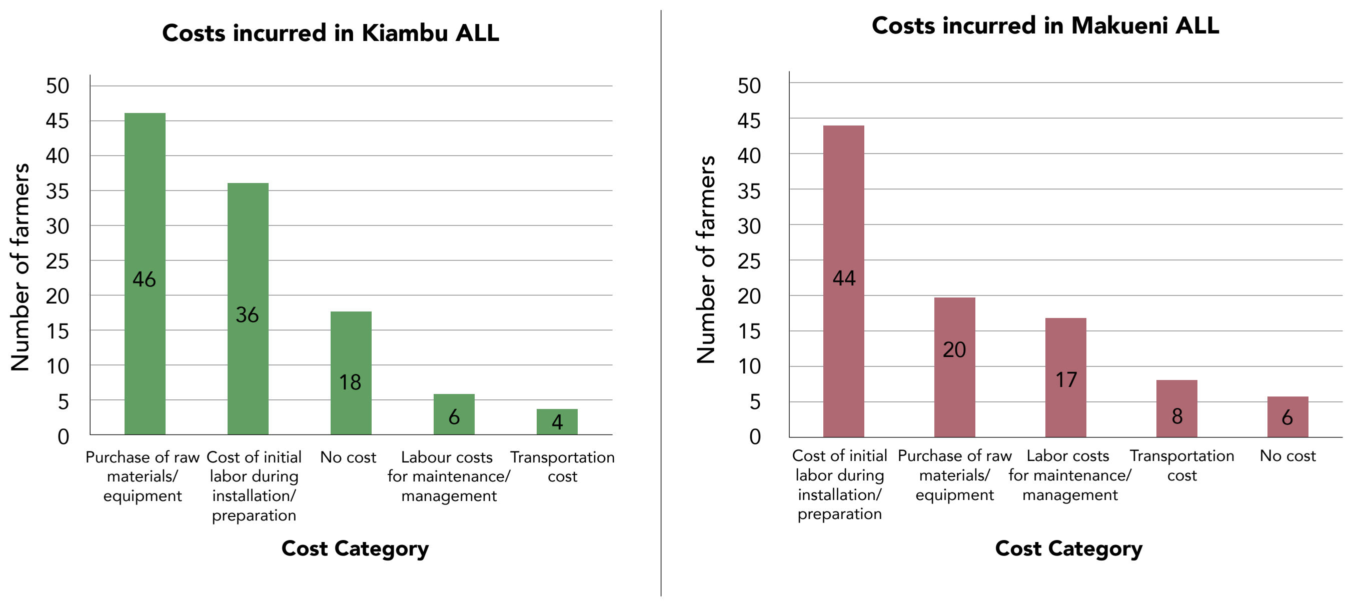
Figure 24: Challenges of the inventoried soil, water, and IPM practices in Makueni ALL



4.5 Costs and labor incurred by farmers implementing the practices

Farmers identified four types of costs associated with the inventoried soil, water, and IPM practices: cost of initial labor during the implementation of the practices (82%), costs of purchasing raw materials and equipment (67%), labor costs during maintenance of the practices (24%), and cost of transportation (13%) (Figure 25).

Figure 25: Overall costs associated with soil, water, and IPM practices in Kiambu and Makueni ALLs

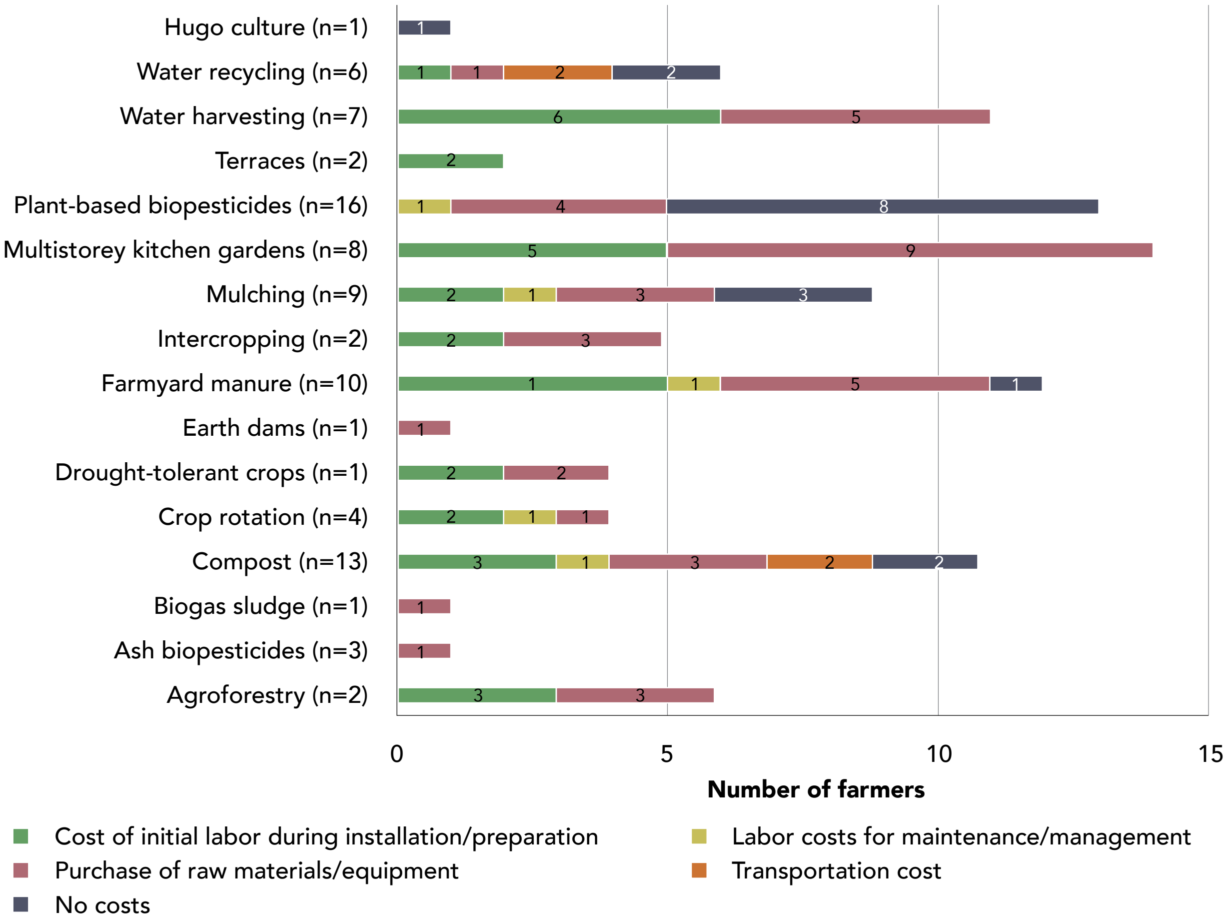


4.5.1 Cost categories

The analysis revealed that the primary costs associated with all the practices were attributed to the initial labor required during installation as well as the expenses incurred in purchasing raw materials or equipment (Figure 26).

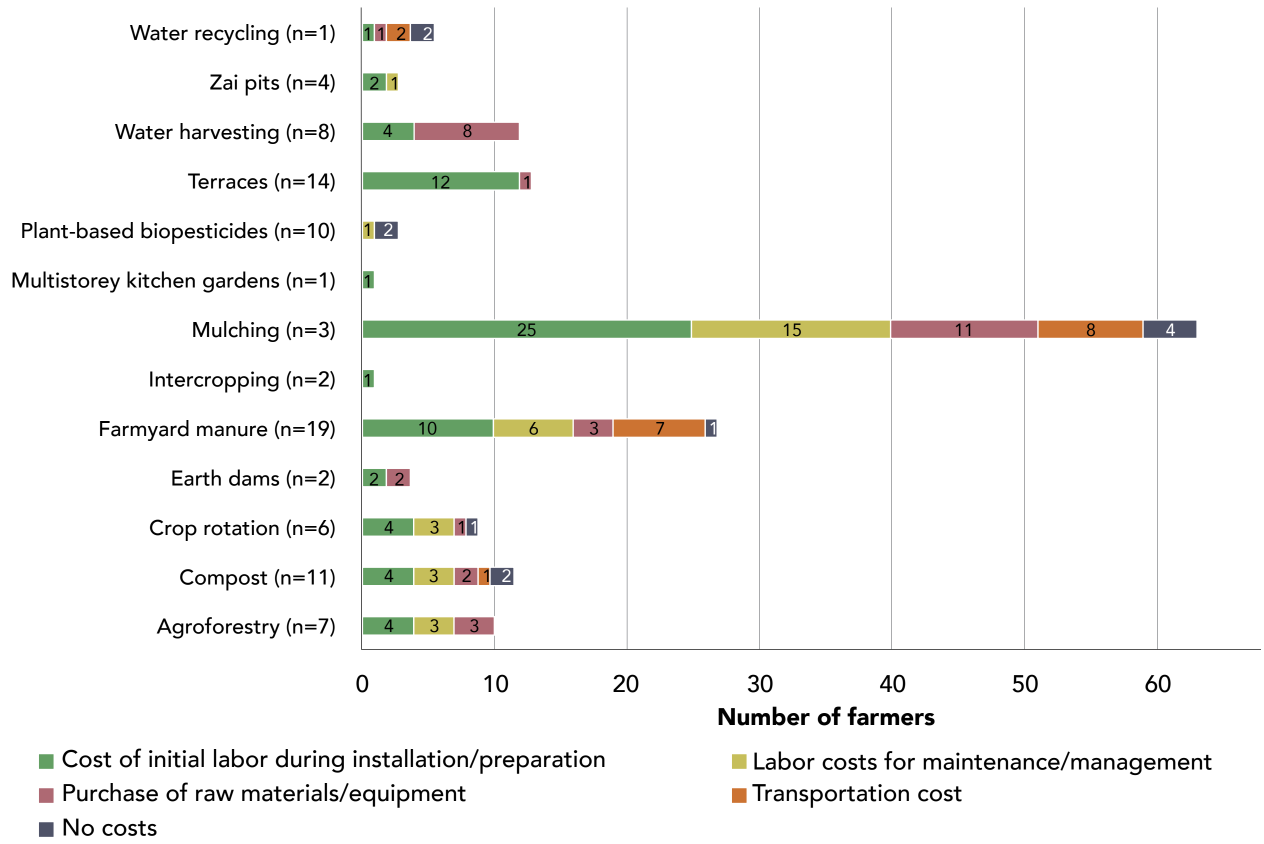
The analysis indicated that the highest costs in implementing the practices were associated with the initial labor required during installation. In Kiambu ALL, practices such as farmyard manure, terraces, and water harvesting were reported to involve the highest initial labor costs. Water harvesting and farmyard manure also incurred significant expenses for purchasing raw materials and equipment. On the other hand, practices such as earth dams, zai pits, and mulching were found to be the most cost-effective and affordable to install. Furthermore, the analysis identified several practices that were perceived as easy to implement without the need for financial resources. These practices were plant-based biopesticides, mulching, crop rotation, farmyard manure, and compost.

Figure 26: Costs disaggregated by practices in Kiambu ALL



In Makueni ALL, practices such as farmyard manure, terraces, mulching, compost, agroforestry, and crop rotation were reported to involve the highest initial labor costs (Figure 27). Mulching and water harvesting also incurred significant expenses for purchasing raw materials and equipment, while mulching and farmyard manure were perceived as incurring significant maintenance costs.

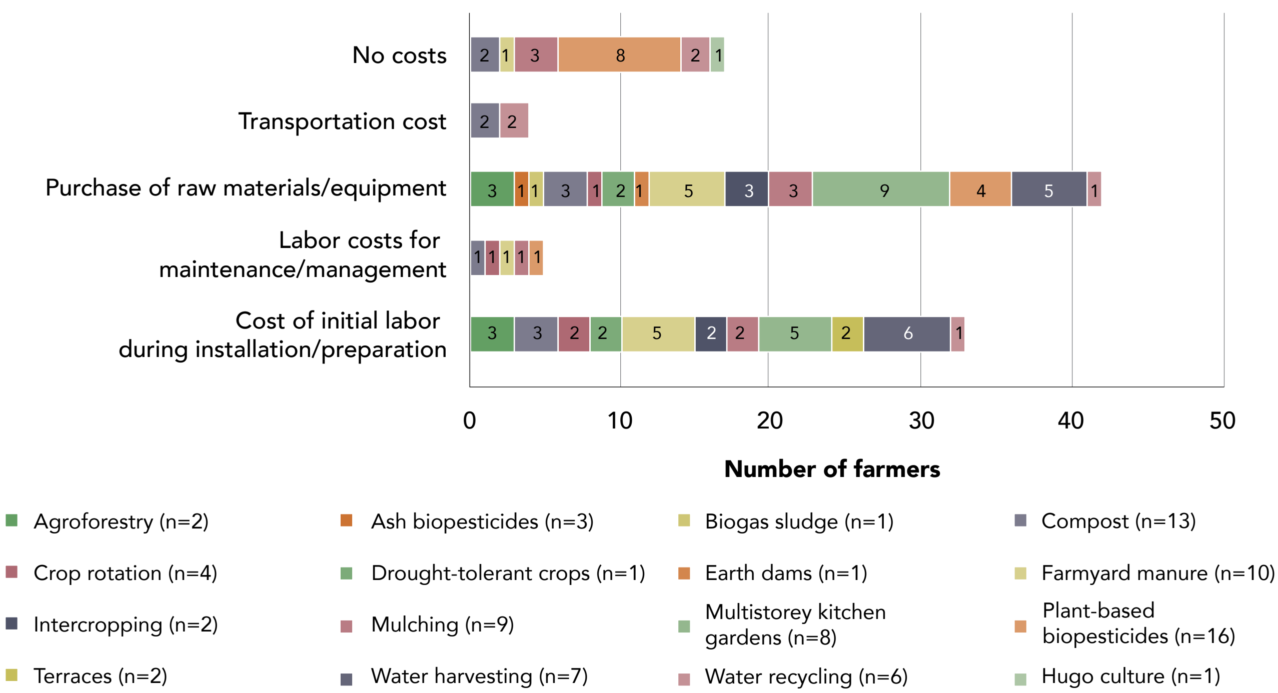
Figure 27: Costs disaggregated by practices in Makueni ALL



4.5.2 Main costs incurred per practice

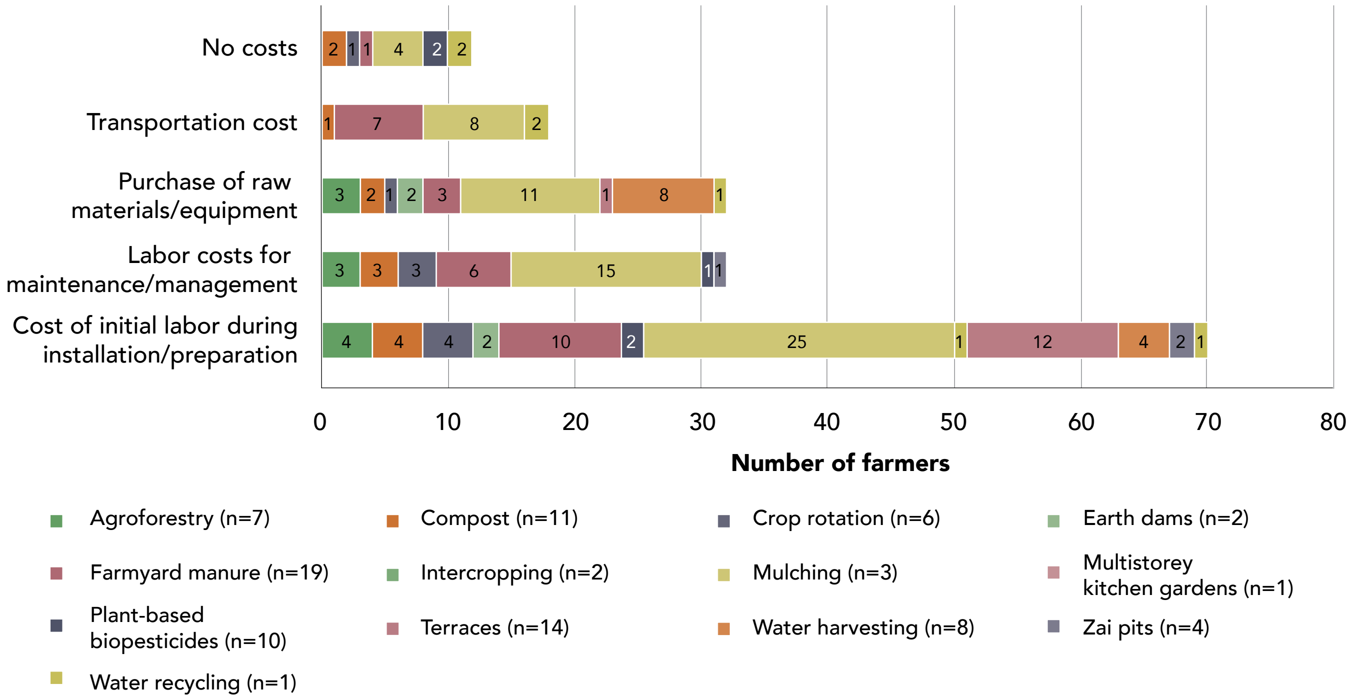
In Kiambu ALL, farmers reported incurring the cost of purchasing raw materials in 13 out of 16 practices and the cost of initial labor during installation in 11 practices (Figure 28). Transportation cost was mentioned in only two practices. Among the practices examined, compost manure and crop rotation were associated with the highest number of cost categories. On the other hand, zai pits were found to have the fewest cost categories, particularly related to labor.

Figure 28: Costs per practice disaggregated by cost categories in Kiambu



In Makueni ALL, farmers reported incurring the cost of initial labor during installation in 12 out of 13 practices, cost of purchasing raw materials in 11 practices, and labor costs during maintenance in 10 practices (Figure 29).

Figure 29: Costs per practice disaggregated by cost categories in Makueni ALL



4.5.3 Types of labor incurred

In the Kiambu ALL, farmers mentioned a wide range of types of labor incurred in the process of using the respective practices (Table 19)

Table 19: Types of labor incurred by farmers in Kiambu ALL

Type of practice	Labor type incurred in Kiambu ALL
Agroforestry (n=2)	Land preparation, digging seedling planting holes, watering, protecting seedlings from damage by livestock.
Farmyard manure (n=10)	Collection of manure from the sheds, transportation, application to crops.
Compost (n=13)	Transporting raw materials such as manure and litter, collecting and gathering litter, crashing eggshells, preparing and mixing the materials, land preparation.
Crop rotation (n=4)	Land preparation, weeding.
Multistorey kitchen gardens (n=8)	Setting up the garden, weeding, watering, mulching.
Mulching (n=9)	Collecting mulch materials, transporting the materials, mulch application.
Plant-based biopesticides (n=16)	Searching for and gathering/ picking plant raw materials, e.g., leaves, processing the biopesticide, spraying.
Ash biopesticides (n=3)	None.
Terraces (n=2)	Digging the terraces.
Water harvesting (n=7)	Construction and installation of harvesting materials, fetching the water for irrigating the crops.
Water recycling (n=6)	Collecting the dirty water, collecting ash, the process of purifying water.
Biogas sludge (n=1)	Handling raw materials.
Intercropping (n=2)	Planting and weeding; nursery establishment and transporting seedlings for transplanting.
Drought-resistant crops (n=1)	Planting, weeding.
Earth dams (n=1)	Constructing dam well, fencing.

Type of practice	Labor type incurred in Kiambu ALL
Hugo culture (n=1)	None.
Sunken beds (n=1)	Digging the holes, looking for materials (manure, etc.).
Trenches (n=1)	Labor for annual silt removal and management.
Traps (n=1)	Setting up the traps.

The Makueni farmers named similar types of labor (Table 20).

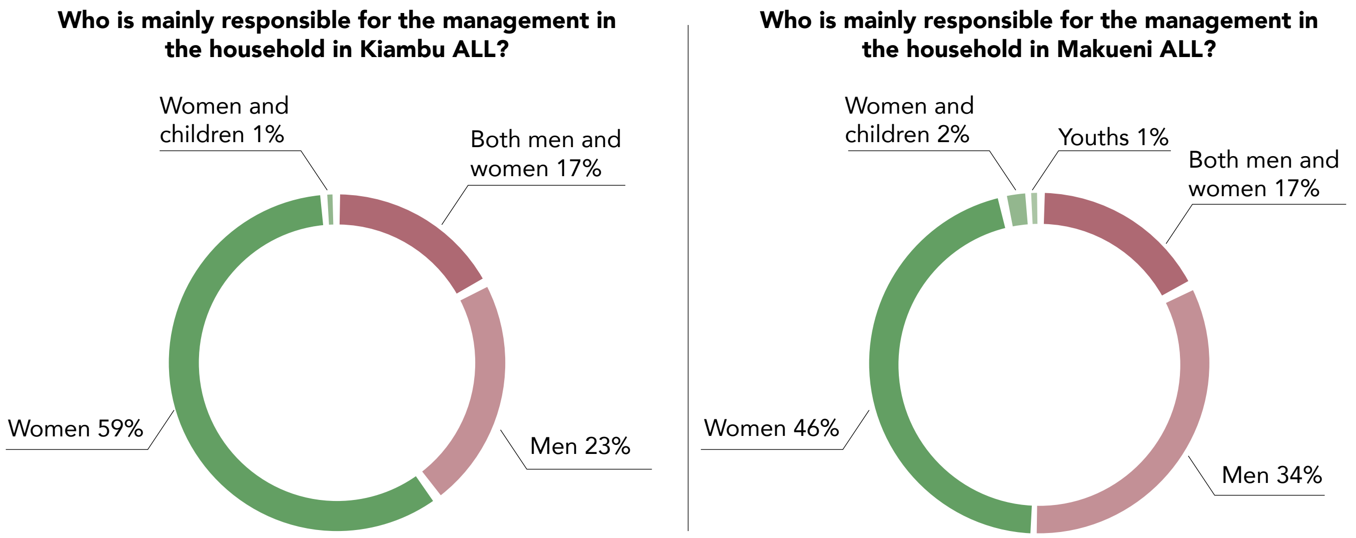
Table 20: Types of labor incurred by farmers in Makueni ALL

Type of practice	Labor type incurred in Makueni ALL
Agroforestry (n = 7)	Land preparation, digging holes, manure application, management (e.g., pruning, weeding, harvesting tree products).
Compost (n = 11)	Digging compost pit, collecting litter and composting materials, compost preparation, compost application in fields.
Crop rotation (n = 6)	Land preparation, planting/sowing crops, harvesting, manure application.
Earth dams (n = 2)	Digging dams.
Farmyard manure (n = 19)	Collection of manure from sheds, turning/processing the manure, transportation, application to crops, harvesting crops.
Water harvesting (n = 8)	Installing gutters, inlets, and outlets.
Intercropping (n = 2)	None.
Mulching (n = 3)	Collection of mulching materials, application of mulch.
Multistorey kitchen gardens (n = 1)	Constructing the gardens.
Plant-based biopesticides (n = 10)	Gathering the raw plant materials, preparing, applying pesticide to crops.
Terraces (n = 14)	Digging the terraces and scooping the soil, clearing land, maintaining the terraces.
Water recycling (n = 1)	None.
Zai pits (n = 4)	Digging the pits, applying manure, maintaining the pits regularly.

4.5.4 Who is mainly responsible for managing the practices in the household (men/women/youth, additional farm labor)?

In Kiambu ALL, 59% of the farmers indicated that women are mainly responsible for managing the practices in the household, while 23% and17% indicated men and both men and women as being mainly responsible for managing practices, respectively (Figure 30).

Figure 30: Who is mainly responsible for managing the practices?

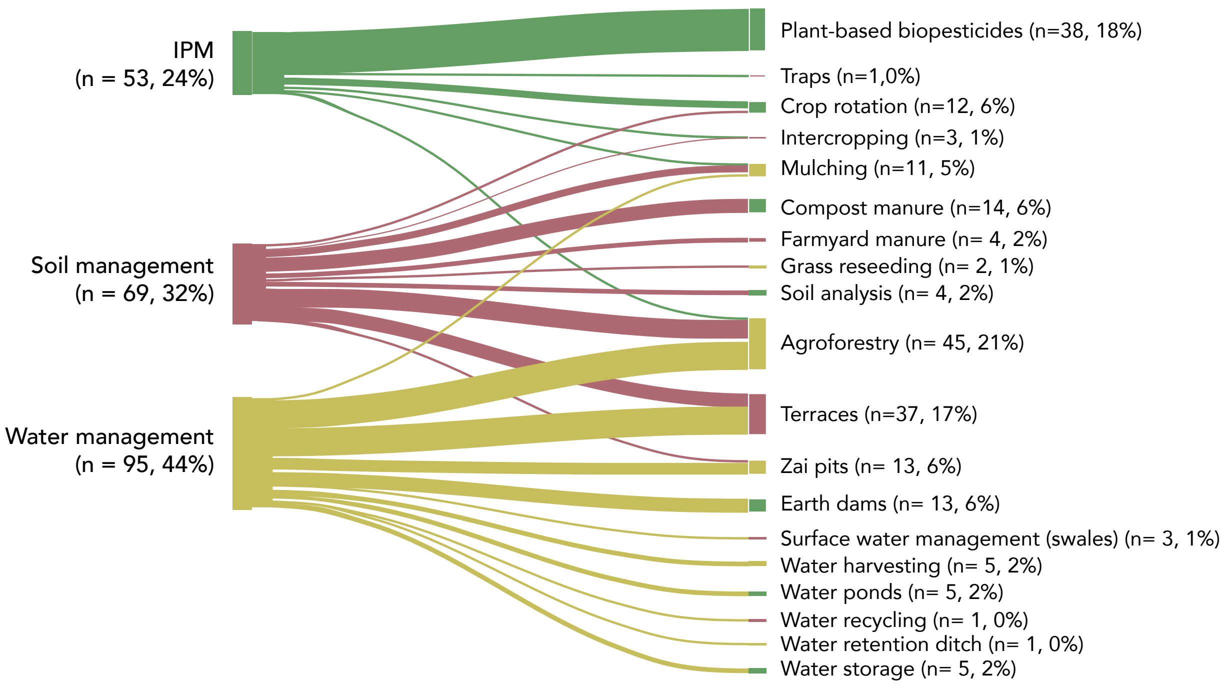


Chapter 5. Future aspirations: preferred practices under soil, water, and integrated pest management areas existing in Makueni and Kiambu ALLs

5.1. Multipurpose preferred practices in Makueni and Kiambu ALLs

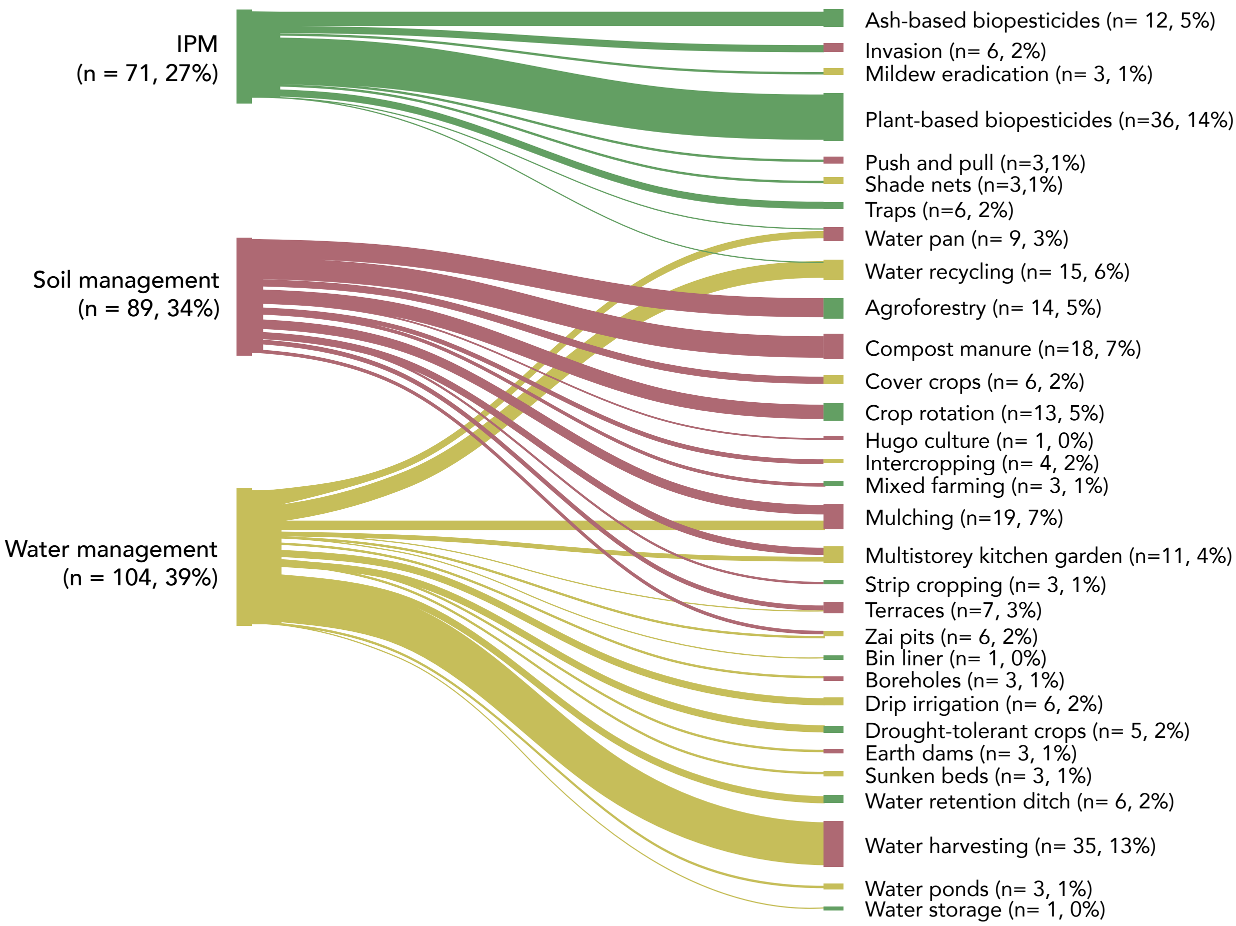
The assessment findings revealed management practices that exhibit multipurpose characteristics, capable of fulfilling various functions in water management, soil management, and IPM. In Makueni ALL, examples of such practices were agroforestry and mulching, which simultaneously addressed all three functions. Additionally, practices such as agroforestry, terraces, mulching, and zai pits fulfilled both soil and water management needs, whereas agroforestry, crop rotation, and intercropping served the purposes of soil management and IPM (Figure 31).

Figure 31: Preferred practices exhibiting multipurpose characteristics per area in Makueni ALL



In Kiambu ALL (Figure 32), the identified multipurpose practices that addressed multiple functions were terraces, mulching, multistorey gardens, and zai pits for soil and water management. Plant-based biopesticides were effective for both soil management and IPM, whereas water recycling contributed to water management and IPM. These findings emphasize the importance of implementing interventions in a coordinated manner and recognizing the complementary roles that these practices can play when implemented together.

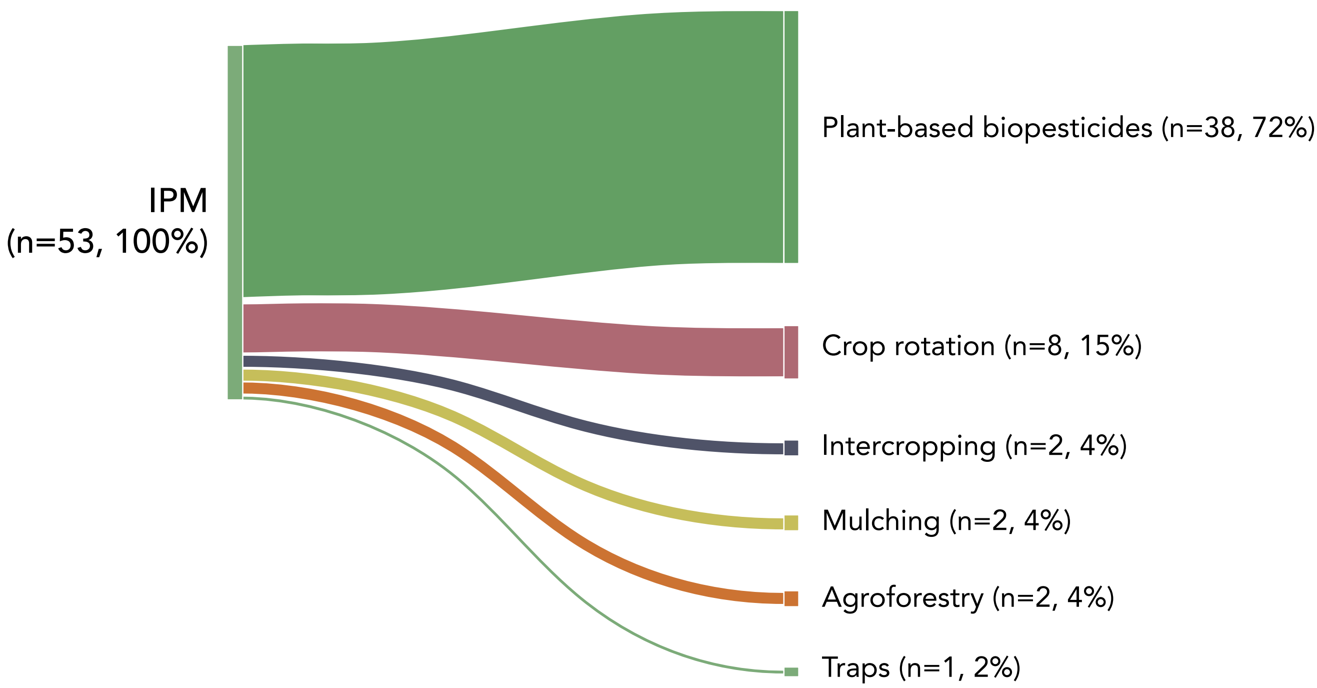
Figure 32: Preferred practices exhibiting multipurpose characteristics per area in Kiambu ALL



5.2. Preferred practices under the three areas in Makueni and Kiambu ALLs

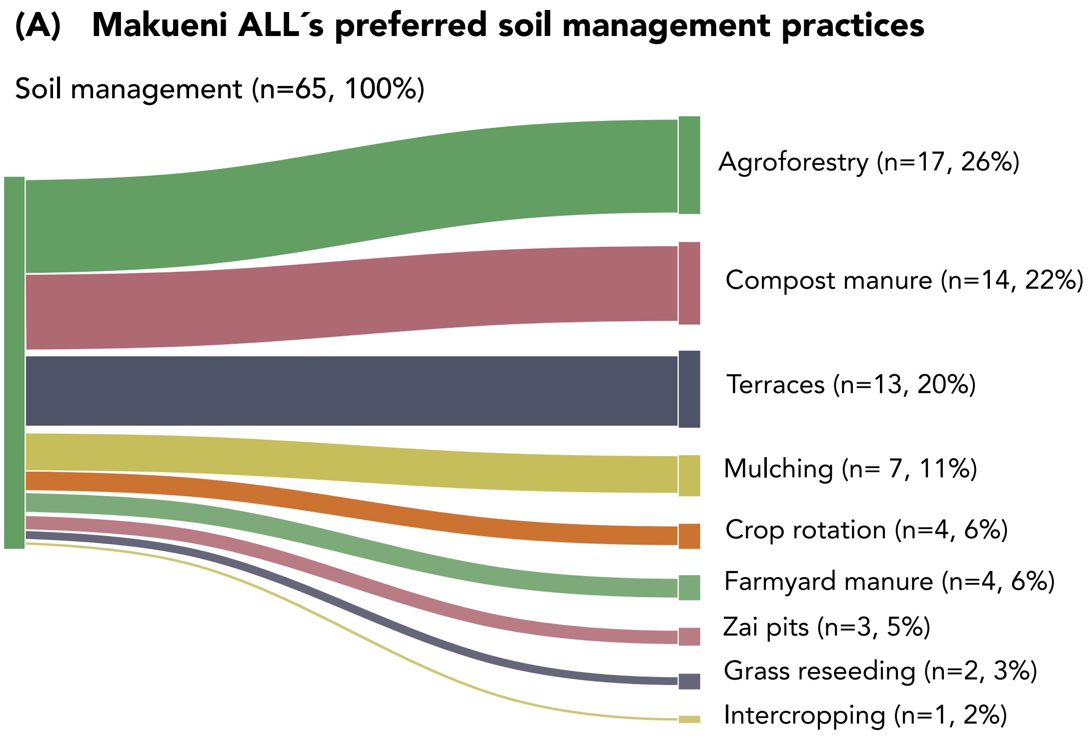
The respondents preferred six practices for IPM (Figure 33). The two most preferred practices were plant-based biopesticides and crop rotation. Other listed practices were intercropping, mulching, agroforestry, and traps for IPM.

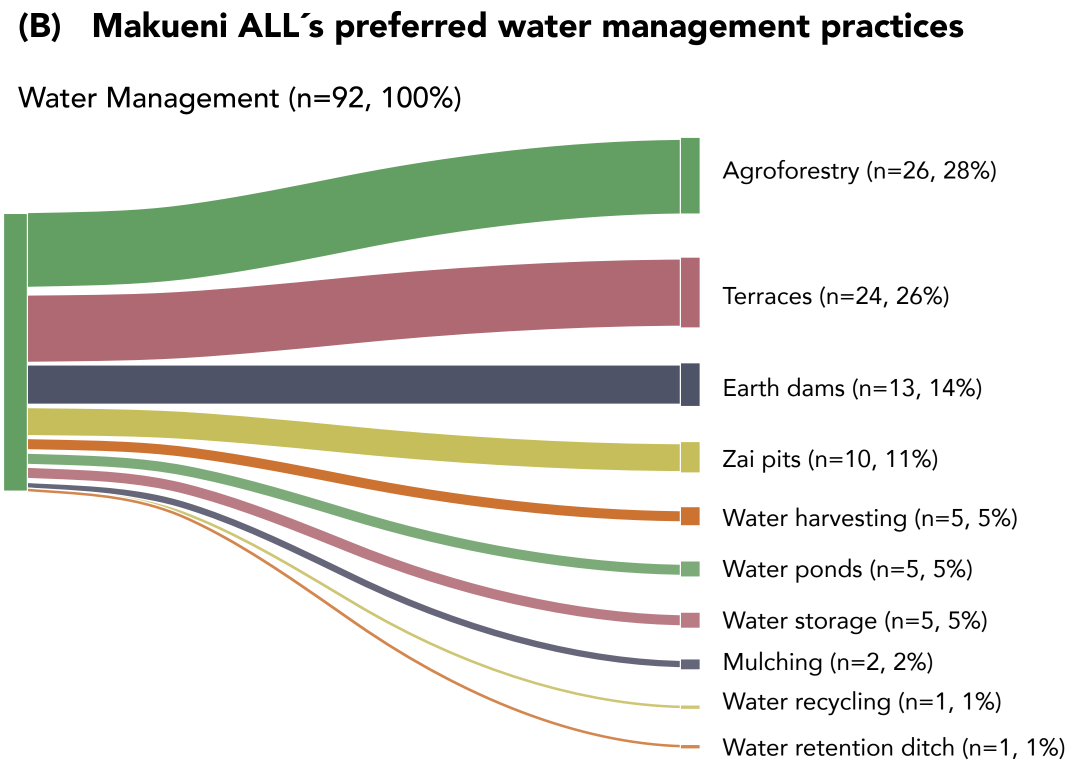
Figure 33: Preferred practices for IPM areas in Makueni ALL



In Makueni ALL, respondents preferred nine individual practices under the priority area of soil management (Figure 34A) and ten practices for water management (Figure 34B). The two most preferred practices in each priority area were agroforestry and compost manure for soil management and agroforestry and terraces for water management. Other listed practices were terraces, mulching, crop rotation, soil analysis, zai pits, and grass reseeding for soil management; and earth dams, zai pits, water harvesting, water ponds, water storage, recycling, mulching, and retention ditches for water management.

Figure 34: Preferred practices for soil and water management areas in Makueni ALL

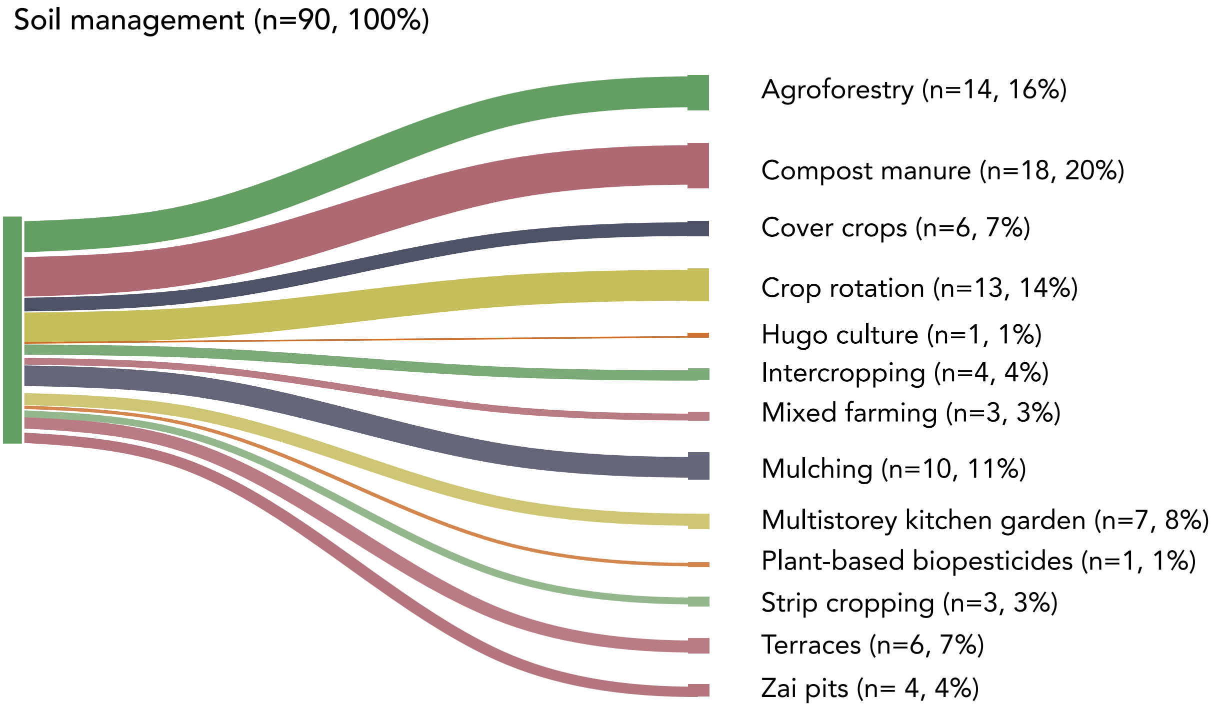




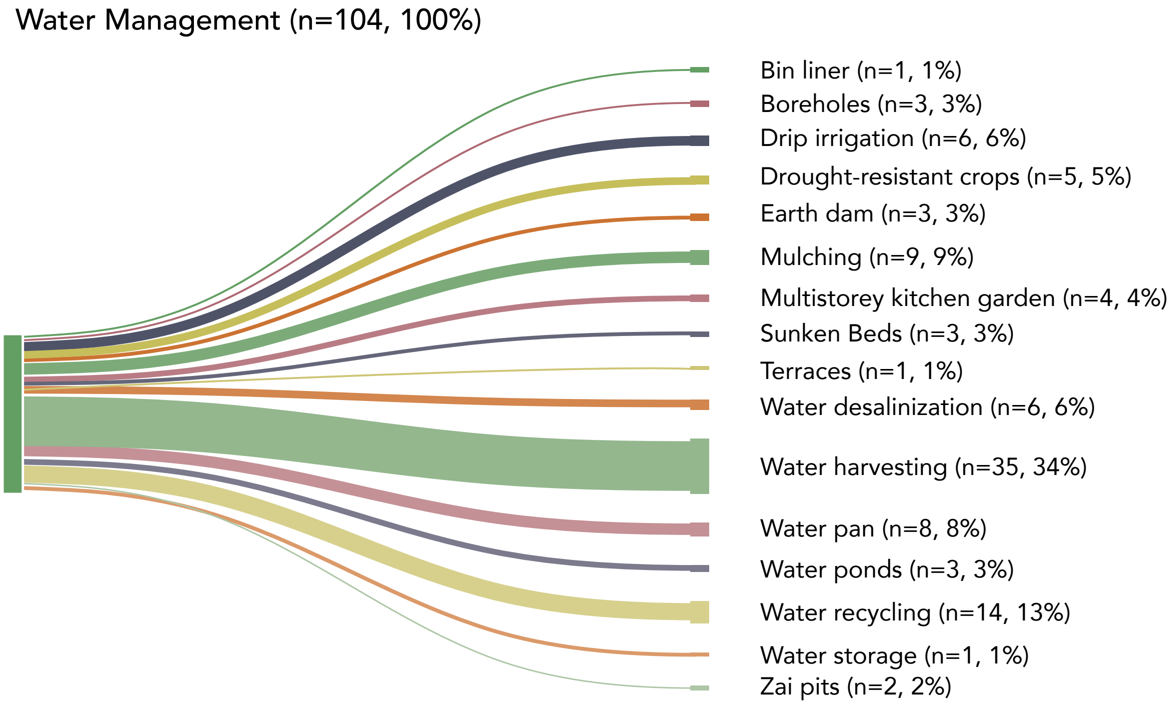
In Kiambu ALL, respondents listed 13 preferred practices for the priority area of soil management (Figure 35A) and 16 practices for water management (Figure 35B). The two most preferred practices in each priority area were compost and agroforestry for soil management (Figure 35A) and water harvesting and water recycling for water management (Figure 35B). The other important existing practices in Kiambu ALL were cover crops, crop rotation, hugo culture, intercropping, mixed farming, multistorey kitchen gardens, plant-based biopesticides, strip cropping, terracing, and the use of zai pits for soil management; and water storage structures such as boreholes, earth dams, water ponds, water pans, and zai pits, along with water harvesting, water recycling, mulching, and multistorey kitchen gardens for water management.

Figure 35. Preferred practices for IPM areas in Kiambu ALL

(A) Kiambu ALL´s preferred soil management practices

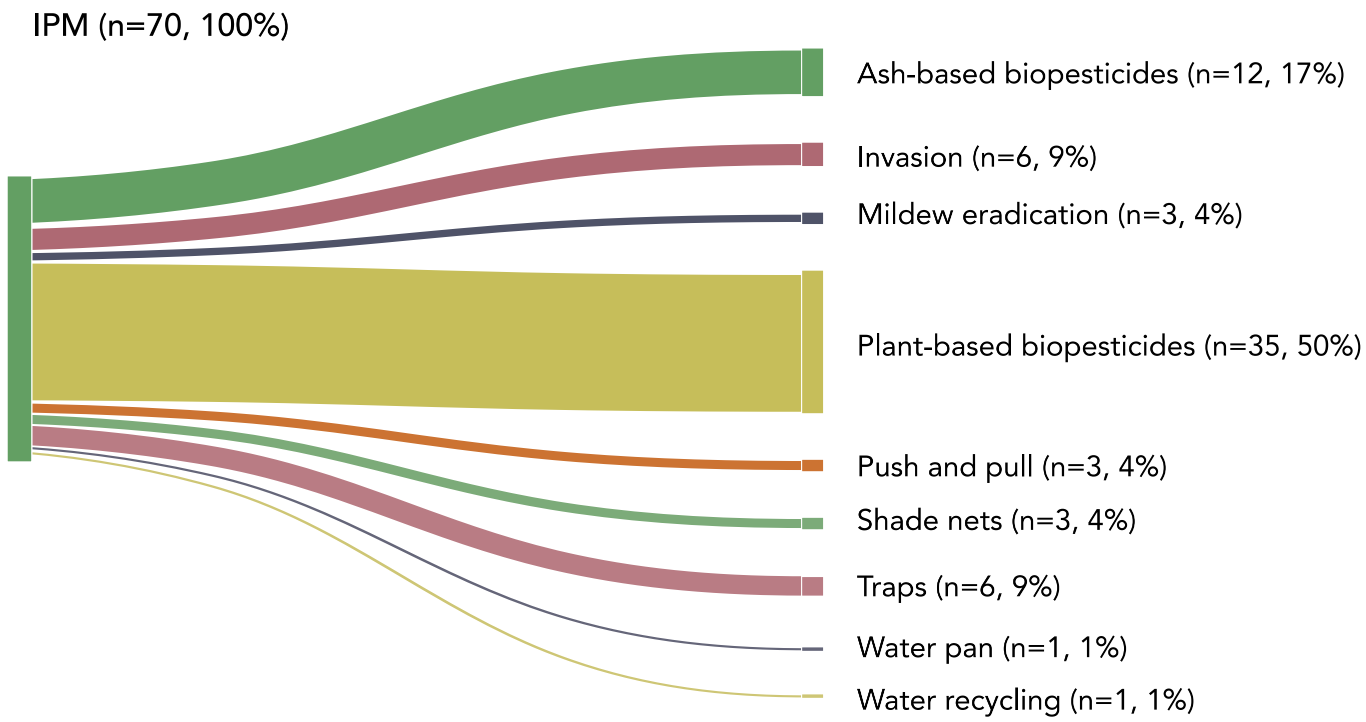


(B) Kiambu ALL´s preferred water management practices



The respondents in Kiambu ALL also listed nine practices for IPM (Figure 36). The two most preferred practices for IPM were plant-based and ash-based biopesticides (Figure 36). Other important IPM practices were push-pull technology, shade nets, and the use of traps.

Figure 36. Preferred practices for IPM areas in Kiambu ALL



Chapter 6. Institutional evaluation of inventoried soil, water, and integrated pest management practices implemented by CSHEP and DNRC host centers

6.1 Classification of existing practices in ALL host centers

Table 21 highlights all the soil management, water management, and IPM practices that are being implemented in CSHEP (Kiambu ALL) and DNRC (Makueni ALL) host centers. Soil management practices being implemented in the ALLs are classified under cultural methods and structural methods, whereas water management practices are classified into water harvesting, green water management (soil moisture/water management), and gray water management. IPM practices are classified into biological and cultural methods.

Table 21: Classification of all soil, water, and integrated pest management practices being implemented at DNRC in Makueni ALL

Soil management practices	Water management practices	Integrated pest management practices
DNRC		
Cultural methods Composting (vermicompost/vermiliquid); farmyard manure; intercropping (crop diversification); cover cropping (e.g., sweet potatoes, pumpkin); agroforestry (well-established tree nurseries); mulching; mixed cropping; green manures; crop rotation; alley cropping; companion planting; permaculture; use of legume crops; integration with deep- & shallow-rooted plants; manure application; afforestation of degraded lands; planting erosion-tolerant crops; vegetative strips; incorporation of organic matter/residues; selecting soil-conserving crops; awareness campaigns on soil management practices. **Structural methods** Collection and disposal of runoff; zai pits; implementation of runoff control measures; soil water conservation.	**Water harvesting** Rainwater harvesting and storage in tanks; use of rainwater for livestock; boreholes; water storage tanks; interception ditches **Green water management/soil moisture conservation strategies** Mulching; ditches/zai pits/sunken beds; erosion control technologies; reforestation and afforestation; awareness campaigns on water conservation; implementation of water-saving technologies **Gray water management** Wastewater recycling.	**Biological methods** Use of biopesticides (e.g., indigenous innovations) such as Sodom apple, concoctions (pepper, neem leaves, *Tithonia*, ash, etc.) to control pests; integrating livestock (e.g., poultry, cattle, etc.) into cropping systems to control pests; practices that encourage natural enemy populations. **Cultural methods** Pruning; mulching; crop rotation; mixed cropping systems; row covers; companion planting; planting pest- and disease-resistant crops; diversifying crops; properly disposing of plant debris; proper weeding; intercropping.

Soil management practices	Water management practices	Integrated pest management practices
CSHEP		
Cultural methods Manure application (compost; farmyard, poultry, and cattle manure; rabbit refuse; slurry); biofertilizer (bokashi, *Azolla*); organic matter application (prunings, leaves); seed saving; crop rotation, intercropping, short-duration fallows; mulching.	**Water harvesting** Rainwater harvesting and storage in tanks; water storage in tanks. **Green water management/soil moisture conservation strategies** Mulching; zai pits/sunken beds; raised beds; vertical gardens. **Gray water management** Wastewater recycling.	**Biological methods** Use of biopesticides (e.g., indigenous innovations) such as Mexican marigold, concoctions (pepper, neem leaves, Tithonia, banana soup), ash, rabbit urine, etc., to control pests. **Cultural methods** Intercropping; push-pull with onions. **Mechanical/physical methods** Use of shade nets to keep off pests and birds.

6.2 Assessment of inventoried soil management, water management, and IPM being implemented in CSHEP and DNRC

6.2.1 Practice focus area and the year the practice was first implemented

Several practices were implemented across the focus areas (water management, soil management, and IPM) at the two ALL host centers. At the DNRC center, five practices were identified under water management: surface water management, mulching, sunken beds, water recycling, and water harvesting. Under soil management, five practices were identified: compost, vermiculture, intercropping, agroforestry, and organic manure. In terms of IPM, the DNRC center identified hand picking, natural predators, biopesticides, mixed cropping, and pest-repellent crops (Table 22). These practices were applied to maize, beans, and vegetables. The three most common practices at CSHEP that were further analysed are multistorey gardens, bio-slurry, and rabbit urine for water management, soil management, and IPM focus areas, respectively (Table 22). These practices were applied to vegetables, tubers, beans, and maize. At the DNRC center, all the practices were first implemented in 2014 except for vermiculture, which was first implemented in 2017. At the CSHEP, multistorey gardens were first implemented in 2010, rabbit urine in 2013, and bio-slurry in 2022.

Table 22: Focus area of the practices inventoried at the DNRC and CSHEP ALL host centers

Focus area	Name of practice identified	
	DNRC	**CSHEP**
Water management	• Surface-water management (swales) • Mulching • Sunken beds • Water recycling • Water harvesting	Multistorey gardens
Soil management	• Compost • Vermiculture • Intercropping • Agroforestry • Organic manure	Bio-slurry
Integrated pest management	• Hand picking • Natural predators • Biopesticides • Mixed cropping • Pest-repellent crops	Rabbit urine

6.2.2 Local resources used for the practices

The local resources used for the practices ranged from green matter to gray matter, ash, water, manure, mulch, kitchen waste, pepper, neem, spades, jembes, and human labor at the DNRC center. At the CSHEP center, the local resources used were manure, rabbits, sacks, and dam liners.

Table 23: Local resources used for the practices at the DNRC and CSHEP host centers

Name of practice	Examples of local resources used
DNRC	
Compost	Green matter (leaves from trees), gray matter (dry laves for carbon), ash, water
Vermiculture	Manure, green matter/kitchen remains, water
Surface-water management (swales)	Spade, jembe
Hand picking	Human labor
Intercropping	Seeds, jembes, human labor
Natural predators	Land
Agroforestry	Seedlings, manure, mulching
Mulching	Green/dry matter
Organic manure	Manure, green matter (remains from kitchen), water
Biopesticides	Pepper, neem, *Tithonia*, Sodom apple, Mexican marigold, human labor
Mixed cropping	Crop seedlings
Pest-resistant crops	Crop seeds, manure, human labor
Sunken beds	Manure, jembe, human labor, spade, dry matter, wheelbarrow, water, green matter
Water recycling	Banana circles, irrigating kitchen garden
Water harvesting	None
CSHEP	
Bio-slurry	Manure
Rabbit urine	Rabbits
Multistorey gardens	Sacks, gardens, dam liners

6.2.3 Awareness of the scientific mechanisms

The evaluation of a practice also sought to identify whether the center was aware of the scientific mechanisms underlying the practices. In the DNRC center, out of the 10 practices that they responded to, they were aware of the scientific mechanisms of 9 of the 10 practices. At the CSHEP center, out of three practices, they were aware of the scientific mechanisms of only one. The scientific mechanism that the center is aware of is presented in Table 24.

Table 24: Awareness of scientific mechanisms for the inventoried practices

Name of practice	Aware	Aware of which scientific mechanisms?
DNRC		
Surface-water management (swales)	Yes	Measuring of contours to allow water to move slowly, use of spirit level.
Intercropping	Yes	Spacing.
Natural predators	No	
Agroforestry	Yes	Spacing, soil erosion control, water conservation, attraction of rain, cool breeze.
Mulching	Yes	Smothering of weeds.
Organic manure	Yes	Using earthworms to produce biofertilizer through decomposition.
Mixed cropping	Yes	Spacing of seedlings.
Pest-resistant crops	Yes	Spacing.
Sunken beds	Yes	Designing the sunken beds, applying mulch.
Water harvesting	Yes	Setting of gutters.
CSHEP		
Bio-slurry	No	
Rabbit urine	No	
Multistorey garden	Yes	It is able to hold water when planting and is very good for small-scale farmers.

6.2.4 Does the practice decrease/substitute the use of synthetic inputs?

At the DNRC center, 11 out of the 15 (73%) implemented practices were identified as having the ability to substitute or decrease the use of synthetic inputs, whereas, at the CSHEP center, all three implemented practices substituted/decreased the use of synthetic inputs. The details of the specific synthetic input substituted/decreased are shown in Table 25.

Table 25: Synthetic inputs substituted/decreased by the inventoried practices at DNRC and CSHEP centers

Name of practice	Substitute/decrease use of synthetic inputs?	Synthetic inputs substituted/decreased
DNRC		
Compost	Yes	Fertilizer.
Vermiculture	Yes	Synthetic topdressing fertilizer.
Surface-water management (swales)	No	N/A.
Hand picking	Yes	Inorganic pesticides, herbicides.
Intercropping	Yes	Seeds (commercial).
Natural predators	Yes	Insecticides, pesticides, herbicides.
Agroforestry	No	N/A.
Mulching	Yes	Fertilizer since it adds nutrients in the soil as they decompose.
Organic manure	Yes	Topdressing fertilizers.

Name of practice	Substitute/decrease use of synthetic inputs?	Synthetic inputs substituted/decreased
Biopesticides	Yes	Inorganic pesticides, fungicides.
Mixed cropping	Yes	Pesticides.
Pest-resistant crops	Yes	Inorganic pesticides and fungicides, purchasing of crop seeds.
Sunken beds	Yes	Vegetable purchasing, raised beds.
Water recycling	No	N/A.
Water harvesting	N/A	N/A.
CSHEP		
Bio-slurry	Yes	N/A.
Rabbit urine	Yes	Synthetic fertilizers and pesticides.
Multistorey gardens	Yes	Use of organic foliars and organic fertilizers

6.2.5 Interaction with other inputs

At the DNRC center, out of the practices identified, eight were reported to be interacting with other inputs while six were not, whereas, at the CSHEP center, of the three identified practices, one was reported to be interacting with other inputs. For the treatment interacting with other inputs, the details of the interaction appear in Table 26.

Table 26: Inputs/treatments interacting at the DNRC and CSHEP centers

Name of practice	Inputs/treatments interacting
DNRC	
Agroforestry	Manure (FYM and compost)
Mulching	Grass
Organic manure	Water
Biopesticides	Bar soap
Mixed cropping	Mulch, manure
Pest-resistant crops	Manure
Sunken beds	Manure, organic matter, water
Water recycling	Mulching, manure
CSHEP	
Rabbit urine	Mexican marigold and *Tithonia*

6.2.6 Financial cost and labor

At the DNRC center, six of the implemented practices entailed a financial cost, whereas nine practices did not. For the CSHEP center, two of the three practices implemented had a financial cost. The cost ranged from low (agroforestry, organic manure, biopesticide, and pest-resistant crops) to moderate (water harvesting) at the DNRC center (Table 27). At the CSHEP center, the cost for the bio-slurry and multistorey gardens was high. The details of the costs incurred for each of the practices are highlighted in Table 27.

Table 27: Financial costs incurred by the practices

Name of practice	Entail financial costs?	Level of costs	What costs are incurred?
DNRC			
Compost	No		
Vermiculture	Yes	Depending on the materials used	
Surface-water management (swales)	No		
Hand picking	No		
Intercropping	No		
Natural predators	No		
Agroforestry	Yes	Low	Hole preparation, seed propagation, planting.
Mulching	No		
Organic manure	Yes	Low	
Biopesticides	Yes	Low	Purchasing bar soap.
Mixed cropping	No		
Pest-resistant crops	Yes	Low	Land preparation, planting, weeding (uprooting).
Sunken beds	No		
Water recycling	No		
Water harvesting	Yes	Moderate	Purchasing of gutters, installation of rain-harvesting tank.
CSHEP			
Bio-slurry	Yes	High	Buying biogas digester, sourcing for manure.
Rabbit urine	No	N/A	N/A.
Multistorey gardens	Yes	High	Sourcing good-quality materials and bolts, labor to make gardens, and transportation.

At the CSHEP center, two of the three practices implemented are labor intensive (bio-slurry and multistorey gardens), whereas rabbit urine is not labor intensive (Table 28). At the DNRC center, seven of the implemented practices are labor intensive, including pest hand picking, mulching, biopesticides, sunken beds, and water harvesting, whereas eight of the practices are not labor intensive. The labor type for each practice is highlighted in Table 28.

Table 28: Labor intensity and type

Name of practice	Labor intensive?	Labor type
DNRC		
Compost	No	
Vermiculture	No	
Surface-water management (swales)	No	Digging and scooping of the soil, measuring the contours.
Hand picking	Yes	Removal of pests per crop manually.
Intercropping	Yes	Ploughing, planting/sowing, weeding.
Natural predators	No	
Agroforestry	No	Hole preparation, planting.
Mulching	Yes	Application of mulch.
Organic manure	No	
Biopesticides	Yes/no depending on the area to be applied	Collection of materials, preparation of concoction, application to plants.
Mixed cropping	No	
Pest-resistant crops	Yes	Ploughing, planting, sometimes application of manure, harvesting.
Sunken beds	Yes	Digging beds, applying different layers of materials, transplanting seedlings, watering.
Water recycling		
Water harvesting	Yes	Installing and fixing gutters.
CSHEP		
Bio-slurry	Yes	Casual labor to mix manure and water into the biogas digester.
Rabbit urine	N/A	N/A.
Multistorey gardens	Yes	Casual labor to prepare the gardens.

6.2.7 Contextual factors, strengths, and challenges of the practices

The contextual factors of influence in the implemented practices for the DNRC center are shown in Table 29, which include surface runoff for surface-water management, hand picking for the pest population, conducive environment and food for predators informing the use of natural predators, and availability of dry matter for mulching. For the CSHEP center, the contextual factors include manure availability for the bio-slurry, rabbits on the farm for rabbit urine, and water availability for the multistorey gardens (Table 30).

At the DNRC center, the sunken beds and agroforestry had a high strength score vis-à-vis the other practices. At the CSHEP center, the multistorey gardens and rabbit urine had a higher strength score than the bio-slurry.

The strengths for the implemented practices were the locally available materials, not being labor intensive, eco-friendly, high yield, cheap, pest and disease control, and conserving soil moisture.

The challenges identified for the implementation of the practices included labor-intensive activity, time-consuming, low/insufficient rainfall, small land space, competition for nutrients, among others, at the DNRC (Table 29); and were access to water to mix manure, access to quality materials, and labor intensity for initial setup for the multistorey gardens at the CSHEP (Table 30).

Table 29: Contextual factors, strengths, and challenges of DNRC practices

Name of practice	Contextual factors of influence on practice	Practice strengths	Practice challenges/ weaknesses
Compost	No	• It is not labor intensive • Materials are locally available • No chemical residues for the soil	No major challenge
Vermiculture	No	• Not labor intensive • Uses locally available materials • Easy to handle and manage	
Surface-water management (swales)	Surface runoff	• Controls the speed of surface runoff • Decreases soil erosion • Increases soil conservation	
Hand picking	Pest population	• Decreases pest spread and population • Eco-friendly	• Labor intensive • Time consuming
Intercropping		• High yield • Better land use • Pest and disease control	Stunted growth for some crops
Natural predators	Conducive environment for predators and plenty of food	• Eco-friendly • Cheap • Not labor intensive	Some can become pests to some crops (e.g., birds)
Agroforestry	• Rainfall • Maintenance practices	• Provides shade and organic matter • Cool breeze • Firewood • Animal feeds	• Competition for nutrients and water with other crops • Low rainfall
Mulching	Availability of dry matter	• Smothers weeds • Provides nutrients to the soil • Conserves soil moisture	
Organic manure	Water	• Uses locally available materials • Environmentally friendly • Cost effective • Not labor intensive	
Biopesticides	Availability of materials used to prepare concoctions	• Cost effective • Uses locally available materials • Environmentally friendly	Not suitable for controlling massive pest attack
Mixed cropping	Availability of diverse seedlings	• High yield • Controls and prevents excessive pest attack • Maximum use of soil nutrients	

Name of practice	Contextual factors of influence on practice	Practice strengths	Practice challenges/ weaknesses
Pest-resistant crops	Low rainfall leading to low yield	• Eco-friendly • High yield • Cheap	• Insufficient rainfall • Land space
Sunken beds	• Water • Topography • Tilth of soil	• Conserve soil moisture • High yield in small piece of land • Minimal farm practices (e.g., weeding)	Labor intensive
Water recycling		• Cost-effective • Uses locally available materials • Environmentally friendly	Withering of some crops
Water harvesting	Rainfall availability	• Provides for domestic use during dry season • Water irrigation for land during dry season	• Water for livestock • Insufficient rainfall

Table 30: Contextual factors, strengths, and challenges/weaknesses of CSHEP practices

Name of practice	Contextual factors	Practice strengths	Practice challenges/ weaknesses
Bio-slurry	Depends on manure availability. If you do not have biogas. If no adequate manure is available, the practice is not effective for obtaining good-quality bio-slurry.	It is productive for the crops.	• Access to water to mix the manure • Access to biogas bag (i.e., bags can be expensive)
Rabbit urine	Readily available on the farm because we have rabbits.	• It is non-pollutant • Affordable • Beneficial as a pesticide and foliar	N/A
Multistorey gardens	Availability of water to ensure that the crops have enough water for growth	• Easy to install and manage • Are long-lasting and can be used for more than 10 years • Are easy for applying organic inputs	• Access to good-quality materials • Are labor intensive before setup

6.2.8 Improved practices of interest for the host centers

For the improved practices of interest under soil management, the CSHEP center was interested in soil testing and soil conservation, whereas, at the DNRC center, the interest was in vermiculture, composting, biochar, etc. For water management, the CSHEP center was interested in soil water conservation techniques, whereas the DNRC center's interests ranged from sunken beds and rainwater harvesting to early-maturing crops. In terms of IPM, the practice of interest at CSHEP was the concentration level of biopesticides, whereas at DNRC it ranged from biopesticides and resistant crops to the use of natural enemies to manage pests (Table 31).

Table 31: Improved practices of interest under soil management, water management, and IPM

Improved practices of interest	CSHEP	DNRC
Soil management	Soil testing, soil conservation.	Vermiculture, composting, biochar (biofertilizers), agroforestry, afforestation, intercropping.
Water management	Soil water conservation techniques in semi-arid areas.	Sunken beds, rainwater harvesting, wastewater recycling, mulching, planting of early-maturing crops.
Integrated pest management	Teach farmers about the concentration levels of the IPM practices and why those are the best to use.	Biopesticides, hand picking, diversity, pests and diseases, resistant crops, encouraging natural enemy population predators.

Chapter 7: Summary and conclusions

7.1 Summary observations about options, context, and preferences

This joint assessment survey was conducted in February 2023 and aimed at identifying and evaluating existing practices under three focus areas, soil management, water management, and integrated pest management, in Kiambu and Makueni agroecological living landscapes (ALLs), and assessing farmers' preferred practices. A total of 80 farmers (40 from each ALL) were interviewed. To arrive at a representative sample of the population's context, stratified random sampling was carried out using a multi-stage approach using the following five key factors: program and non-program farmers, geography (villages), gender, age, and land size.

Socioeconomic farm and household characterization

The results indicate that respondents' average age was 56 ± 15 years in Kiambu and 56 ± 13 years in Makueni, with a majority of the respondents in both ALLs being females, comprising 78% in Makueni and 72% in Kiambu. At least 50% of the respondents from both ALLs had acquired a secondary school education. The average farm size was 1.73 ha. in Makueni ALL and 0.84 ha in Kiambu ALL. Overall, respondents across the two ALLs perceived their soils as being of medium quality (i.e., 51 respondents; 65%), and these constituted 51% of the respondents in Makueni ALL and 78% in Kiambu ALL. The most commonly used soil-based indicators across the ALLs by farmers to classify soil quality were soil color, texture, and soil organic matter, whereas the main crop-based indicators of soil quality were crop yield, crop vigor, and indicator plants. In both the Makueni ALL and Kiambu ALL, all farmers interviewed reported experiencing climate changes and a yield decrease for their main crops over the past 5–10 years. The two most common climate-related changes identified by the respondents in Kiambu and Makueni ALLs, respectively, were drought/low rainfall (68% and 62%) and poor yield (38% and 35%).

Existing practices (options)

Joint assessment of the options revealed that a total of 16 soil management practices were observed in both ALLs, with 16 distinct practices encountered in Kiambu and 9 in Makueni. Soil management practices most commonly implemented in Kiambu were compost manure (63% of farms), farmyard manure (60%), and crop rotation (33%); whereas, in Makueni, they were farmyard manure (63%), compost manure (43%), and agroforestry (40%). Likewise, a total of 16 water management practices were observed in both ALLs, with 13 distinct practices encountered in Kiambu and 10 in Makueni. The most commonly encountered water management practices in Kiambu ALL were mulching (35% of farms), multistorey kitchen gardens (30%), and water recycling (30%); whereas, in Makueni, they were water harvesting/storage tanks (35%), terraces (33%), and zai pits (18%). A total of eight IPM practices were observed in both ALLs, with eight distinct practices encountered in Kiambu and three in Makueni. Dominant IPM practices in Kiambu were plant-based biopesticides (88% of farms), repellent crops (25%), and crop rotation (15%); whereas, in Makueni, they were plant-based biopesticides (38%), repellent crops (3%), and intercropping (3%). Therefore, this demonstrates that there are numerous options for soil management, water management, and IPM to choose from, which can, through innovations, be either improved or adapted to improve their performance. This will also guide the identification of gaps in terms of whether there are other potential practices that are not found locally in the ALLs, but that could be introduced, based on what scientists and other stakeholders have successfully tested and introduced elsewhere in a similar context.

Performance and evaluation (context)

Evaluation of the above options revealed varying and heterogeneous context between the Kiambu and Makueni ALLs. For example, different host crops were associated with various practices and diverse locally available materials were present. Further, knowledge gaps were identified with regard to the scientific mechanisms of the practices, although a majority of the farmers reported not collecting data regarding the practices. Further, the farmers reported various context-specific challenges. In Kiambu ALL, the farmers identified 18 strengths associated with the practices, with the key benefits being increased crop yield, raw materials being locally available, pest control, and improved soil health/fertility. Likewise, in Makueni ALL, the farmers identified 19 strengths associated with the practices, with the key strengths being increased yield, soil erosion control, water conservation, and soil fertility. On the other hand, Kiambu farmers identified 11 challenges, with the key ones being water shortage/drought, temperature effects, and labor-intensive practices. Makueni farmers identified 11 challenges, with the key ones being water shortage/drought, costly practices, and labor-intensive practices. The farmers identified four main costs, with the main one being the purchase of raw materials, followed by the cost of initial labor during installation, labor during maintenance, and finally transportation cost. The farmers also expressed concern about the responsibility for managing the practices. The heterogeneity in context calls for the co-design of innovations that are locally relevant and appropriate and that address local challenges.

Future aspirations (preferences)

The results from the preferred practices revealed that farmers view their farms from a systems point of view and prefer practices that serve multiple and complementary functions on their farms; hence, their future aspirations involve practices that are capable of fulfilling various functions in water management, soil management, and IPM simultaneously. The farmers expressed a preference for a total of 31 practices, with 77% of these being suited for each of the three areas (soil management, water management, or IPM), while 33% exhibited multipurpose characteristics and thus are capable of fulfilling multiple functions in at least two of the three areas simultaneously, such as soil and water management (terraces, mulching, multistorey gardens, and zai pits); soil and IPM (plant-based biopesticides); and water management and IPM (water recycling, water pans). The eight most preferred practices in Kiambu across the three areas were plant-based biopesticides, water harvesting, compost manure, agroforestry, mulching, crop rotation, water recycling, and water pans. In Makueni ALL, the eight most preferred practices across the three areas were plant-based biopesticides, agroforestry, terraces, zai pits, compost manure, earth dams, mulching, and crop rotation. These findings demonstrate that farmers in both Kiambu and Makueni ALLs, which are characterized by varying biophysical and socioeconomic contexts, prefer to have diverse options for soil, water, and integrated pest management that will meet their livelihood needs. The findings further emphasize the importance of implementing interventions in a coordinated manner and recognizing the complementary roles that these practices can play when implemented together.

The findings from this study will play a key role in the co-design workshops during which farmers jointly with Agroecology Initiative researchers, technical experts from government and other stakeholders, will prioritize one option per focus area, whose characteristics and performance will be investigated further through monitored trials in the ALL host centres and on farmers' fields.

7.2 Additional ecological benefits of the most preferred practices across the two ALLs and their potential contributions to the principles of agroecology

The assessment clearly evidenced that the use of organic manure (FYM and compost), terraces, and biopesticides emerged as the most preferred in soil, water, and integrated pest management across the two ALLs (Makueni and Kiambu). Besides the strengths and benefits mentioned by the respondents, some additional ecological roles for ecosystem stabilization and possible contributions to the different principles of agroecology can be highlighted.

7.2.1 Organic manure (farmyard manure and compost)

The addition of organic inputs (FYM and compost), for example, can enhance soil structure and improve soil water-holding and nutrient retention capacities, along with providing additional nutrients necessary for plant growth. The enhancement of soil structure allows better water infiltration in the soil as well as promoting good air circulation, hence improving soil health. These organic inputs are also drivers for soil biodiversity and could enhance soil health by promoting the growth and diversity of beneficial soil microorganisms that could promote nutrient cycling and disease/pathogen suppression, and hence improve crop production. On the other hand, the use of organic inputs promotes carbon reallocation into the soil, and this can further contribute to carbon sequestration, hence minimizing greenhouse gas emissions.

Figure 37: Pictures of contributions and preparation of organic manure in the Kenyan ALLs

Credit: Bioversity International and CIAT.

Already, the use of organic manure contributes to several principles of agroecology involving input reduction, recycling, biodiversity, co-creation and sharing of knowledge, soil health, and promotion of synergy, among others. For instance, relating to soil health, diversity, recycling, and input reduction, organic manure provides nutrients (minimizing the purchase of synthetic nutrients) and creates enabling soil conditions (microclimate) that promote the build-up of beneficial soil biodiversity. The use of organic inputs also draws from traditional and local knowledge and techniques, and this strongly aligns with the principle of co-creation and sharing of knowledge. The use of organic manure also promotes the recycling and re-use of organic wastes. The nutrients liberated by the organic inputs promote robust growth of crops and plants consumed by human beings and livestock, which further produce manure returned to the soil, hence underscoring the principle of synergy. Besides, in some instances, the organic manure can be sold, thus generating income and boosting livelihood, and hence potentially contributing to the principle of economic diversification.

7.2.2 Terracing

Terracing can provide benefits involving control of soil erosion, promotion of biodiversity, and improvement of crop production, among others. Terraces can effectively intercept and retain flowing water (thus increasing moisture availability for plant growth) and minimize further degradation by decreasing top-soil erosion and nutrient losses. In addition, terraces can support increased biodiversity (i.e., both flora and fauna) by promoting growth of several plants and providing additional habitat niches for beneficial insects involving pollinators, hence potentially contributing to the principle of biodiversity. By conserving soil from erosion and water and nutrient losses, terraces potentially contribute to the principle of soil health.

Figure 38: Terraces in the Kenyan ALLs

Credit: Bioversity International and CIAT.

7.2.3 Plant-based biopesticides

Plant-based biopesticides are generally less harmful to the environment than chemical pesticides, and their prolonged usage has the potential to increase the production of healthy crops with high yields and product nutritional quality. In addition, the use of plant-based biopesticides can both substitute the costly synthetic pesticides and decrease toxicity to non-target organisms (both above- and belowground). This indicates the potential of plant-based biopesticides contributing to the principles of input reduction, biodiversity, soil health, and animal health (i.e., through the consumption of healthy food). In addition, the preparation of the concoctions used in these biopesticides entails lots of co-creation and sharing of knowledge on the right plants (herbs) and preparation procedures, among others. Furthermore, some of these plant-based biopesticides can also be sold, thus generating income for farmers and hence contributing to the principle of economic diversification.

Figure 39: Pictures of terraces in the Kenyan ALLs

Credit: Bioversity International and CIAT.

7.3 Potential value propositions for the most preferred agroecological practices

7.3.1 Possible value propositions for organic manure (farmyard or compost manure)

During the assessment, the farmers across the two ALLs (and from the two ALL host centers) expressed interest in knowing the nutritional quality of their soils, and sometimes the organic inputs they use. Thus, soil or input quality testing could be a viable value proposition. Besides, another value proposition that might be explored could entail supporting the farmers to process the organic manure, package it as compost fertilizer (in different quantities and with proper labels), and sell it to different markets. If possible, the Agroecology Initiative could support the farmers in obtaining organic certification for their products arising from the use of organic manure. Moreover, the farmers can be supported conducting training programs and awareness campaigns on the benefits of using organic manure, thus imparting the farmers with the requisite knowledge.

7.3.2 Possible value propositions for terraces

For terraces, the farmers can be supported with periodic training and awareness campaigns. In addition, the Agroecology Initiative can encourage the farmers to plant different cover crops and forage/fodder along the terraces to further prevent soil erosion. Such forages/fodder can later be sold, thus generating income for the farmers.

7.3.3 Possible value propositions for plant-based biopesticides

In Kiambu ALL, some of the respondents (and the ALL center) mentioned their interest to know the chemical composition of the concoctions they prepare and use as biopesticides. Akin to this, the Agroecology Initiative could support the farmers by providing comprehensive training programs touching on production, formulation, and appropriate application of biopesticides. The Initiative can also support them by soliciting policy protection considerations on their formulated biopesticide products (i.e., patenting). Moreover, the farmers could be helped to market their biopesticide products and the crop produce grown using the biopesticides. This can be achieved by establishing connections with organic food producers, retailers, processors, or exporters (i.e., basically all the actors in this value chain). If this was taken forward, it would be important to give the farmers support on the regulatory compliance requirements regarding biopesticides.

List of farmers who were interviewed

MAKUENI		KIAMBU	
1.	Angeline	1.	Alice Njeri
2.	Ann Sammy	2.	Anne Wanjiru Mungai
3.	Anna Gideon	3.	Ashford Mungai Njoroge
4.	Anne Ngei	4.	Charles Njoroge
5.	Benedict Mwania	5.	Christine Nungari Ndiki
6.	Beth Mutinda (Kitandini)	6.	Daniel Kinuthia
7.	Christine Kyalo	7.	David Njoroge Kimani
8.	Cosmas Mwema	8.	Esther Wangari
9.	Daniel Nzioka	9.	Faith Njeri Ndungu
10.	Elizabeth Nduku	10.	Geoffrey Karanja Gatonye
11.	Esther Muli	11.	Gladys Nyambura
12.	Eunice	12.	Hannah Gikuyu Maina
13.	Everlyne Mueni	13.	Jane Njoki Ngige
14.	Felista Mongeli	14.	Jane Nyambura Rugu
15.	Felister Mbithi	15.	Jane Wairimu Kagai
16.	Florence Mbithi	16.	Jane Wairimu Kioi
17.	Francis Muteti	17.	Jane Wambugu Karanja
18.	Janet Ngotho	18.	Jeremia Muturi
19.	Jonathan Kitemei	19.	Joyce Njuhi
20.	Josephine Kyalo	20.	Julia W. Waiyaki
21.	Kasyoka Kiema	21.	Karanja Ngure
22.	Kaviku Musili	22.	Leah Wairimu Mbugua
23.	Mueni Marieta	23.	Lucia Wanjiru
24.	Mutinda Mbathe	24.	Magret King'ära
25.	Ndiliko Mutula	25.	Margaret Wairimu
26.	Patricia Kiringu	26.	Mary Muhichu
27.	Patricia Matha	27.	Mary Mumbi Kimani
28.	Patricia Mukongo Munyola	28.	Mary Njeri Ngugi
29.	Patricia Mutheka	29.	Mary Njoki Karanja
30.	Petronilla Mueni Mukula	30.	Mary Wambui
31.	Phillip Kiitu Mwendo	31.	Mary Wangeshi
32.	Phoebe Peter	32.	Mathew Kamau
33.	Phylis Wambua	33.	Monica Kunaiu
34.	Rhoda	34.	Monica Nduta Njuguna
35.	Ronald Mutinda	35.	Nancy Njeri Ngugi
36.	Rose Nduku Nditho	36.	Peninah Waithera Ndegwa
37.	Sabeth Nundu Maingi	37.	Peter Karegi
38.	Sarah Ngumbi Kaluve	38.	Peter Ngugi Kimani
39.	Scolar Mueni	39.	Peter Wainaina
40.	Stella Mbithe	40.	Susan Nduta

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