Planting and farmers' perception on environmental impacts of Moringa stenopetala Tree in Offa Woreda, Southern Ethiopia

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Research Article

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Abstract

Moringa stenopetala has increased a great consideration currently in Ethiopia due to its multiple uses. The study was accompanied in Offa district of Southern Ethiopia through the objective of evaluating planting and farmer's perception of Moringa stenopetala tree on the environmental impacts. In order to attain these objectives, three potential sites were purposively selected due to the availability and distribution of M.stenopetala tree on the farmstead. Data collected from 116 respondents across wealth categories. The data obtained via these techniques were analyzed by using descriptive statistics, chi-square and one way ANOVA. The results revealed that majority (48%) of respondents initially planted M.stenopetala to consume its leaves as household food. The Chi-square test showed that there is no difference in reason for initial planting of M.stenopetala among wealth categories. However, the results revealed that there is difference in reason for primary planting among different age categories. Accordingly, households those in age group >61 (50%) planted it to protect fields on the farm land. Most farmers experienced positive environmental impacts from M.stenopetala, but few farmers had negative experiences which is the tree harbours birds which destroy other crops and it usually is associated with expansion of Monsonia angustifolia weed. However, therefore, it could be concluded that there is a great scope to improve the planting of M.stenopetala with suitable M.stenopetala approaches for maximizing income of the farmers.

Introduction

Ethiopia is one of unindustrialized country which is majority of people are involved in cultivation of food crops and livestock which are produced for sustenance, however; particularly important as human food because the leaves, which have high nutritional value (Abuye et al., 2003). The country's ever increasing population along with recurrent drought and poor agricultural practices with low productivity has pulled the country into a vicious circle of food insecurity. On the other hand, planting trees is currently seen as an alternative livelihood strategy, particularly in drier areas of the country (Pender, 2006). The link between tree planting or tree resources and rural livelihoods, through the consumption of timber, fuelwood, fodder, and fruits directly satisfy household needs (Nibbering, 1999).

In Southern part of Ethiopia, agrarians use M. stenopetala (Moringa) as one of the major arable tree inter-crop in their agricultural systems, particularly in Konso, Derashe and Gamogofa areas (Dechassa *et al*., 2006; Eyassu, 2014). In these areas, Moringa is cultivated mainly for its edible leaves, pods and flowers, and also used as animal fodder, human and animal medicine, shade and for local income generation (Abera et. al, 2011). Apart from being consumed as a vegetable, *M. stenopetala* is also marketed as a source of income in a local market in the Konso (Endeshaw, 2003) and daily used as cash income for rural household in Offa areas of southern Ethiopia (Tagay and Yemiru, 2021).

M. stenopetala was domesticated in the east African lowlands and is indigenous to southern Ethiopia. It is often called "cabbage tree" and is an important indigenous vegetable in south western Ethiopia where it is cultivated as a food crop (Abuye et al., 2003). The southern parts of Ethiopia and Northern Kenya are

believed to be the origin and place of endemism and diversity to the species (Lalas et al. 2003; Pasternak et al. 2009). The Gofa, Konso, Burji, Dherashe, Debub Omo and Gamo communities consume its leaves as a vegetable, especially during the dry season (Aynalem, 2008; Edwards et al., 2000). In marginal dry parts of Ethiopia *M. stenopetala* tree is found intercropped with agricultural crops by the Konso people and as on farm tree (homegarden) that supports nearly high population density in South Ethiopia. Moringa trees are multi-purpose trees of economic importance with several industrial and feeding values. Moringa is a versatile tree of a great economic importance, as it has vital nutritional, industrial, and medicinal applications (NRC, 2006)

M. stenopetala has a wide range of adaptation from arid to humid climates and can be grown in a various land use patterns. It is more resistant to insect pests than other species in its family (ICRAF, 2006). It is cultivated both for social food and used as animal feed in Southern Ethiopia and has been recently dispersed to other regions of Ethiopia under its original locations. The use of *Moringa stenopetala* based agroforestry for soil conservation, and other the wide range is livelihood supporting strategy which is human food, livestock forage, medicine, dye, water purification and green manure attention getting actively (Palada and Chang, 2003; Eyasu, 2008; ECHO, 2009; Morey, 2010; Abera, 2011).

However, this evidence and systematic feedback regarding *M.stenopetala* tree the main reason of initial planting and farmers' perception on its environmental impact on agricultural crop is relatively unidentified in the context of Offa Woreda. Consequently, evaluating the purpose of preliminary planting of *M.stenopetala* tree and farmers' perception of its impacts on environment were the main focus of exploration in the study area.

Research Methodology

2.1 General Description

The research site Offa woreda is located in western part of Wolaita zone in south nation nationalities and people region (SNNPR). It is located at 37° 29' 59.99" E and 6° 44' 59.99" N having altitude ranging of 1200–2600 masl which is located below Fig. 1. The amount of rain fall and range of temperature were 800-1400mm and 14-340C respectively (Tibebu and Zinabu, 2016). As the data gained from Offa Woreda Agriculture and Rural Development Office the Woreda is bound by Humba and Kucha Woreda in South and south East, Kawo Koysha and Kindo Koysha Woreda in the West and North –West, Bayra Koysha Woreda in the North and Soddo zuriya Woreda in the North-East. Similar to other rural Ethiopian ethnic groups, the economy of Offa Woreda households is based on farming. As Offa's past records reveal that the people conduct farming and animal husbandry for centuries. Therefore, varied farming is the major agricultural activity for the Offa. The larger part of the people resided in geography relied on a mix of livestock and crop farming.

2.2 Research methods

Study Site and Household Selection

Multi-stage sampling techniques which were combinations of purposive, random and stratified sampling methods were applied to select the sample Kebeles and households. The study site was selected purposively based on the presence of more distribution of *M.stenopetala* tree plant in farmland. Therefore, out of 21 kebeles in Offa Woreda, three representative kebele (Mancha, Kodo and Tida) were purposively selected due to the availability of Moringa tree based agroforestry practices more than the others. The determination of sample size is fixed by means of Slovin's sampling formula with 90 percent confidence level;

$$n = \frac{N}{1 + N(e)^2}$$

n = sample size for the research use

N = total number of HHs in three *M.stenopetala* practicing kebele

e = margin of errors at 10%

Where, 95% degree of confidence is selected in the study. Based on this, a total 116 sample households were carried selected proportionally across three wealth categories within the three kebele. Then data collection was done through interview and observation survey of households sampling from *M. stenopetala* tree growers and focus group discussion with experts of office of WoARD administration office and local administrators.

Methods of data Analysis

The statistical analysis were conducted using statistical software (SPSS version 20), and X^2 test was also run for any association between the wealth categories related with why primarily they plant this tree. One-way ANOVA was used to test whether there is a significant difference among different household categories.

Results And Discussion

4.1 Demographic and Socio Economic Characteristics of Households

Among the total sampled respondents, 92% were male headed households and 8% were female headed households. There were no significant difference (p = 0.094) across wealth categories in terms of age class. According to the local wealth category classification standardization; the total of households

(19.2%) poor, (55.4%) medium and (25.4%) rich were categorized. Households' of education, occupation and age ranged among wealth category were acutely discussed below Table 1.

Table 1
The Chi-square tests of demographic characteristics of the HHs among wealth categories (n = 116)

Variables		Wealth categories				
		Poor (%)	Medium (%)	Rich (%)	χ^2	p value
Age	19–40	12	29	36		
	41–60 years	53	58	41		
	> 61 years	35	19	23	4.824	0.094 ^{ns}
Education	Not write and not read	41	29	17		
	Read and write	53	58	59		
	High school and above	6	13	24	1.343	0.115 ^{ns}
	Farmer	100	87.7	90.9		
occupation	Non farmer	0	12.3	9.1	2.327	0.260^{ns}

Source: Own survey 2021 Note ^{ns}=not significant, p > 0.05

4.2 Reasons for Planting *M. stenopetala*

Now in latest time, *M. stenopetala* were widely promoted in the study area through farmer to farmer extension. According to the Focus Group Discussion, *M.stenopetala* used for a range of purposes such as food nutrition, fodder, traditional medicine, reduce soil erosion, boundary planting and improve the soil fertility. In overall affording to respondents' survey, the result revealed from 116 households the initial reason of planting *M.stenopetala* was 48% to provide food nutrition, 31% to protect field or to control soil erosion, 11% to provide fodder, and 8% for medicinal value, to improve soil fertility and to aesthetic each had 1%. The Chi-square test showed that among the three wealthy categories there were no statistical differences (p > 0.05) in terms of initial reason of planting *M. stenopetala* (Table 2). The result indicates the *M.stenopetala* tree is planted in rural households for the mainly for food source. This is consistence with Dechasa et al. (2006) reported that Konso people plant *M.stenopetala* tree because it is a strategic plant and unique food tree in drought prone areas and high social and economic values.

Table 2
Initial reasons of planting *M. stenopetala* among wealthy categories (n = 116)

Responses across wealth categories (%)					
Initial reasons	**Poor (n = 21)**	**Medium (n = 67)**	**Rich (n = 28)**	χ^2	**P Value**
Improve the soil	0	1.75	0		
Aesthetic	0	1.75	0		
Provide fodder	17.6	10.5	5	7.227	0.323^{ns}
Control soil erosion	35.3	28	36		
Provide food nutrition	41.2	45.6	59		
Medicine	5.9	12.4	0		
Total	100	100	100		
Source Own Survey: 2021 ^{ns} =Not significant different at p > 0.05					

However, according to household survey and FGD, a primary reason for initial planting was different in different age categories (Appendix). The majority of the respondents across the wealth categories (87.1%) with age of 19–40 years stated that the primary reason of planting *M. stenopetala* was to provide food nutrition, followed by providing fodder, control soil erosion and traditional medicine (4.3% of the respondents each). Similarly age between 41–60, 49% of the respondents replied the initial reason was to provide food nutrition, 35.8% for control soil erosion on the farm land and providing fodder and tradition medicine (5.9% each) and to improve the soil and for aesthetic value (1.96% each).

In contrast, the initial reason of age > 60, 50% to control soil erosion on the farm land followed by provide fodder (27.3%), traditional medicine (18.2%) and the remainder (4.5%) to provide food nutrition. The finding indicates that primary reason of planting *M.stenopetala* by formerly (aged) farmers was less considered for food purpose. All the age categories of the respondents about the initial purpose of planting the Moringa were discusses below (Appendix 1). Focus group discussants, Key informants and experts from agricultural office confirmed the result. This implies at the time it has less information on food contribution and they give less attention for use *M.stenopetala* for food purpose. Nina (2012) also reported that in Ethiopian food traditions provides no more information about using Moringa in the diet and reason for that may be because the use of Moringa is only common in smaller parts of Ethiopia. According to household survey and FGD, in recent times, farmers expand planting *M.stenopetala* mainly for nutrition, leaf for sale in local market and medicinal values. This finding is supported by Lowell (2003) where he described in recent, multifunctional use of *M.stenopetala* for nutrition through decreasing hunger, improving health and human nutrition and livelihood improvement is highly distinguished.

The study of (Garrity, 2004; Roshetko et al., 2007c) also described that currently millions of smallholders of tree planting approach is for the most part to meet their needs for essential resources of food, timber, fodder and market commodities. Zenebe et al. (2010) also noted that farmers' planting selected trees by rural area is currently seen as an alternative livelihood strategy, particularly drier areas. However, in this event crop tree like *M. stenopetala* is used as the most important daily food source for households especially in the dry season and currently for cash income. In addition, view of FGD, recent farmers considering different attributes as criteria of deciding to plant selected specific tree species, these attribute or purposes include income contribution, food, fodder production, and watershed benefits (e.g. soil conservation).

4.3 Farmers' perceptions towards the environmental impacts of M.stenopetala

A census study conducted on *M. stenopetala* tree farming, as it was indicated in Table 3 and 4 depicted, respondents perceived by their native experiences both positively and negatively impacts of Moringa tree on their farming environment.

Positive aspects of environmental impacts of M.stenopetala tree

As it was indicated in Table 3 below, the respondents perceived more about positive aspects of environmental impacts of *M.stenopetala* tree on the soil, water and on the agricultural crops due to its presences.

Table 3
Farmers' perceptions towards the Positive aspects of environmental impacts of *M.stenopetala* tree (n = 116)

1. Positive aspects of environmental impacts on soil	**what causes these impacts**	**Frequency (n = 116)**	**Percent (%)**
Couldn't understand		17	14.6
Soil erosion control	Root	76	65.5
Soil fertility enhancement	Leaf decomposition	37	31.9
Shade	branch	49	42.2
2. **Positive aspects of environmental impacts on water**	**what causes these impacts**	**Frequency (n = 116)**	**Percent (%)**
Couldn't understand		93	80.2
Percolation of water to other crop	Root	23	19.8
3. **Positive aspects of environmental impacts on agricultural crop**	**what causes these impacts**	**Frequency (n = 116)**	**Percent (%)**
Couldn't understand		2	1.7
Shade	branches	27	23.2
climber	stem	21	18.1
Windbreak	branches	59	50.8
Make good condition to Understory root crop	root	61	52.6
Source: Own survey 2021			

On Soil

Accordingly, most of the respondents (65.5%) indicated that *M.stenopetala* tree control soil erosion on the fields due to its extensive and branched roots. Moreover, 31.9% believe that it enhances soil fertility through shedding its leaf by wind and during harvesting. They explained that leaf litters fallen to the ground changed their color to yellowish on the soil thus observing the decomposition process. This finding was consistent with Assefa et al. (2015) which reported that soil organic matter was high around *M.stenopetala* tree canopy due to decompositions of the plant residue; leaf litters fall, elongated pods that contained many seeds and dead roots from the tree as compared to the adjacent open area. On the other hand, about 23.7% the respondents mentioned that the shades provided by the crowns of *M.stenopetala* and the cover of the litter fall provide cover to the soil and keep the moisture which is a

good condition for root crops mainly in homestead area. This is also supported by the findings of Dupuy and Dreyfus (1992) which described the tree facilitates infiltration and reduces the sun radiation microorganisms under the shade during the dry season.

On Water

From the total respondents, 23.9% point out that *M.stenopetala* tree has impacts on the water by improving percolation of water or moisture release around the area it is planted. They observed that it has more vertical deep roots and root crops around *M.stenopetala* tree usually have more green leaves during the dry season compared to those in the open areas. In addition, when soil around the trees is dug, in autumn season the soil appears to be moister. This is in agreement with the study by Huchu and Sithole (1993) who reported that trees planted in farmland as windbreaks or shelterbelts may help to conserve topsoil moisture by retaining surface ground water for water recharge and providing shelter from high temperatures and intense rainfall.

Impacts On Agricultural Crops

Related to the impacts of *M.stenopetala* tree on agricultural crops, the study revealed that, 63.5% of the respondents perceived the role of *M.stenopetala* trees in creating good conditions to understory regeneration and root crops in underground improving their reproduction. The root crops especially mentioned by respondents were Enset (*Ensete ventricosum*), sweet potato (*Ipomoea batatas*), Godere (*Colocasia esculenta*), Boyee (*Disocoria alata*) and Cassava (*Manihot esculenta*). They assume Moringa creates comparatively better understory vegetation than other commonly used plantation species in farmlands. Therefore, they usually bury these root crops near to the root or under the shade of *M.stenopetala* tree for replication purpose especially during the dry season and they noticed survival rate was higher compared to other homegarden plants like *Mangifera indica*, *Persea americana*, *Croton macrostachyus* and with open area. In other study (Mann and Saxena, 2001) the same was reported, where crop yields under selected trees are generally reported to be higher than in the open field due to various factors that contribute microsite enrichment by the tree. In addition, Talemos *et al*. (2013) described that farmers conserved food plant diversity species in the homegarden agroforestery in Wolaita homegarden or /Darkuwaa[1]/ and used commonly as food, medicinal and understory for other crops (e.g. *Moring stenopetala*, *Allium sativum* and *Solanum dasyphyllum*).

Respondents accounting to 59.4% of the total perceived its role as windbreak for agricultural crops in the field while 28.1% seemed to observe the shading effect of the tree on other undergrowth species in the field like *Coffee arabica* and *Zingier officinal*. Focus group discussants, Key informants and Experts from agricultural office confirmed the result. Similarly, Yitebitu (2004) also reported that Moring tree provided environmental services as windbreaks, and as a shade tree in areas of its natural range. As it is indicated in Table 3, 21.8% of respondents used *M.stenopetala* tree to stake maize while cut in the field at the harvesting time.

Other Positive environmental impacts

Furthermore, according to the focus group discussion and reconnaissance survey conducted and observations made from the respondents, 63.3% perceived the tree has position to the environment due to having aesthetic value. This is supported by ETFF, (2004), that culture by itself has a great role in conservation and sustainable utilization of locally important tree species.

Accordingly, most of the respondents (65.5%) indicated that *M.stenopetala* tree control soil erosion on the fields due to its extensive and branched roots. On the other hand, the study revealed that, 42.2% of the respondents perceived the role of *M.stenopetala* trees in creating good conditions to understory regeneration and root crops in the field by shading. The root crops especially underneath Moringa mentioned by respondents were Enset (*Ensete ventricosum*), sweet potato (*Ipomoea batatas*), Godere (*Colocasia esculenta*), Boyee (*Disocoria alata*) and Cassava (*Manihot esculenta).*

Hence, they usually bury these root crops near to the root or under the shade of *M.stenopetala* tree for replication purpose especially during the dry season and they noticed survival rate was higher compared to other homegarden plants like *Mangifera indica, Persea americana, Croton macrostachyus* and with open area. In the former Talemos *et al*. (2013) described that farmers conserved food plant diversity species in the homegarden agroforestry in Wolaita homegarden or /Darkuwaa[2]/ and used commonly as food, medicinal and understory for other crops (e.g. *M. stenopetala, Allium sativum* and *Solanum dasyphyllum*).

Negative impacts of M.stenopetala tree on the environments

Farmers in their native experience, they have more knowledge and perception on tree how it interacted with the environment. As it is shown in Table 4 below, respondents' perceived also negative aspects of environmental impacts/consequence of *M.stenopetala* on the soil, water and on the agricultural crops as its presence in farmland due to having shading effects, providing shelter or harboring insects and birds, causing hindrance or obstacle in agricultural operation, weed effects and occupying parts of land in agricultural operation were the most negatively perceived by the respondents. Perception of farmers response accordingly their indigenous knowledge were conferred below table

Table 4
Farmers' perceptions towards the Negative aspects of environmental impacts of *M.stenopetala* tree (n = 116)

1 Negative aspects of environmental impacts on soil	**What causes these impacts**	**Frequency (n = 116)**	**Percent (%)**
Couldn't understand		92	79.3
Decreasing fertility of soil	Root	17	14.6
Changing soil color	Root	7	6.1
2 **Negative aspects of environmental impacts on water**	**What causes these impacts**	**Frequency (n = 96)**	**Percent (%)**
Couldn't understand		112	96.5
drying out the area	Root	4	3.5
3 Negative aspects of environmental impacts on agricultural crop	**what causes these impacts**	**Frequency (n = 116)**	**Percent (%)**
Couldn't understand		28	24.2
Provide harbors to insects and bird	Branch	53	45.7
Cause Hindrance in agricultural operation	Root	11	9.5
Weed effects	Around root	9	7. 7
Shade effects	Branch	6	5.2
Occupy parts of land in agricultural operation	Stem	4	3.4
Competition with crop	Root	3	2.6
Affect grain filling	Branch and leaves 2		1.7
Source: Own survey 2021			

On Soil

In agreement to the observation of the respondents, most respondents claimed no negative impact of *M.stenopetala tree* on the soil from their understanding. A negative impact on soil was mentioned by only 14.6% of the farmers who replayed as their perception; *M.stenopetala* tree decrease the soil fertility comparing with other tree like *Cordia africana* and *Croton macrostachyus.*

On Agricultural Crop

According to the view of the respondents, the most adverse effects of *M.stenopetala* tree in relation to agricultural crop on the field were related to attraction of pests. About near to half of the respondents (45.7%) perceived that *M.stenopetala* tree harbors birds which nest in the trees and destroys other crops seed, fruit and flowers. These birds are attracted to nest in *M.stenopetala*. Therefore, bird come to feed on the insects which live in *M.stenopetala* stem especially the ants and bees that collect nectar from the flowers of *M.stenopetala* tree. The most affected crops are sorghum and maize at fruiting stage, haricot bean (Boloke) at the stage of flowering for the most part at the summer seasons and Boyee (*Disocoria alata*) at the young stage. For that reason, farmers recommend planting *M.stenopetala* at front yard of homegarden seeing as to control movement of birds straightforward.

A few farmers (9.5%) complained about the physical hindrance in agricultural operation by the roots of the trees during ploughing by oxen. This mainly occurs at old ages as it has more biomass and also strong and extensive root system. This is supported by Muhammad and Chris (2005) described that the negative impacts of growing trees were also recognized in that they can cause physical hindrance in performing agricultural operations, shade annual crops (thereby reducing yields), and provide shelter to birds, insects, pests, and diseases that ultimately damage crops. However, farmers make their own explanation that they try to reduce these effects by regular pruning at the time of sowing these crops. The other limitations which was perceived by some respondents (7.7%) was the association of *M.stenopetala* tree with *Monsonia angustifolia* weeds (Phedhdhaa[3]) that tend to expand around its root. Only 2.6% of the farmers interviewed were competition with crops by its huge root. This is contrast with Ashfaq (2012), reported Moringa tree is deep rooted and does not compete with crops for nutritional concerns; it does not have any direct competition with food crop.

[1] DARKKUWAA is around the home or house
[2] DARKKUWAA is around the home or house

[3] Pheedhdhaa is local name of weed which affects mainly cereal crop on farm land in the study site

Conclusion And Recommendations

M.stenopetala is plant of farmstead agroforestry tree, which provide opportunities for sustaining many environmental services for local community and provide quite a lot of socio-economic welfares in the study areas. In recently the majority of households' reason for planting *M.stenopetala* tree was to provide food nutrition followed by protection of agricultural fields and control of soil erosion. Moreover, findings also revealed that these appreciated roles and values of *M. stenopetala* and thus the primary reason for its initial planting was different among different age categories. This implies, at earlier times, initially it was planted mainly to protect farmlands, for soil conservation and other environmental services. Separately from its economic role, there are several other positive environmental impacts of *M.stenopetala* tree that has been experienced by the farmer's perception on soil, water and on agricultural crop including soil conservation. However, there is also some negative side of *M.stenopetala* that has been perceived by some farmers. But its benefits outweigh any negative effects. Therefore, conducting on

tree-soil interactions on cultivated lands to know its effect on soil, water and on agricultural crops and litter quality (litter decomposition) and canopy of the tree should be emphasized in order to determine its actual impacts related to environments.

Declarations

Conflicts of Interest

The Authors declare that there is no conflict of interest concerning the publication of this research paper

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Figures

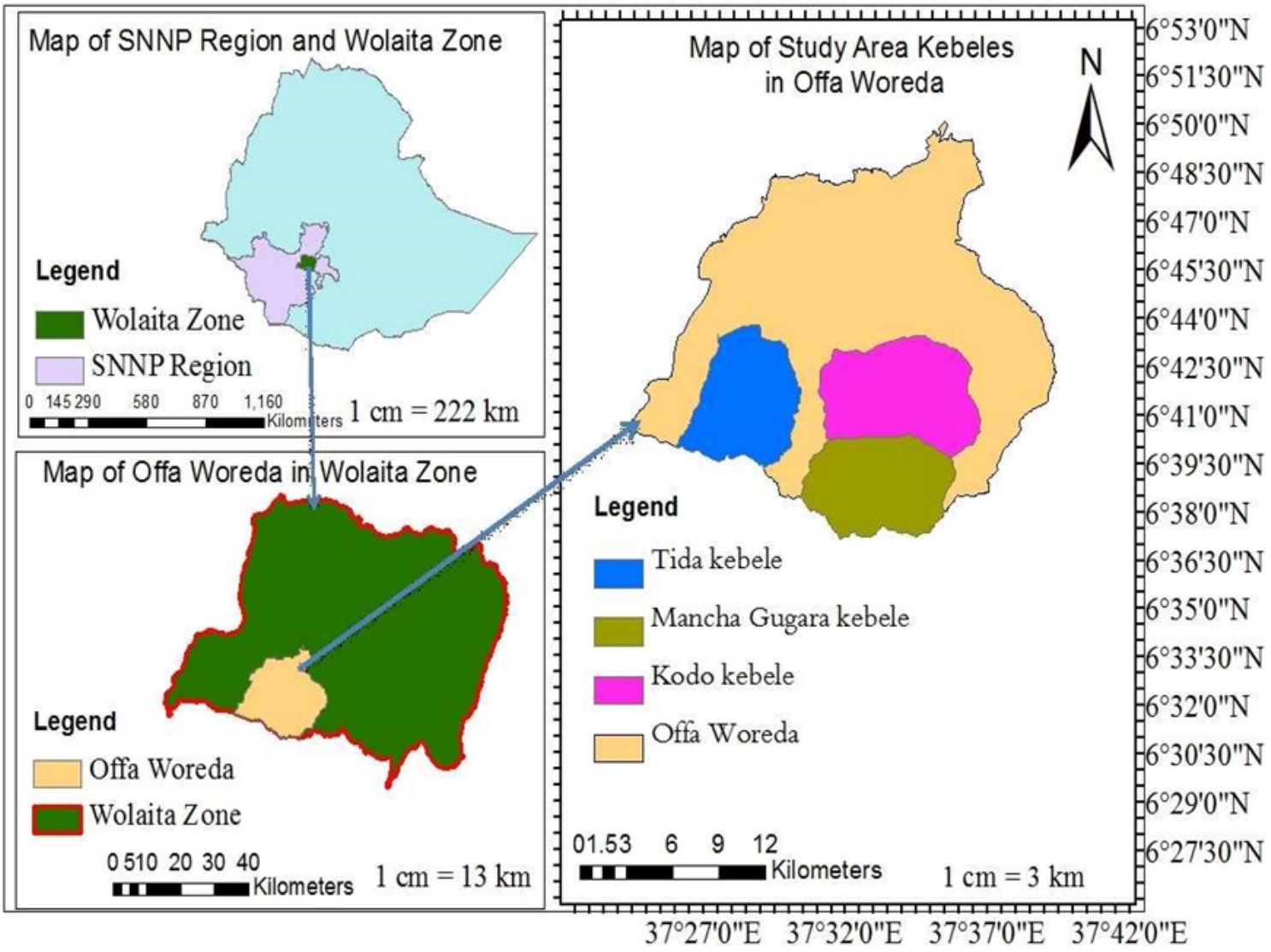

Figure 1

Map of the study area

Supplementary Files

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