



Meta-Analysis of Socio-Economic Impacts of Land Fragmentation in Ethiopia

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From fragmentation to future: empowering communities,
transforming agriculture & improving governance

Impressum

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Acronyms

ANRS	Amhara National Regional State
CALM	World Bank Climate Action Through Landscape Management Project
CSA	Central Statistical Agency
EPRDF	Ethiopian Peoples Revolutionary Democratic Front
FAO	UN Food and Agriculture Organisation
FHHM	Farm Household Model
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
GDP	Gross Domestic Product
HH	Household
LaGo	Ethio-German Land Governance Project
LAUD	Land Administration and Use Directorate
LC	Land Consolidation
LF	Land Fragmentation
LIFT UK	Foreign, Commonwealth and Development Land Investments for Transformation Project
MVP	Multi-Variant Probit
NRLAIS	National Rural Land Administration Information System
ONRS	Oromia National Regional State
REILA	Ethio-Finish Responsible and Innovative Land Administration Project
SI	Simpson Index
SLLC	Second-Level Land Certification
SLM	Sustainable Land Management
SNNPR	Southern Nations, Nationalities and Peoples Region
TC	Transaction Costs

Executive summary

Land is a scarce natural resource, and the demand for land is continuously growing to fulfill basic human needs, as well as ever-expanding desires. It serves as a cornerstone for achieving food security and sustainable development. Maximizing the efficient use of land resources becomes imperative to maintain economic, social, and ecological benefits for present and future generations. In nations like Ethiopia, heavily reliant on agriculture, preserving and developing the natural resource base in an environmentally conscious manner is of paramount importance. However, a complex interplay of political, social, economic, and natural factors contributes to the severe degradation of the country's land resources. The government of Ethiopia has undertaken commendable efforts to address this issue, by implementing improved land management practices and measures aimed at ensuring land tenure security. Despite these initiatives, agricultural land in Ethiopia continues to grapple with a significant challenge of farmland fragmentation that poses a substantial impediment to the desired agricultural transformation.

The literature elucidates both detrimental and advantageous facets of land fragmentation with regard to agricultural production efficiency, land management, and risk mitigation. Negative attributes impacting crop productivity emanate from the presence of small, irregularly shaped land parcels, dispersion of parcels, distances from the owner's homestead, boundary disputes, limitations in machinery use, losses incurred due to land left for parcel boundaries, diminished opportunities for investments in irrigation and soil conservation, and a lack of access routes. Conversely, land fragmentation proffers benefit in terms of risk management, crop scheduling, and ecological diversity.

The socioeconomic and environmental damages associated with farmland fragmentation outweigh its benefits, making land consolidation a crucial instrument for enhancing agricultural productivity and promoting rural development. The existence of severe land fragmentation in Ethiopia, coupled with ongoing initiatives towards land consolidation, poses a substantial challenge in land policy. Reliable empirical data is essential to substantiate the rationale behind the shift towards land consolidation.

In response to the pervasive issue of severe land fragmentation and its consequential impediments to agricultural productivity in Ethiopia, the Ethio-German Land Governance (LaGo) project, in consultation with the Land Administration and Use Directorate of the Ministry of Agriculture, commissioned a comprehensive study on the Socioeconomic Impacts of Land Fragmentation in the country. The primary objectives of this study include delineating the extent of land fragmentation, assessing its repercussions on agricultural productivity, fostering policy dialogue, and advocating for the formulation of a robust legal framework to regulate land consolidation measures within the nation. This investigation involved a meticulous review of contemporary studies on land fragmentation, with a particular emphasis on empirical evidence pertaining to its social, economic, and environmental impacts both within Ethiopia and in analogous contexts globally. Furthermore, a meta-analysis was conducted to systematically examine the socioeconomic effects of land fragmentation specifically in Ethiopia. The

overarching goal was to discern the adverse effects on crop productivity and pinpoint crucial parameters influencing sustainable land management practices. The findings of this study are anticipated to provide valuable insights for policymakers and foster informed decision-making processes to address the challenges posed by land fragmentation.

To establish a comprehensive understanding of the average landholding per household and the level of land fragmentation in Ethiopia, a total of 340 woredas situated in the Amhara, Oromia, and Southern Nations, Nationalities and Peoples (SNNP) regions were included in the study. The landholding data of farm households in 11 zones and 112 woredas of the Amhara region, 17 zones and 124 woredas in the Oromia region, and 18 zones and 104 woredas in the SNNP region were sourced from the database maintained in the National Rural Land Administration Information System (NRLAIS) for land holding and land fragmentation analysis. In this analysis, the land holdings of 6,351,597 rural landholders were considered, comprising 3,373,742 farm landholders in the Amhara region, 1,972,474 in the Oromia region, and 2,005,381 in the SNNP region, all residing in 6,413 rural kebel. The total recorded area in the name of the farm householders is 11,995,477 hectares, distributed as 4,943,527 hectares in the Amhara region, 4,832,189 hectares in the Oromia region, and 2,219,761 hectares in the SNNP region.

An analysis of farm land holdings in the Amhara region reveals that the average land holding per household is 2.08 hectares. Across the 11 zones, the figures range from 1.73 hectares in East Gojam to 3.03 hectares in Central Gonder in the highlands. West Gonder stands out with a higher average of 7.24 hectares, as the rural land law permits land holdings up to 7 hectares in the lowland areas. Notably, 40.2% of households in the region own one hectare or less, while 25.5% own 1.1 to 2 hectares. Some 14.3% possess 2.1 to 3 hectares, and the remaining 20% own more than 3 hectares.

Moving on to the Oromia region, the average land holding per household is 2.45 hectares. Across the 17 zones, variations are significant, ranging from one hectare in the Bale zone to 5.1 hectares in the Guji zone. A substantial 81.4% of farm households in the region own one hectare or less, with 10.6% possessing 1.1 to 2 hectares, and the remaining 8.1% holding more than 2 hectares. In the SNNP region, the average land holding per farm household is 1.11 hectares. Across zones, the range is notable, from 0.3 hectares in Kembata to 3.8 hectares in Konso. Approximately 58.4% of households own one hectare or less, 24% own 1.1 to 2 hectares, 13.5% own 2.1 to 3 hectares, and the remaining 4.8% own more than 3 hectares.

At the national level, the data indicates that about 37.9% of households own less than or equal to 0.5 hectares, 22.1% have 0.51 to 1 hectare, 10.4% own 1.1 to 1.5 hectares, approximately 15.4% possess 1.51 to 2.5 hectares, and the remaining 14.3% have more than 2.5 hectares. The overall land holding per household appears low, and the substantial percentage of farm households with 0.5 hectares or less in the three regions signals a severe shortage of farmland. These figures underscore the urgent need for proper land management and increased productivity per unit area to meet the national demand for agricultural products.

The analysis of parcel holdings reveals that the national average number of parcels held by farm households is 3.2. Disaggregated figures across regional states further illustrate variations in parcel distribution, with the Amhara region averaging 4.2 parcels per household, Oromia at 3.44, and the SNNP region at 1.94. At the national level, approximately 46.1% of total farm households possess 1 to 2 parcels, 35.9% hold 3 to 5 parcels, 18.2% manage 6 to 8 parcels, and 3.5% own more than 8 parcels. The presence of a substantial number of farm households

with multiple parcels underscores the necessity for initiating a land consolidation program on a nationwide scale. Further investigation into parcel areas reveals that the national average is 0.68 hectare. Regionally, the Amhara region has an average parcel size of 0.5 hectare, Oromia at 0.79 hectare, and the SNNP region at 0.71 hectare. This analysis suggests an overarching trend of smaller parcel sizes across the three regions.

In-depth examination of specific zones within each region highlights notable instances of land fragmentation. In the Amhara region, South Wollo, North Shewa, South Gonder, North Wollo, East Gojam, and Awi zones exhibit pronounced land fragmentation. Similarly, in Oromia, North Shewa, West Wollo, Kelem Wollega, Guji, South-west Shewa, East Bale, and Arsi zones experience higher levels of fragmentation. Conversely, land fragmentation in the SNNP region is relatively low, with the average number of parcels per household standing at 1.94. However, specific zones such as Konso, Gamo, and Yem Special demonstrate a more visible degree of fragmentation. These findings can serve as valuable indicators for land administration institutions and development partners to prioritize the identified zones for targeted land consolidation interventions.

The meta-analysis on the impact of land fragmentation on crop productivity has highlighted several variables, including the Land Fragmentation Index, the number of parcels held by a household, and the distance between parcels, all of which adversely affect crop productivity. An examination of the costs associated with land fragmentation in Ethiopia, coupled with a failure to implement strategies for land consolidation based on various studies, reveals that the country is at risk of losing several thousand tons of grain annually due to land fragmentation. Beyond the evident negative social and ecological implications, the analysis based on previous studies indicates an estimated annual grain loss ranging from 31,863.7 tons to 284,934 tons at the national level. This estimation is derived by assuming that the total land area covered with cereal crops at the national level in 2020 was 7.8 million hectares. Taking proactive measures to address land fragmentation is imperative to mitigate these losses and promote sustainable agricultural practices in Ethiopia.

The review of various studies on land fragmentation in Ethiopia emphasizes its significant impact on agricultural land productivity and management practices. This impact is attributed to historical, institutional, and sociological factors. Despite positive government measures, several challenges, including the growing rural population, increasing rural landlessness, weak enforcement of rural land laws, and illegal land transactions, are further exacerbating the issue of land fragmentation.

To effectively address these challenges, there is a pressing need for a comprehensive land consolidation program tailored to both local and national interests. A thorough analysis of Ethiopia's land fragmentation scenario suggests the following recommendations to mitigate the problem and institute successful land consolidation:

- **Synthesis of Empirical Evidences:** Addressing extensive land fragmentation and leading the effort towards land consolidation requires the synthesis of empirical evidences illustrating the actual conditions of land fragmentation and its consequential impacts. This data should be presented in policy dialogues to secure the necessary political commitment from relevant authorities. Once this foundation is established, the Land Administration and Use Directorate within the Ministry of Agriculture, with support from development partners, should formulate legal frameworks for implementing land consolidation. This process should actively involve all relevant stakeholders and draw insights from global experiences, and align them with national contexts, including rural land proclamations.

- **Raising Awareness and Enhancing the Landholding Database for Improved Land Consolidation Implementation:** To foster trust among farmers and promote the acceptance of land consolidation, it is imperative to undertake comprehensive awareness-building initiatives. These efforts should highlight the drawbacks of land fragmentation while emphasizing the numerous benefits associated with land consolidation. This approach aims to reinforce the ongoing voluntary parcel exchange practices initiated by farmers across various regions. Concurrently, proactive measures should be taken to identify woredas and kebeles where land fragmentation is particularly severe, utilizing data from the National Rural Land Administration Information System (NRLAIS). Prioritizing these areas for systematic land consolidation interventions will contribute to effective and targeted outcomes. Additionally, leveraging insights gained from pilot projects on land consolidation will provide valuable knowledge to further strengthen the consolidation process. In all these efforts policy-makers should play a crucial role in actively endorsing and encouraging the land consolidation process. Furthermore, land administration institutions should be diligent in updating their land registries with accurate information on land transactions. This step is vital to mitigate uncertainties surrounding land-holding rights, thereby creating a conducive environment for successful land consolidation initiatives.
- **Multi-Stakeholder Engagement and Resource Mobilization:** The successful implementation of land consolidation requires the active involvement of diverse stakeholders, the availability of sufficient financial and physical resources, competent technical experts, and robust engagement with local communities. It is also crucial to identify the lead institution and collaborating organizations that will closely cooperate with local communities to facilitate and support the land consolidation process. These measures should aim to establish a structured framework for addressing challenges related to land fragmentation, initiating effective land consolidation, and promoting sustainable land management practices in Ethiopia.

1. Introduction

Land, a scarce natural resource, remains in constant demand to meet humanity's basic needs, desires, and aspirations. It serves as a cornerstone for the economic development of nations, both developing and developed alike (Burns and Dalrymple, 2008). Achieving food security and sustainable development hinges significantly on land, with approximately 70% of Africa's population relying on it for livelihoods and resource utilization (ECA, 2004). Thus, responsible and efficient utilization of land resources is imperative to sustain economic, social, and ecological benefits for present and future generations (FAO, 2010).

Ethiopia, predominantly reliant on agriculture for its economy, faces challenges in conserving and developing its natural resource base. Political, social, economic, and natural factors have led to severe land degradation. The Ethiopian government has earnestly sought to mitigate this by implementing soil and water conservation programs, tree planting initiatives, and measures ensuring land tenure security. However, despite these efforts, agricultural land in Ethiopia suffers from significant fragmentation, posing a hindrance to agricultural transformation.

Land fragmentation denotes the division of land into numerous distinct plots, resulting in smaller average farm holdings, increased scattering of land, and reduced plot sizes per farmer (Demetriou, 2014; Tan et al., 2006). This phenomenon, pervasive globally, stems from institutional, historical, and sociological factors (del Corral et al., 2011; Negash, 2013). Sub-Saharan Africa, including Ethiopia, experiences a considerable decrease in farm sizes, impacting economies of scale in food production. Causes of land fragmentation include inheritance laws, land scarcity, population growth, land markets (informal land market in the case of Ethiopia), and historical/cultural perspectives, among others (Demetriou et al., 2013; Bentley, 1987). Analyzing these assertions within the Ethiopian context is crucial to justifying policy interventions addressing land fragmentation.

One major strategy for addressing issues related to land fragmentation is the promotion of rural land consolidation. Land consolidation involves the reorganization of land tenure rights and usage in rural areas (FAO, 2008). It is recognized as the process of reallocating and, at times, spatially redesigning rural land holdings to enhance agricultural production efficiency and improve social conditions. This process may include the transfer of existing land parcels between owners, and more transformative applications may involve parcel mergers or redesign.

Drawing on extensive experience in Western European countries, land consolidation is acknowledged as an effective instrument in agricultural and rural development programs (Vitikainen, 2004). It has the potential to foster improved natural resource management, support enhanced land use planning, and resolve conflicts arising from land use changes. Additionally, land consolidation is deemed essential for rural development initiatives that contend with numerous small and fragmented farms.

The implementation of land consolidation not only supports the achievement of food security but is also integral to the success of integrated rural development projects. Furthermore, adherence to recent legal guidelines is crucial for ensuring the efficacy of land consolidation

initiatives in meeting the needs of farmers and implementing agencies (FAO, 2020). In essence, land consolidation facilitates improved natural resource management, enhances land use planning, and effectively resolves conflicts associated with land use changes.

Literature presents conflicting views on land fragmentation's implications from the perspectives of inefficiency in agricultural production and land management and risk aversion. The negative view in the literature shows that the small size and irregular shape of the land parcels, the dispersion of parcels, and, in particular, the large potential distance between the parcels and the owner's farmstead incur cost, time, wastage of resources and provoke boundary disputes (Wan and Cheng 2011; Blarel et al., 1992). Difficulties in applying new technologies, loss of land due to boundaries, transporting farm inputs and outputs, and increasing negative externalities such as reduced opportunities for irrigation and soil conservation investments and access routes are additional problems identified by Cheng et al. (2009). Although land fragmentation is associated with a negative connotation, there are arguments regarding its benefits. For example, Van Dijk (2003) discussed its benefits from different aspects such as risk management, crop scheduling, and ecological variety. These vital and contentious issues need to be investigated in the Ethiopian context.

In developing countries, including Ethiopia, the level of rural land fragmentation plays a significant role in national food production as it impacts the efficiency of productivity and the environment of the rural ecology (Altes and Im, 2011; Demetriou, 2014). Although further analysis of empirical evidence on the impact of land fragmentation in Ethiopia is required, the prevalence of land fragmentation is claimed to impede current agricultural practices, exacerbating issues of food insecurity, poverty, and sustainable development. Addressing this requires promoting rural land consolidation, a process that reorganizes land tenure rights to enhance agricultural efficiency and social conditions.

Depending on the objectives of land consolidation, Asiama et al. (2021) delineate five distinct land consolidation instruments. The first approach, focused on the consolidation of land use, is applicable to processes aiming to enhance farm productivity without altering land rights and farm boundaries (Kathiresan, 2012; Muhinda & Dusengemungu, 2013). In the Ethiopian context, this approach is referred to as Cluster Farming. In this method, land use consolidation emphasizes the cultivation of the same crops by different owners whose farms share boundaries, allowing for the amalgamation of their farming operations without the need for parcel exchanges.

The second approach is voluntary land exchange, which is considered the basic form of conventional land consolidation. In this scenario, farmland parcels are exchanged between right holders without manipulating the boundaries of the parcels. The primary objective of this instrument is to mitigate the fragmentation of farmland parcels, thereby increasing food productivity. The reorganization of farmland parcels during the land exchange necessitates the registration of existing users and/or owners of the parcels to ensure land tenure security in the areas of implementation.

The third land consolidation tool is land realignment (Demetriou, 2014). Land realignment not only involves the exchange of farmland parcels but also extends to the regularization of parcel boundaries as an additional objective. In this context, the parcel shape index is considered a key indicator of land fragmentation that should be minimized. The aforementioned three land consolidation instruments collectively aim to mitigate physical land fragmentation.

The fourth land consolidation instrument, Land Banking, entails a process where landowners, disinterested in expanding their landholding, make surplus portions available for the expansion of other farmland holdings (Berg et al., 2005; Van Dijk & Kopeva, 2006). The primary goal of land banking, as a land consolidation tool, is to enhance farmland holdings with the ultimate aim of increasing overall agricultural productivity.

The fifth land consolidation instrument is Land Development. This involves the exchange, realignment, and expansion of farmland parcels, not solely for the purpose of increasing food productivity but also for providing essential structures for farming operations and undertaking comprehensive reconstruction in rural areas, thereby contributing to total and integrated rural development (Louwsma & Lemmen, 2014).

In Ethiopia, where the majority of the population relies on farming as their primary livelihood, the agricultural sector significantly contributes to the GDP (Teshome et al., 2016). However, persistent challenges such as land scarcity and fragmentation continue to impact the agricultural landscape. According to studies, the national average total farmland area per smallholder is reported to be 0.78 hectares, with an average of four plots per farmer (FAO, 2018, as cited in Abebaw, 2019). Alternatively, Headey et al. (2014) suggest a national average farmland size of 0.96 hectares per household, displaying regional variations. Specifically, Tigray and Southern Peoples Regions each exhibit an average of 0.49 hectares, Amhara Region having 1.09 hectares, and Oromia Region possessing the largest average of 1.15 hectares per household.

Contrastingly, the Central Statistical Agency (CSA) Agricultural Sample Survey for the year 2020/21 indicates an average landholding of 0.83 hectares. It is noteworthy that the current study, utilizing NRLAIS database, reveals a higher average national landholding per farm household, which is 1.88 hectares, and the average number of plots held by a household to be 3.2. The prevalent farmland fragmentation across Ethiopia poses a significant challenge to land policy, emphasizing the need for reliable empirical data to support initiatives aimed at land consolidation.

Several studies conducted by various scholars in different parts of the country have explored farmers' perceptions of land fragmentation and the impact of land consolidation interventions on agricultural productivity (Abebaw et al., 2019; Gebreegziabher et al., 2022; Girum et al., 2019). Additionally, some studies have focused on analyzing distances between homesteads and farm plots, as well as average distances among different plots held by a household (see Table 6). The wealth of scientific documents and government reports on land fragmentation gains greater significance when subjected to comprehensive analysis and used to generate policy ideas.

Recognizing the gravity of land fragmentation in Ethiopia and its consequential impact on agricultural productivity, the Ethio-German Land Governance (LaGo) project, in collaboration with the Land Administration and Use Directorate (LAUD) of the Ministry of Agriculture, has initiated a study on the Socio-Economic Impacts of Land Fragmentation. This comprehensive study aims to evaluate NRLAIS data on farmland holdings and land fragmentation in the Amhara, Oromia, and Southern Nations, Nationalities, and Peoples (SNNP) Regions. It further involves conducting a meta-analysis of existing reports and studies, assessing the social, economic, and environmental implications of land fragmentation.

The study also endeavors to analyze land holdings, parcel numbers, and parcel sizes across the three regions of Ethiopia. Based on these findings and an evaluation of legal provisions, the study advocates for a tailored land consolidation strategy aligned with Ethiopia's unique

context. This initiative seeks to provide empirical evidence that substantiates the imperative for effective land consolidation strategies in Ethiopia, addressing the critical issue of land fragmentation for sustainable agricultural and economic development.

The following major technical activities were carried out to achieve the objectives of the study.

- Collecting, systematizing, and analyzing all NRLAIS-based data (covering 340 weredas) concerning the number, distribution, situation, and status of landholders' parcels.
- Analyzing existing land fragmentation-related data derived from NRLAIS, disaggregated to zonal, wereda, and regional levels, such as average parcel size and the average number of parcels per landholder.
- Gathering, analyzing, and systemizing studies and reports from relevant sector institutions, including the Ministry of Agriculture Land Administration and Use Directorate, regional land administration institutions, research institutions, universities, and other concerned bodies.
- Reviewing and producing a qualitative description of the impact of land fragmentation on the rural economy.
- Reviewing and quantifying the impact of land fragmentation (costs of inaction) based on land used for cereal production at the national level and assumptions derived from meta-analysis.
- Reviewing experiences in land consolidation interventions and providing a qualitative and quantitative description of their socio-economic impact.
- Identifying strategies for implementing land consolidation effectively.

2. Methods of data collection and analysis

2.1 Review of contemporary literature on land fragmentation and Land Consolidation

This study conducted a comprehensive Meta-analysis of the socioeconomic impacts of land fragmentation in Ethiopia. Before this analysis, numerous articles focusing on land fragmentation and consolidation underwent meticulous review to assess their relevance to the study. The evaluation criteria encompassed research methodology, inclusion of social, economic, and environmental variables, and the depth of exploration into various facets of land fragmentation. Key considerations during this investigation involved crucial issues, such as the concept of land fragmentation, historical and cultural factors triggering land fragmentation, socioeconomic and environmental impacts of land fragmentation, perception studies regarding fragmentation and consolidation, prerequisites for consolidation, challenges associated with the process, national experiences, and empirical evidence detailing the effects of fragmentation and consolidation.

Relying extensively on available literature, this study reviewed a catalog of both published articles and unpublished reports on land fragmentation in Ethiopia and beyond, primarily sourced from the internet. Each article and report underwent rigorous scrutiny, identifying treated variables and summarizing significant findings. These findings were meticulously analyzed within the framework of the research objectives, aiming to delve into the implications of land fragmentation on agricultural productivity, socioeconomic development, and environmental management. Over 40 articles were carefully considered, categorized thematically based on the primary issues addressed in each article. This thematic grouping facilitated an in-depth analysis of land fragmentation's impact on the rural economy. Additionally, pertinent articles addressing land fragmentation were reviewed, covering topics such as land consolidation concepts, consolidation rationale, legal frameworks, technical approaches, challenges, which ultimately were used as inputs for proposing a land consolidation strategy.

2.2 Study woredas for investigations on land fragmentation

The primary objective of this study is to evaluate the degree of land fragmentation in Ethiopia, utilizing the land-holding database of rural households in the Amhara, Oromia, and SNNP regions, which is meticulously maintained within the National Rural Administration Information System (NRLAIS). This database stands as a crucial instrument for safeguarding the land rights of farmers and fostering efficient land administration and management practices across the nation.

Presently, second-level rural land certification initiatives are underway in various woredas across the Oromia, Amhara, and SNNP regions, mainly supported by projects like LIFT, ReI-La, SLM, CALM, and GIZ, a global bilateral development cooperation organization is also contributing its share. To comprehensively understand the landscape of farmland fragmentation and analyze variables related to landholding among households nationwide, a total of 340 woredas from these three regions, where second-level land registration has been conducted, were included in this study.

In the Amhara region, the study encompassed 11 administrative zones, 112 woredas, and 1,697 rural kebeles, and evaluated the land holdings of 2,373,742 farm households. Similarly, in the SNNP region, the study covered 18 administrative zones, 104 woredas, and 2,104 rural kebeles, and analysis was made on the land holdings of 2,005,381 farm households for land fragmentation and per-household land ownership. In the Oromia region, the study spanned 17 administrative zones, 124 woredas, and 2,612 rural kebeles, and assessed the land holdings of 1,972,474 farm households for land fragmentation and individual land ownership per household.

Table 1. Amhara Region: Study zones, the number of woredas, rural kebeles, and farmland holders used for land holding and land fragmentation analysis

S/N	List of Zones	Number of Woredas in each zone	Number of rural Kebeles in each woreda	Number of landholders in each Woreda having their land registered in the NRLAIS Data base
1	Awi	9	164	185,545
2	Central Gonder	11	137	172,512
3	East Gojjam	17	324	475,251
4	North Gonder	2	5	7,718
5	North Wollo	9	152	247,122
6	South Gonder	12	240	390,714
7	South Wollo	12	126	191,636
8	West Gojjam	14	303	377,071
9	North Shewa	22	225	300,270
10	West Gonder	2	5	5,635
11	Waghemra	2	16	20,268
Total	11	112	1697	2,373,742

Table 2. Oromia Region: study zones, number of woredas, rural kebeles and farmland holders used for land holding and land fragmentation analysis

S/N	List of Zones	Number of Woredas in each zone	Number of rural Kebeles in each woreda	Number of landholders in each Woreda having their land registered in the NRLAIS Data base
1	West Hararge	10	301	247,948
2	East Harage	12	352	275,229
3	West Arsi	7	142	123,312
4	West Shewa	14	286	244,505
5	North Shewa	14	262	239,956
6	Arsi	19	380	291,551
7	East Wollega	7	98	97,313
8	Kelem Wolega	2	40	12,968
9	West Wollga	2	27	4701
10	Horogudru Wollega	6	83	47100
11	Guji	5	73	23295
12	Jimma	5	83	57785
13	East Shewa	7	199	128907
14	South-west Shewa	10	215	108362
15	Bale	1	21	47218
16	East Bale	1	18	10234
17	Buno Bedele	2	32	12090
Total	17	124	2,612	1,972,474

Table 3. SNNP Region: Study zones, number of woredas, rural kebeles and farmland holders used for land holding and land fragmentation analysis

S/N	List of Zones	Number of Woredas in each zone	Number of rural Kebeles in each woreda	Number of landholders in each Woreda having their land registered in the NRLAIS Data base
1	Wolayta	14	235	202,141
2	Kembata	6	79	202,145
3	Hadiya	11	283	197,699
4	Silte	9	163	156,066
5	Sidama	11	203	247,122
6	Gamo	11	244	240,144
7	Dawro	5	77	40,598
8	Konso	2	25	24,763
9	Dehub Omo	1	33	22,455

S/N	List of Zones	Number of Woredas in each zone	Number of rural Kebeles in each woreda	Number of landholders in each Woreda having their land registered in the NRLAIS Data base
[cont.]				
10	Kefa	1	25	14,055
11	Halaba	3	71	50,459
12	Yem Special	1	34	14,615
13	Basketo	1	30	6,434
14	Derashe	1	16	40,747
15	Gurage	15	367	261856
16	Goffa	5	129	112464
17	Gedeo	6	72	144157
18	Ale Special	1	16	27461
Total	18	104	2,104	2,005,381

2.2.1 Data Analysis

To give a clear picture on the land holding size distribution among farm households, the area of land owned by each household is disaggregated in different land holding size categories as indicated in Table 4.

Table 4 Land holding size categories

S/N	Land Holding category
1	≤ 0.5 ha
2	0.51 - 1 ha
3	1.1 - 1.5 ha
4	1.51 - 2 ha
5	2.1 - 2.5 ha
6	2.51 - 3 ha
7	> 3 ha

Once the NIRLAS data become available, computations were conducted to determine the average land holdings across the three regions and at the national level. Similarly, an analysis was performed to ascertain the average number of parcels held by each household. Additionally, to provide insights into the distribution of parcel numbers among farm households, an examination was carried out on the percentage of households falling within various parcel range categories (1 to 2 parcels, 3 to 5 parcels, 6 to 8 parcels, and over eight parcels). The variables included in this analysis are summarized in Table 5, and the findings are presented through bar graphs.

Table 5. Summary of variables included for analyzing land holding and land fragmentation at National, Regional, Zonal and household level

Measurement Unit: Hectare/Number of parcels	I: Average land holding and number of parcels held by households across the study regions						
	Average land holding by a farm household (ha) across zones in the study regions.	Average land holding by a farm household in each region (ha).	Average National farm land holding by a household	Average number of parcels held by farm households in the study zones	Average number of parcels held by farm households in each region	Average National number of parcels held by a farm household at national level	
II: Land holding description in different area categories in percent across the study regions							
Percent of farm households in each land holding category across regions, zones and woredas and at national level	Up to 0.5 ha	0.5-1	1.1-1.5 ha	1.51-2 ha	2.1-2.5 ha	2.51- 3 ha	More than 3 ha
III: Percent of farm households in different number of parcel categories across the study zones and regions							
Parcel Category	1-2 parcels	3-5 parcels	6-8 parcels	More than 8 parcels			
Percent of Farm households in different parcel category							

2.3 Meta-analysis of socio-economic impacts of land fragmentation

Meta-analysis involves the statistical analysis of data from distinct primary studies that focus on the same question, aiming to generate a quantitative estimate of the studied phenomenon (Gopalakrishnan and Ganeshkumar, 2013). This approach leverages a wealth of existing research on a topic, enhancing the breadth of participant data available to address a research question, bolstering result reliability, and offering conclusive answers to debated research queries.

The primary rationale behind Meta-analysis lies in its capacity to synthesize data from multiple sources, aiding in research planning and guideline formulation. It optimizes the use of existing data, ensuring generalizability, verifying relationship consistency, explaining data disparities, and quantifying information (Gopalakrishnan and Ganeshkumar, 2013). To address the objective within Meta-analysis, the initial step involved defining the research question or formulating the hypothesis related to land fragmentation and agricultural productivity. In this study, the hypothesis posited that land fragmentation adversely affects agricultural productivity

This process entailed several stages, including a systematic literature review on land fragmentation, filtering studies to select pertinent ones, summarizing data or outcomes from each study, and assessing study quality while calculating and combining outcome measures. The specific sources of literature on land fragmentation, inclusion and exclusion criteria, and model specifications are detailed in the following section.

Land fragmentation studies utilized for the Meta-analysis were sourced from various platforms such as Web of Science, Google Scholar, AgEcons search, and other online databases using specific keywords. Furthermore, additional data were also obtained from unpublished theses and reports. Keywords and variables like land fragmentation, land fragmentation index, number of parcels, distance of parcels from the homestead, and the impact of fragmentation on crop productivity and income were employed to secure relevant articles aligning with the study's research question/hypothesis.

Most of the studies incorporated in this Meta-analysis originated from journal publications. Initially, a total of 47 studies were identified, with 20 conducted in Ethiopia and the rest in other countries. Of these, 27 studies were excluded due to incomplete information regarding potential explanatory variables, study location (outside Ethiopia), or paper nature (e.g., review articles). Consequently, 20 studies were deemed suitable for the Meta-analysis. None of the land fragmentation and productivity studies in this Meta-analysis utilized panel data. Each study in a Meta-analysis represents a single outcome variable with a sufficient number of independent variables. Information was extracted and coded from these studies on reported coefficients, standard deviations, and several potential explanatory variables significantly influencing the dependent variables.

2.3.1 Econometrics Model Specification for the effects of land fragmentation on crop productivity

The Random Effect Model Estimation:

Econometrics models indicate the theoretical relationship between different dependent and explanatory variables. The effect of land fragmentation on crop productivity was mainly analyzed using multiple linear regression, stochastic frontier, and semi-log models. The Meta-analysis statistical methods are generally based on standard fixed or random effects models by considering the results in the different articles. As applied in this study, the random effects model is described as follows. A collection of k studies were considered, where the i^{th} study estimated effect size Y_i depends on the true effect size (θ_i) and the disturbance term (e_i). A general model is then specified by:

$$Y_i = \theta_i + e_i \dots (1)$$

Where;

e_i indicates random deviations from the true effect size and assumed independent with mean zero and variance σ^2 . This implies that the estimated effect size Y_i is normally distributed with mean θ_i and variance σ^2 . Y_i can be any measure of effect, provided the assumption of normality is appropriate.

In general the parameter of interest is the overall effect, denoted by μ . The fixed effects model assumes $\theta_i = \mu$ for $i = 1, 2 \dots k$, implying that each study in the Meta-analysis has the same underlying effect. Note that even if θ_i are assumed to be the same, the Y_i are not identically distributed due to the possibility of differing σ^2 . The estimator of μ is generally a simple weighted average of the Y_i , with the optimal weights proportional to $w_i = 1/\text{var}(Y_i)$. In practice the variances are not known, hence, estimated variances $\hat{\sigma}_i^2$ are used to estimate both μ and $\text{var}(\hat{\mu})$.

Any effect of this is generally ignored in practice, but to indicate this estimation the notation δ^2_i was used throughout. Hence, we define $w_i = 1/\delta^2_i$ giving:

$$\hat{\mu} = \frac{\sum w_i Y_i}{\sum w_i} = \frac{\sum \frac{Y_i}{\sigma_i^2}}{\sum \frac{1}{\sigma_i^2}} \text{ and } \widehat{var}(\hat{\mu}) = \frac{1}{\sum \frac{1}{\sigma_i^2}} \dots (2)$$

In contrast to the fixed effects model, the random effects model does not assume that θ_i are equal, but it assumes that they are normally distributed. This gives the two-stage model:

$$Y_i = \theta_i + e_i \text{ where } e_i \sim N(0, \sigma_i^2)$$

$$\theta_i = \mu + \varepsilon_i \text{ where } \varepsilon_i \sim N(0, \tau^2) \dots (3)$$

The error terms e_i and ε_i are assumed to be independent. In this case, the true effect for the study i is centered on the overall effect, allowing individual studies to vary both in estimated effect and true effect. The random effects variance parameter σ^2 is a measure of the heterogeneity between studies. The fixed effects model is a special case of the random effects model, with $\tau^2 = 0$.

The random effects model given in (1) can be written as:

$$Y_i = \mu + \varepsilon_i + e_i \dots (4)$$

The model explained above and used for Meta-analysis considers a summary of findings of land fragmentation and productivity studies carried out by different researchers in Ethiopia. The Meta-analysis also presents the weighted coefficient and standard errors of different articles. The coefficient of the independent variables indicates the effects of land fragmentation and other parameters on crop productivity.

3. Review of the impact of land fragmentation on the rural economy

There is a substantial body of literature addressing various aspects of land fragmentation. This section commences by offering a definition of land fragmentation, followed by an overview of its attributes. It further delves into arguments detailing the adverse effects and positive characteristics of land fragmentation on crop productivity, labor/technical efficiency, and sustainable land management. Finally, this section outlines the policy implications of land fragmentation in relation to land consolidation.

3.1 Land fragmentation: Definition and the pros and cons of land fragmentation on crop productivity and sustainable land management

The literature defines land fragmentation as the situation where a farming household owns several non-contiguous land plots scattered over a wide area (Bentley, 1987). It is also characterized as the division of land into multiple distinct plots, leading to smaller average farm holdings and increased scattering of land among farmers (Tan et al., 2006). This concept involves numerous spatially separated parcels, considering factors like plot size, shape, distance from farm buildings, and intervals between plots (Ciaiana et al., 2018; Kiplimo and Ngeno, 2016).

Debates around land fragmentation present two contrasting arguments. Arguments against fragmentation—implicitly supporting land consolidation and related measures—highlight increased travel times, higher boundary waste, limitations on larger scale investments, and labor supervision challenges. Observations suggest that fragmentation is an indicator of inefficiency in agricultural production across many countries (Monchuck et al., 2010). Additionally, irregularly shaped fields pose difficulties for machinery, as most farming equipment is designed for larger, regular farmlands (Bentley, 1987). Furthermore, fragmented parcels create a complex boundary network leading to uncultivated land at parcel margins, although this may assist in reducing soil erosion (Dhakal and Narendra, 2018).

Conversely, land fragmentation presents arguments in its favor. Proponents highlight its role in reducing risks in crops and promoting diversified production (Monchuck et al., 2010). Studies in Albania suggest that fragmented holdings lead to greater diversification, particularly for households focused on self-consumption rather than market-oriented production (Ciaiana et al., 2018). In the Ethiopian context, farmers produce both for home consumption and for the market. Hence, a balance has to be struck when considering land consolidation. Fragmentation is also argued to offer ecological benefits by creating a natural mosaic of parcel shapes and crops, blending more harmoniously with the landscape, especially in semi-mountainous areas. Additionally, smaller land sizes are considered less prone to wind damage, crop diseases, and soil erosion (Demetriou, 2014).

3.2 Triggering factors for land fragmentation

Agricultural land fragmentation, a widespread phenomenon globally, stems from a complex interplay of various factors encompassing institutional, political, historical, and sociological dimensions, as delineated in the subsequent sections. In the literature, two prevalent explanations concerning the emergence and persistence of land fragmentation have been articulated: the demand-side explanation and the supply-side explanation (Bentley, 1987; Blarel et al., 1992). The demand-side perspective interprets land fragmentation as a deliberate choice made by farmers, while the supply-side rationale regards it as an external imposition on farmers, influenced by factors such as population pressure, inheritance norms, and land scarcity. The demand-side viewpoint assumes voluntary decision-making by farmers, perceiving fragmentation as a rational response wherein the benefits might outweigh the costs (Blarel et al., 1992; Di Falco et al., 2010).

For instance, it suggests that farmers may opt for operating on dispersed plots to mitigate production risks in the face of varying land qualities or to manage labor distribution efficiently in the absence of a formal labor market. Moreover, during commodity market failures, fragmented lands facilitate diversification in crop cultivation to ensure household consumption. Similarly, when economies of scale are unfavorable for specific crop productions across individual parcels, farmers resort to fragmentation to optimize production by cultivating diverse crops—a practice notably observed in the highlands of Ethiopia where mixed farming prevails.

On the other hand, the supply-side explanation focuses on involuntary land fragmentation imposed on farmers due to external factors. Land scarcity, propelled by population pressure and a policy of equitable land distribution, often necessitates fragmented holdings as communal lands transform into smaller parcels. Factors such as cheap labor prevalent in many African and Asian countries, legal rights favoring partible inheritance, and limited off-farm job opportunities contribute to this phenomenon. Additionally, imperfect land markets, restrictive land transaction laws, and inadequate credit facilities are external influencers leading to land fragmentation (Blarel et al., 1992; Tan et al., 2006).

Several authors argued that the egalitarian principle of land allocation with an attempt to accommodate the landless reasonably, considering plot diversification based on plot quality and location, has led to fragmented holdings (Segers et al., 2010). Similarly, in Albania, the land reform of 1991 that adopted the egalitarian principle to ensure that everyone has equal access to land is considered the major cause of land fragmentation. Pursuant to this, Ciaiana et al. (2011) argued that the land reform done in the early 1990s caused the split of land into many small plots of heterogeneous quality, and the effort to provide ground in equal quantity and quality to the community means that there were fertile rooms for the land to be fragmented.

Literature shows that triggering factors for land fragmentation in central European countries are linked to poor cultural and ethical practices, adverse land law and policy, weak enforcement of rules, inability to defend rights, imperfections in the land registry, negative community characteristics, intense competition for land, pressure on resources, and land degradation (Sklenicka, 2016). In the Sub-Saharan Africa context, the occurrence of land fragmentation is activated by four significant factors: inheritance; population growth; land markets; and historical/cultural perspectives (Kiplimo and Ngeno, 2016). In China, the egalitarian land distribution policy with the aim of equitable access to land has been considered a driving force of land fragmentation. In addition, the trend to cultivate high-value-added crops was also a cause of higher land fragmentation. Agricultural dependency is also identified as a cause of land fragmentation in South Asia (Niroula and Thapa, 2005).

In most countries, the most cited cause of land fragmentation is inheritance. In inheritance, the land is divided among all heirs. In this modality of land transfer, the land may either be physically divided among heirs or the new heirs increase the number of land co-owners (Sklenicka, 2016). The other common reason for fragmentation is parcel division during the sale or change of use – basically due to land conversion induced by development pressure (Sklenicka, 2016). In the Ethiopian context, although informal land transaction is contributing its share to land fragmentation, Solomon Assefa (2013) contends that land fragmentation happens due to two principal factors: population pressure and egalitarian land reforms over the years. Yigremew (2002) recognizing Solomon's arguments, contends that land inheritance is a critical and notable factor of land fragmentation in Ethiopia. The preceding explanations demonstrate a comprehensive understanding of the causes of land fragmentation is fundamentally essential to craft policy interventions that could help halt land fragmentation and pave the avenue for land consolidation.

3.3 Socioeconomic and environmental impacts of land fragmentation

The practice of land fragmentation carries implications for economic, social, and environmental facets, notably impacting agricultural productivity in various ways. Firstly, fragmentation can elevate transportation requirements, particularly when farmlands are dispersed, necessitating time-consuming travel between plots and residences. This logistical challenge amplifies the complexities, costs, and management efforts associated with these scattered parcels (Nath and Narendra, 2018). Additionally, the need for fencing, border construction, paths, and roads to connect scattered parcels leads to an inefficient use of land that could otherwise be utilized for productive farming activities.

A study in Sri Lanka noted a decrease in domestic paddy production, from 65% to 45% of domestic supply, owing to increased plot numbers. The rise in plot numbers corresponded with a significant negative impact on productivity, with an estimated reduction in yield of 56 kg per acre (Wickramaarachchi and Weerahewa, 2016). It is not solely the number but also the shapes of these plots that influence productivity; irregularly shaped parcels hinder mechanization, potentially limiting the land's production potential in the absence of such advancements.

Furthermore, fragmented land holdings pose challenges in cultivating high-profit crops, like fruits requiring larger plots. Farmers managing fragmented, dispersed land holdings may be constrained to grow less profitable crops due to land size and location limitations, contributing to economic inefficiency (Nath and Narendra, 2018). Studies suggest that land fragmentation is indicative of production inefficiency.

Beyond its impact on productivity, land fragmentation strains social relationships among landholders. Fencing disputes and conflicts over boundaries arise, leading to tensions among neighboring farmers (Jha et al., 2005; Solomon Assefa, 2013; Gashaw Tenna et al., 2017). Moreover, fragmented land complicates soil conservation efforts and irrigation practices, raising construction costs and impeding efficient resource management, ultimately affecting farmers' incomes (Demetriou, 2014).

Addressing food shortages and bolstering agricultural productivity necessitates focusing on increasing yields per hectare rather than expanding cultivated land due to its limited availability. Land consolidation emerges as a potential solution, aiming to shift from fragmented land practices towards consolidated farming units. Implementing land consolidation programs, coupled with mechanization, offers prospects for enhancing productivity. Consolidated land minimizes travel times, reduces boundary inefficiencies, allows for larger-scale production and efficient labor utilization, mitigates boundary conflicts, and streamlines land management, collectively contributing to enhanced agricultural productivity. It should however be noted that for land consolidation to materialize apart from winning the willingness of the farm households and it needs to be complemented by infrastructure development such as field roads networks, irrigation or drainage networks and other social amenities which all require provision of adequate financial resources and efficient institutional arrangements.

While assertions suggest that land fragmentation negatively impacts agricultural productivity, some evidence suggests its ecological benefits, as highlighted in section 3.1. The research findings and methodologies from various articles addressing land fragmentation and its implications are summarized below in Table 6 to provide a comprehensive overview of the aforementioned issues.

The review compiled in Table 6 clearly demonstrates that in most cases land fragmentation is a hindrance to agricultural productivity. It should however be noted that there are incidents indicating positive features. The scenario in general suggests that it is essential to be cautious when designing land consolidation programs.

Table 6 Summary of Some Land Fragmentation Literatures

Abbreviations meaning: SI = Simpson Index; N = Number of Plots; D = Average Plot Distance;

A = Average Plot Size; FHHM = Farm Household Model; LF = Land Fragmentation;

LC = Land Consolidation; HH = Household; TC = Transaction Cost; MVP = Multi Variant Probit

S/N	Authors	Location of the study	Independent Variables		Dependent Variables	Research Methods		Results <i>Crop productivity, Input efficiency, Agro-biodiversity, SLM, crop diversification</i>	Conclusion	Recommendation
			LF parameters	Other Variables		Sample Size	Model Used			
1	Solomon Assefa (2013)	Northern Ethiopia	A,N,I,D	Labor, Fertilizer; Soil type; Soil Fertility; Slope	Farm productivity; efficiency; Crop diversity	421 HH and 1918 Plots	Stochastic frontier	No evidence to the conventional claim that land fragmentation could be detrimental to productivity or efficiency A=0.24 N=5.61 D=22.22 I= 0.72	Signs of negative implication of land fragmentation are observed only in the dominant crop model that ignores diversification.	Focus on land consolidation policy
2	Akalu Teshome et al. (2014)	Northwest Ethiopia (Sekela; Gozamen; Yilmana Densa)	A,N,D	Soil Type; class; depth; fertility	SLM	300 HH 1,700 plots	Descriptive; inferential; Multivariate probit (MVP) model	The overall results indicate that farmland fragmentation hinders SLM investments. N=4.54 A=0.26	Land fragmentation influence farmers' investments in SLM	Policy measures are needed to stop further fragmentation of cultivated land.
3	Dafa Gudina (2011)	Southeast Ethiopia	D,A,N & Januszewski Index	Labor; Fertilizer; Compost	Productivity		General Linear Model & Cobb Douglas Production Function	The mean of the current landholdings of the sample population was found to be 2.3 ha with standard deviation of 1.31, while the mean current household's landholdings would fall to be 0.9 hectare	The output elasticity estimates showed that farm fragmentation had influenced the productivity of crops and croplands negatively.	Problems due to fragmentation can be solved by implementing a policy that supports formalization of non-monetary exchanges /in-kind/ and the accommodation of the practice of voluntary land exchange

S/ N	Authors	Location of the study	Independent Variables		Dependent Variables	Research Methods		Results <i>Crop productivity, Input efficiency, Agro-biodiversity, SLM, crop diversification</i>	Conclusion	Recommendation
			LF parameters	Other Variables		Sample Size	Model Used			
4	Gashaw et al. (2017)	Northwest Ethiopia (Dega Damot, Quarit, and Sekela)	LF: 0N, D, A	Inputs Variables: Oxen power intensity	Crop productivity; Net farm income	240HH	Linear and Cobb-Douglas production functions	Land productivity negatively affected by distance from the homestead ($p \leq 1\%$) (Average farmland size of 1.25 ha was obtained as minimum size that can generate minimum food and cash requirement of an average family of five adult equivalents.)	Farmland productivity is negatively explained by variations in land fragmentation parameters	Population growth controlling program to reduce land inheritance; government should come up with (revise) land policy to encourage consolidation. Take actions to improve land productivity
5	Cholo et al. (2019)	Gamo Highlands of Ethiopia	I, N, D, A	SLM Parameter	Climate change adaptation & Food security	297HH	Probit and Poisson Regression	A marginal increase in the Simpson index increased the probability of food security, by 83%. Moreover, a unit increase in the number of plots increased the probability of food security	The study found that land fragmentation provides more potential opportunities for improving food security than being a challenge	Reducing severe LF through the assembly of small parcels into larger heterogeneous plot clusters could enhance food security by exploiting synergies between adaptation practices and LF.
6	Gebregezi-abher et al. (2019)	Northwest Ethiopia	I, N, D, A	Land quality parameters	SLM	194 HH	Multivariate Probit	-	The overall results indicate that farmland fragmentation hinders SLM investments.	Policy makers should consider various land associated factors in designing SLM policies and programs. The consolidation policy should be encouraged.
7	Tesfaye et al. (2018)	Southwest Ethiopia	I, N, D, A		Climate Adaptation Measures	297	Probit model	LF poses a challenge to the application of effective SLM practices and hence can exacerbate land degradation and vulnerability to food insecurity and climate change	A qualitative analysis indicated that farmers perceive land fragmentation as an obstacle to land improvement but good for adaptation strategy in case of crop failure	Proposed further research that identifies fit-for-purpose land consolidation strategy and promotes sustainable development to decide the impact of LF.

S/ N	Authors	Location of the study	Independent Variables		Dependent Variables	Research Methods		Results <i>Crop productivity, Input efficiency, Agro-biodiversity, SLM, crop diversification</i>	Conclusion	Recommendation
			LF parameters	Other Variables		Sample Size	Model Used			
8	Daniel et al. (2010)	Micro evidence from India	SI, N D, A	Input variables	Land fragmentation and efficiency		Unique household survey	The analysis of results indicated that certain variables of land fragmentation do appear to adversely affecting production	Land fragmentation affect efficiency negatively	Land consolidation programs in India appear to be rather costly in terms of time and other resources, hence cost-effective approaches should be looked for.
9	Blarel et al. (1992)	Ghana & Rwanda	SI, N D, A		Production		Pooled Ordinary Least Square Method (OLS)	Yield (-) Cost (+)	LC is unlikely to increase productivity significantly	Focus on reducing root causes of LF. Promote land & non-land factor markets.
10	Parikh and Shah (1994)	Pakistan	N		Production Efficiency		Stochastic Frontier, Maximum Likelihood Estimation (MLE)	Negative relationship (no causality identified)	LF can be result of technical inefficiency rather than a cause of it.	Increasing education and availability of credit along with land consolidation would improve efficiency.
11	Jabrin and Epplin (1994)	Jordan	A		Production Cost; Efficiency		Generalized Least Square Method (GLS)	Cost (+) Production efficiency (-)	LF is indeed an impediment to efficient wheat production.	Consolidate land by encouraging land market.
12	Nguyen et al., (1996)	China	A		Production cost; productivity		Production function	Cost (+) Productivity (+)	Outcome could be expensive in terms of output forgone.	LC with less government intervention; improve land market, grain market and access to credit

S/ N	Authors	Location of the study	Independent Variables		Dependent Variables	Research Methods		Results <i>Crop productivity, Input efficiency, Agro-biodiversity, SLM, crop diversification</i>	Conclusion	Recommendation
			LF parameters	Other Variables		Sample Size	Model Used			
13	Hung et al. (2007)	Vietnam	N, Labor		Labor efficiency; Land productivity		Standard FHHM Frontier Regression	Production (-) Labor use (+)	Real benefits to FHHs from LC may not be apparent until the real opportunity cost of farm labor begins to rise.	Consolidate land by creating new off-farm jobs and movement of agricultural labor force to other sectors of the economy.
14	Tan et al. (2010)	China	A, D SI		Cost Efficiency	Farm Household Model (FHHM)	Cost (-)	The net impact on total production cost is not significant.	LC can stimulate, technological adoption, but also can reduce agricultural employment and increase the rural labor surplus.	
15	Rahman and Rahman (2009.)	Bangladesh			Production efficiency	SPFA (MLE)	Productivity and efficiency (-)	Productivity and efficiency are adversely affected by fragmentation	Address the structural causes underlying the process of LF, revise the law of inheritance and political economy of the agrarian sector.	
16	Di Falco et al. (2009)	Bulgaria			Agro-biodiversity; Farm Profit	Two Stage Least Squares (Village fixed effect)	Profit (-) Agro-biodiversity (+)	Policy measure of LC must carefully maintain the net effect of LF between Agro-biodiversity and profit.	Instead of LC improve functioning of land, labor, credit and food markets, and access to improved technology and off farm employment.	

Source: *Own review*

4. Ethiopia: Brief history of land tenure in the context of land fragmentation

Ethiopia's historical evolution over the past centuries has witnessed three prominent regimes: The Imperial regime, the Marxist Derg Regime, and the EPRDF regime, which is currently undergoing political and socioeconomic reforms. Before 1974, under the Imperial rule, Ethiopia's land tenure was region-specific, characterized by diverse systems (Deninger et al., 2008). In the northern highlands, the prevalent land tenure was *rist*, representing communal ownership within family lineages. Here, land belonged to the family collectively, preventing its sale, mortgage, or transfer outside the family. With family expansion, parcels were repeatedly subdivided, creating numerous smaller properties.

Conversely, in the southern regions, land tenure was marked by *gult* and private ownership, known as the *gebar* system. Sharecropping prevailed here, constituting a substantial portion of land use, especially under the *gebar* system, which continuously subdivided to accommodate more tenants. Historical assessments during the Imperial period underscored a continuous trend of subdivision and reduction in land holdings. The need for progressive taxation on underutilized land spurred the subdivision for cultivation purposes, affecting both northern and southern regions. Subdivision and land fragmentation were identified as key obstacles to agricultural production before 1974 (Yigremew Adal, 2002).

In 1975, following the overthrow of the Imperial regime, the Marxist Derg regime initiated a radical land reform program that nationalized all land and abolished tenant-landlord relations. The state seized land from large landowners and redistributed it, aiming for equitable allocation, categorizing land quality and allocating parcels accordingly. This redistribution, while aiming for equity, exacerbated land fragmentation, notably witnessed in studies such as those conducted in Gojam, northern Ethiopia (Ofcansky and Berry, 1991 cited in Knippenberg et al., 2017). The egalitarian redistribution principle led to severe diminution of holdings, identified as a major cause of farmland fragmentation during the Derg regime.

The subsequent EPRDF regime, from 1991 onwards, maintained state ownership of land but restricted further redistributions in its 1995 Federal Constitution (FDRE, 1995). Though land redistribution continued until 1997, subsequent rural land laws stipulated redistributions only if deemed beneficial without compromising productivity, supported by society and established by law. Minimum parcel size restrictions were implemented for rain-fed and irrigated land, aiming to limit excessive subdivision among households. Land access and fragmentation in Ethiopia, as reviewed by Knippenberg et al. (2017), have persisted across regimes, hindering agricultural development and the economy overall. The prevalent land fragmentation highlights the necessity for strategies promoting gradual land consolidation to alleviate fragmentation-related issues and foster sustainable productivity.

5. Global experiences in land consolidation

FAO's (2020) legal guide on land consolidation defines land consolidation as "a legally regulated procedure led by a public authority and used to adjust the property structure in rural areas through a comprehensive reallocation of parcels, coordinated between landowners and users in order to reduce land fragmentation, facilitate farm enlargement and/or achieve other public objectives, including nature restoration and construction of infrastructure." The same source also underlines that land consolidation should be highly participatory, gender-sensitive and ensure that all participating landowners are at least as well off after the procedure as compared with before. Land consolidation is a constantly evolving land management instrument closely linked to many dynamic fields, such as the economy, democracy, policies, technologies, and the environment.

When correctly implemented, land consolidation is a land management instrument designed to develop efficient land tenure structures and eliminates inefficiencies that have emerged from historical, political, economic, and environmental changes. The fact that land consolidation programs have been in place for decades or even centuries, they offer ample evidence of its potential for rural prosperity.

Different studies indicated that the disadvantages of land fragmentation outweigh its advantages; hence land consolidation schemes are promoted to curb the problems associated with land fragmentation. It should however be noted that there is no need to rush to land consolidation intervention because it has public and private costs. The experience in Cyprus shows the process of land consolidation is tiresome and costly. Among other things, the land must be surveyed, with detailed maps of each community showing "the location, elevation, size, soil type, land use type, value, and owner of each parcel". Doing so requires an extensive cooperation of different stakeholders: agronomists, surveyors, and local farmers (Bentley, 1987). Not only this, there must be technical and financial capacity to rearrange the parcels into larger blocks, which is followed by a drawing up of a second map containing the location of the new parcels and this should be clarified to farmers in a manner they can understand.

As witnessed in Cyprus, the process of land consolidation was confronted by series of litigations as farmers were found unsatisfied with their new holdings. The devised strategy was then to establish a panel composed of legal professionals and people with a detailed knowledge of local agriculture to hear the litigation proceedings (Ibid). Staying on Cyprus, one can note that expensiveness is not the only disadvantage of land consolidation, it is also slow. Data revealed that a land consolidation program in a single average village takes 5-7 years to complete (Ibid). Considering these, care should be taken in the process of consolidation as the process may lead to disruption of the crop cycle for two to three years due to surveying, litigation, road building (Ibid).

Although there are three generic forms of land consolidation, namely voluntary, majority based, and mandatory, the experience of land consolidation in the Netherlands shows two possibilities for consolidating farmlands. The first is the requirement for mutual agreement by the respective landowners. It is qualified that most landowners should vote in favor of the consolidation. The second is by the force of the law. Under this condition, land consolidation is possible upon permission from owners of over 50% of the land. Data indicate that nearly all the land consolidated in the Netherlands has been done through the second option. Gradually many of those who were not happy with the land consolidation approach have accepted the land consolidation program. In India, too, land has been consolidated by force, given that the farmers were not voluntarily cooperating with the consolidation (Ibid). In Kenya, its 2009 National Land Policy emphasizes the need to allocate and use land in an economically viable, socially equitable, and environmentally sustainable way (Kiplimo and Ngeno, 2016).

The literature underscores that a country can employ three strategies, which are not mutually exclusive and are ideally intertwined, to effectively address land fragmentation and facilitate rational agricultural development. The initial strategy involves the promotion of legislation pertaining to aspects influencing land fragmentation to proactively prevent the exacerbation of the issue. This strategy entails the implementation of legal provisions, predominantly restrictions, and entails modifications to legislation concerning inheritance, the minimum size of parcel division, absentee landowners, prevention of transfer to non-farmers, leasing regulations, and the imposition of a maximum limit on the size of a holding, among other measures (Demetriou, 2014). These legislative measures collectively serve to discourage land fragmentation within a nation.

The second strategy is to apply specific land management approaches to tackle problems specific to land fragmentation. The specific strategies here include land consolidation, land funds, land banking, voluntary parcel exchange, and cooperative farming. Basically, land consolidation is a prominent measure applied as a solution to land fragmentation. The third strategy is to apply specific land protection policies to protect agricultural land from possible housing and commercial land use encroachment. This is basically the case when there is mixed land use, i.e., agricultural and housing, and this has been common in the United States of America. Such policies maintain the agricultural land that is a driving force to accelerate economic development, though its notable disadvantage is its high cost of implementation (Demetriou, 2014).

The other precaution in dealing with land consolidation as a policy intervention for land fragmentation is the need not to overlook the advantages of land fragmentation from the farmers' perspective. There should be evidence-based decisions and actions on whether consolidation programs lead to significant productivity that makes farmers better off or not before the issuance of policy on land consolidation. Gashaw et al. (2017) confirmed that the possible effects of land fragmentation parameters (distance of parcels, number of parcels owned, and average size of parcels) should be considered on a separate basis with the view to take proper measures on each of them. In this regard the feedbacks from land consolidation feasibility studies and the recently introduced cluster framing practices in Ethiopia are vital inputs to guide the land consolidation process.

While there are efforts to regulate land fragmentation and enhance voluntary land consolidation in Ethiopia, there remains a long way to get things governed in detail. Girum and Stiem-Bhatia (2019) argued that the regulations so far failed to regulate the following issues to the extent required: a) the different procedures that should be followed from initiation until final implementation of voluntary land consolidation; b) the guiding principles that should be

followed and applied during the implementation of voluntary land consolidation; and c) the implications of inheritance regulations for voluntary land consolidation and how this should be legally handled to tackle future fragmentation. They further noted that given this state of the regulations pertaining to land fragmentation, a need for further refinement of the regulations relating to land consolidation, considering the different perspectives of the farming communities, is warranted (Ibid). There is a general understanding in Ethiopia that land fragmentation is a challenge to agricultural development. Despite some limitations, the rural land laws are giving due consideration to it, as described below.

6. Mirroring rural land policy Issues in the context of land fragmentation and consolidation in Ethiopia

As previously stated, government-led land redistribution or the transfer of land through inheritance or gifts results in land fragmentation, leading to a gradual reduction in parcel size. The persistent trend of increasing land fragmentation, coupled with diminishing parcel sizes, poses a significant challenge to subsistence agriculture. Several years ago, national survey results indicated that the average farm size in the highlands was fragmented into 2.3 plots, each measuring 0.35 hectares (Menberu, 2014). Recently, however, various studies have reported a higher degree of average land fragmentation. For instance, Melese Damtie (2018) reported 4.38 parcels, Yigremew Alemu (2018) reported 5.96 parcels, Gebreegziabher (2019) reported 5.46 parcels, Teshome (2022) reported 3.54 parcels, Dafa (2011) reported 3.34 parcels, and Girum and Stiem-Bhatia (2019) reported 5.15 and 3.54 plots in two different woredas. It is evident that the trend of increasing land fragmentation has been consistently observed in recent studies, emphasizing the urgency for comprehensive strategies to address this issue and ensure the sustainability of subsistence agriculture in the region.

Land fragmentation remains a pervasive national issue in Ethiopia, prompting the enactment of rural land proclamations that include provisions aimed at restricting land redistribution. However, these laws do not completely preclude the possibility of land distribution. For instance, the Federal Rural Land Use and Administration Proclamation has provisions that restrict future land redistribution. The proclamation explicitly stipulates that, in cases where landholders express the desire for and resolve that land distribution is the only viable option, such redistribution must adhere to certain criteria. Specifically, it should not result in holdings smaller than the minimum prescribed size, and it should be executed in a manner that prevents the fragmentation of land and degradation of natural resources (FDRE Proc. No. 456/2005, Art. 9/3).

Furthermore, the law recognizes the transfer of rural land through succession, underscoring that such transfers must adhere to specified standards. Notably, when land is transferred through inheritance, the size of the land being transferred should not fall below the minimum landholding stipulated by relevant laws (Ibid, Art. 11/2). Another mechanism employed to discourage land fragmentation is the legal preference for the exchange of land parcels among

landholders. This approach facilitates the consolidation of small farm plots, making them more conducive for development (Ibid). Encouragingly, there have been instances where farmers voluntarily initiated the exchange of parcels, strategically positioning them closer to each other or to their homesteads. Given that such initiatives are rooted in the free consent of the farmers, they present a significant opportunity for large-scale nationwide land consolidation.

The regional states of Amhara, Oromia, and SNNP are cognizant of the challenges posed by land fragmentation, and their rural land laws, in principle, discourage such fragmentation. For instance, the Amhara National Regional State (ANRS) rural land administration and use proclamation has explicitly prohibited land redistribution. According to the law, „in any part of the region, land redistribution and allotment shall not be carried out upon the coming into force of this proclamation“ (ANRS Proc. No. 252/2017 Art. 13/1). Notably, the legislation does not prohibit the allotment of irrigation land to users (Ibid, Art. 13/2). This provision becomes particularly relevant when landholders are displaced from their holdings due to irrigation development projects supported by government or non-government organizations. In such cases, irrigation users have the opportunity to acquire land through allotment (Ibid, Art. 13/3). The redistribution process takes into consideration the minimum land size applicable for irrigable lands as well as that of rain-fed farms. Under Regulation No. 159/2018, Art 5, specific minimum plot sizes have been defined. These include not less than 0.25 hectares for rain-fed cultivation, 0.06 hectares for irrigable land, and 0.02 hectares for the construction of a dwelling house (ANRS Reg. No. 159/2018, Art. 5). These regulations aim to address the challenges associated with land fragmentation while ensuring equitable distribution and sustainable land use practices within the region.

The ANRS rural land law offers a solution when land is inherited among legal heirs, and the subsequent division results in parcel fragmentation below the recommended minimum size. In such instances, if a parcel is set to be inherited by two or more heirs, and the share allocated to each heir falls below the minimum farmland requirement specified by regulations, they are precluded from dividing the farm. Instead, they are mandated to utilize it collectively (ANRS Proc. No. 252/2017 Art. 17/9). Moreover, the rural land law actively promotes the exchange of parcels among landholders, implicitly discouraging land fragmentation. Consequently, rural landholders have the option to mutually agree to consolidate their individually held smaller plots, creating contiguous and more suitable areas for development. Importantly, this intervention is firmly grounded in constitutional principles (Ibid, Art. 20/2).

The Oromia National Regional State Rural Land Use and Administration Regulation outlines mechanisms aimed at discouraging land fragmentation and implicitly promoting land consolidation. According to the regulation, the redistribution of rural land is generally prohibited in the region, with an exception made for irrigation land (ONRS Proc. No. 56/2002, Art. 14/1).

For modern irrigation schemes constructed by the government or through donor assistance, redistribution is permissible for the benefit of landless farmers. This process is subject to confirmation by the public and approval by the Woreda Administrative Councils (ONRS Reg. No. 151/2012, Art. 4/1). However, it is important to note that redistribution of irrigation land is restricted if the land has been developed with permanent properties such as coffee, mango, papaya, orange, sugar cane, etc. (Ibid, Art. 4/2).

Furthermore, the regulation prohibits redistribution in areas where rural landholders have collectively or individually developed traditional or modern irrigation schemes utilizing streams, ponds, springs, etc. Additionally, individuals with rural land holdings below specified thresholds (i.e., less than 0.5 hectares for crops, 0.25 hectares for permanent crops, and 0.25 hectares of irrigable lands) have no entitlement to redistribute the holding as a gift or inheritance to their family or landless children (Ibid, Art. 10/8).

In the SNNP regional state, pursuant to Proc. No. 110/2007, Art. 9/2, reallocation is possible for irrigable land constructed at the government's expense and held by peasants, semi-pastoralists, or pastoralists with the view to use irrigable land properly and equitably. Reallocation is also possible when rural landholders are evicted from their holdings to construct irrigation structures. Accordingly, land reallocation shall be undertaken „to make landholders get equitable benefit from the irrigation development“ (Ibid, Art. 9/3). The other possibility for land redistribution is when land is reallocated to landless youths and peasants who have small farmland if the land is not occupied individually, and where the land is under the possession of the community or government and has the potential for agriculture (Ibid, Art. 9/4). The law also allows unoccupied cultivated lands to be allocated for landless peasant farmers and those having smaller land sizes. Likewise, based on the benefit of the local community and the region in general, unoccupied state land can be reallocated for farmers or leased to investors. When peasant farmers move from densely populated areas to relatively sparsely populated areas by resettlement programs, they shall get farmland through reallocation (SNNP Reg. No. 66/2007, Art 9/1).

In accordance with Proclamation No. 110/2007, Article 9(2) in the Southern Nations, Nationalities, and Peoples' (SNNP) Regional State, reallocation of irrigable land is permissible when it has been constructed at the government's expense and is currently held by peasants, semi-pastoralists, or pastoralists. The primary objective of such reallocation is to ensure the proper and equitable utilization of irrigable land. Additionally, reallocation is authorized in cases where rural landholders are displaced from their holdings to facilitate the construction of irrigation structures. In these instances, land reallocation is mandated to guarantee that landholders receive equitable benefits from the development of irrigation projects (Proclamation No. 110/2007, Article 9(3)).

Furthermore, land redistribution is feasible when unoccupied irrigable land, held either individually or under communal or governmental possession, is earmarked for allocation to landless youths and peasants with small farmland. The allocation is contingent upon the absence of individual occupancy and the land's potential for agricultural use (Proclamation No. 110/2007, Article 9(4)). The legislation also allows for the allocation of unoccupied cultivated lands to landless peasant farmers with smaller land sizes. Similarly, unoccupied state land can be reallocated for farmers or leased to investors based on the benefits accruing to the local community and the region at large. In the context of resettlement programs, when peasant farmers relocate from densely populated areas to relatively sparsely populated areas, they are entitled to farmland through the process of reallocation, as stipulated in SNNP Regional Regulation No. 66/2007, Article 9(1).

In the process of inheriting land, the transferred land size must meet or exceed the minimum holding requirement stipulated in the region (see *Ibid*, Article 11/2). Another policy measure aimed at preventing land fragmentation within this regional state involves prohibiting divorced couples from dividing their holdings if the resulting possession falls below the specified minimum holding size. In such cases, the law encourages divorced spouses to collaboratively utilize the land through any means available (*Ibid*, Article 11/3). Furthermore, the legislation promotes land consolidation within the region. To facilitate the consolidation and enhance the practicality of small farm plots for development, farmers are actively encouraged to engage in voluntary exchanges of farmland (*Ibid*, Article 11/4). Additionally, a settlement and villagization process, driven by community requests and participation, is to be undertaken with due consideration given to land consolidation (*Ibid*, Article 11/6).

A study conducted nearly two decades ago revealed that land redistribution was not widely embraced among peasants. Even in regions where land holdings were relatively small, the majority of the population did not see land redistribution as a viable policy option. The findings suggested that, instead of persisting with land redistribution, the government should consider promoting non-farm economic activities in urban centers and alleviating population pressure in rural areas (Nega et al., 2003). In a country where land is predominantly held in small sizes across its territories, redistribution may not be a feasible policy strategy.

Despite the well-intentioned rural land laws in the three regions, certain legal provisions inadvertently open the door for additional rural land fragmentation under the guise of distributive justice. It is crucial to note, however, that legislation and policies across the regions highlight the severity of the issue of land fragmentation in Ethiopia. Urgent interventions are needed to impede further land fragmentation. In the subsequent sections, empirical evidence on land fragmentation is presented to underscore the extent of the problem in Ethiopia. This aims to provide policymakers and other stakeholders with a comprehensive understanding of the issue, enabling them to develop consolidated legal frameworks that discourage land fragmentation and explore options for farmland consolidation.

7. Analysis of empirical evidences on land holding land fragmentation in the Amhara, Oromia and SNNP regions

As part of the national initiative to ensure land tenure security, facilitate land transactions, and bolster national economic development, the Ethiopian government has initiated a second-level rural land certification program. This program involves the establishment of a rural land cadastre to register farmers' land holdings. The cadastral data presents detailed information regarding each landholder's farmland, including the number of parcels and the area of each parcel. These comprehensive records are maintained at the Regional Land Administration Bureaus and the Federal Land Administration and Use Directorate (LAUD) within the Ministry of Agriculture.

This study aims to establish empirical evidence on the average land holdings and the average number of parcels held by households across three regions—Amhara, Oromia, and SNNP—while disaggregating data across zones. To provide a comprehensive understanding of the extent of per capita farmland holdings and land fragmentation at both national and regional levels, an analysis was conducted on the land holdings of 6,351,597 farm households residing in 340 woredas where the NRLIAS data has been completed and distributed across 6,413 rural kebeles, as outlined in section 2.2.

7.1. ANRS: Analysis on land holding per household and number of parcels held across zones based on Woreda level land holding data

7.1.1 Land holdings per farm household

The landholding and fragmentation study conducted in the Amhara region encompassed 11 Administrative zones comprising 112 Woredas (Figure 1) and 1,697 Kebeles. These areas accommodated a total of 2,373,740 farm households. The study recorded a total of 9,959,704 parcels within the region, covering an area of 4,943,526.95 hectares. A summary of the data, detailing the study zones, woredas, farm households, land holdings, land fragmentation, and the subsequent analysis, is presented in table 7.

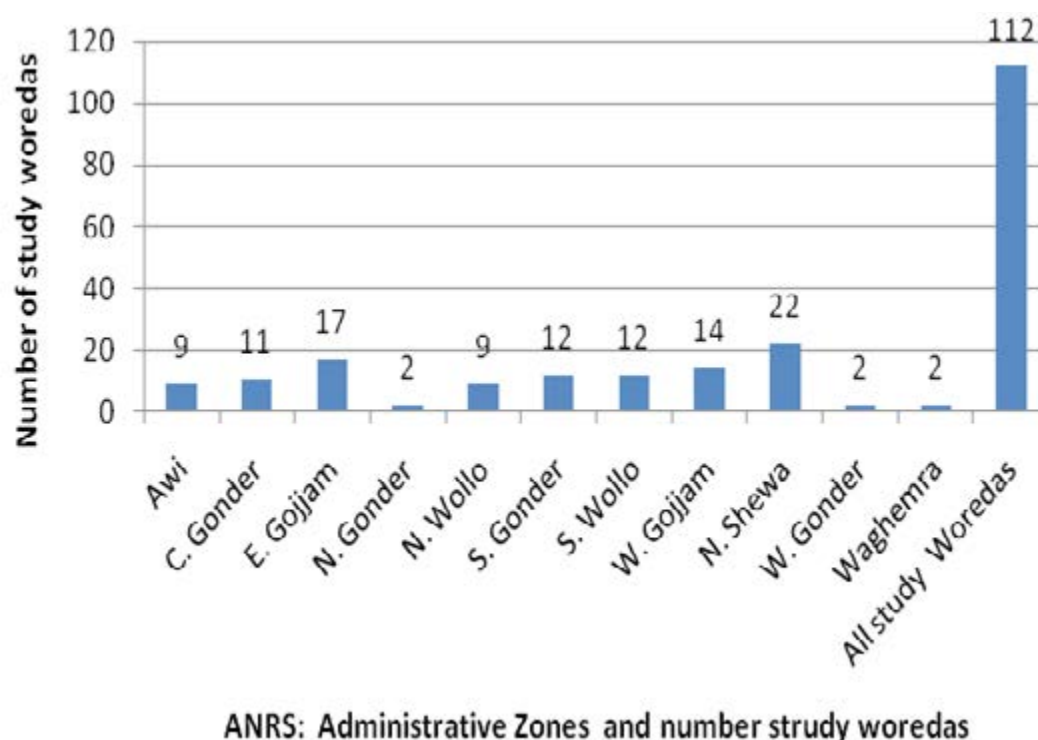


Figure 1. ANRS: Distribution of study woredas across administrative zones

At the regional level, as can also be seen in table 7, the average landholding per farm household stands at 2.08 hectares, while the averages across zones vary, ranging from 1.73 hectares in North Gondar to 7.24 hectares in West Gondar. The notably higher average landholding in West Gondar is attributed to its location in the lowlands, where rural land laws permit households to own up to 7 hectares (Figure 2).

Table 7 ANRS: Summary of data on study zones, woredas, rural kebeles, farm households, land holdings and land fragmentation

Category		No. of woredas	No. of rural kebeles	No. of parcels	No. of farmland holders	Farmland Area (ha)	Average land holding per farm household (ha)	Average No of parcels held by a farm household	Average parcel area (ha)	Minimum parcel area
Percent of households in different land holding categories across Woredas	Waghemra	2	16	64,531	20,268	60,085	2.96	3.18	0.89	0.02
	W. Gonder	2	5	16,519.00	5,635	40,792	7.24	2.93	2.47	0.02
	N. Shewa	22	225	1,491,656	300,270	722,671	2.41	4.97	0.49	0.02
	W. Gojjam	14	303	1,532,470	377,071	709,504	1.88	4.06	0.48	0.04
	S. Wollo	12	126	1,095,724	191,636	343,377	1.79	5.72	0.32	0.01
	S. Gonder	12	240	1,663,382	390,714	818,374	2.09	4.26	0.51	0.02
	N. Wollo	9	152	1,048,358	247,122	462,840	1.87	4.24	0.43	0.02
	N. Gonder	2	5	29,174	7,718	13,315	1.73	3.78	0.45	0.04
	E. Gojjam	17	324	1,810,473	475,251	845,937	1.78	3.81	0.44	0.04
	C. Gonder	11	137	566,580	172,512	523,568	3.03	3.28	0.96	0.039
	Awi	9	164	640,837	185,545	403,058	2.17	3.45	0.43	0.06
	Total	112	1,697	9,959,704	2,373,742	4,943,526	2.08	4.20	0.496	0.03

Table 8. ANRS: Summary of percent of households in different land holding categories

Category		% of HHDs having up to 0.5 ha	% of HHDs having 0.51 to 1.0 ha	% of HHDs having 1.1 up to 1.5 ha	% of HHDs having 1.51 to 2.0 ha	% of HHDs having 2.1 ha to 2.5 ha	% of HHDs having 2.51 to 3.0 ha	% of HHDs having more than 3 ha
Percent of households in different land holding categories across Woredas	Wagemra	21.01	23.94	13.01	13.28	6.54	6.46	15.76
	W. Gonder	5.52	3.83	4.92	6.12	5.18	6.46	67.97
	N. Shewa	14.10	20.15	12.09	14.19	7.62	8.61	23.24
	W. Gojjam	17.43	23.03	13.89	15.06	8.15	8.65	13.78
	S. Wollo	19.95	27.49	15.50	13.99	7.68	6.05	9.35
	S. Gonder	17.16	22.63	13.73	15.39	8.88	8.11	14.11
	N. Wollo	27.88	24.67	11.56	11.56	5.71	5.66	12.96
	N. Gonder	29.22	22.81	11.90	12.03	6.22	6.19	11.62
	E. Gojjam	19.13	27.11	15.01	14.95	7.89	7.37	8.55
	C. Gonder	15.58	21.52	11.21	12.36	6.96	7.95	24.41
	Awi	14.25	23.79	14.29	14.67	7.29	7.29	18.42
	Total	18.29	21.90	12.47	13.05	7.10	7.16	20.02*

*15.22 excluding W. Gonder

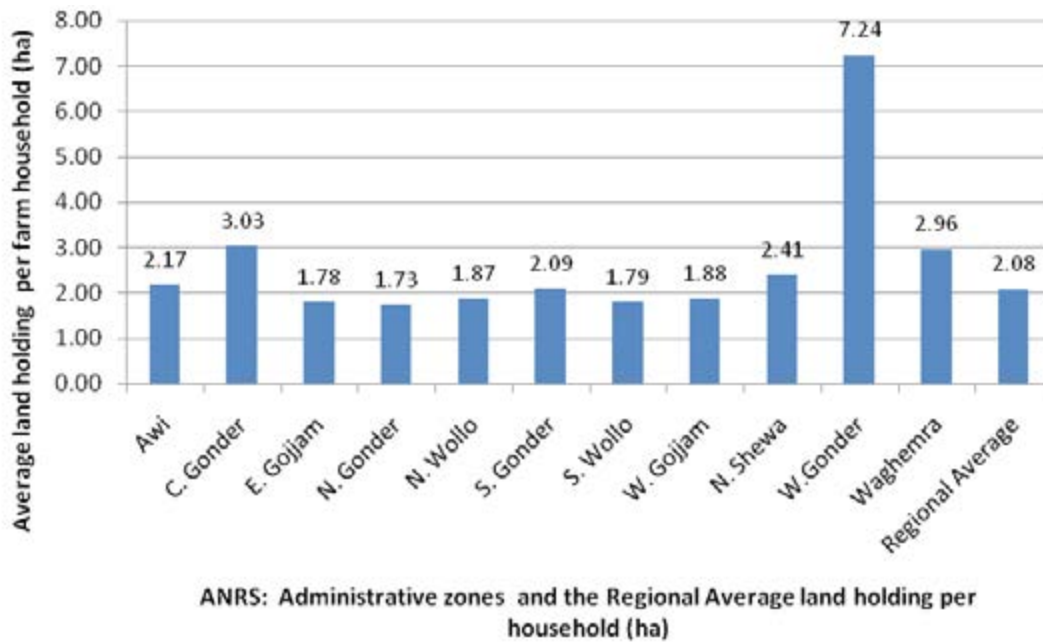


Figure 2: ANRS: Average farm land holding per household across administrative zones and the regional average (ha).

The analysis of the percentage of farmland holders in different land area categories (Table 8) shows that approximately 40.19% of farm households possess less than or equal to one hectare. Around 23.52% own land ranging from 1.1 to 2.0 hectares, while 14.26% possess 2.1 to 3 hectares, and about 15.22% own more than three hectares (Figure 3). The figures in Table 8 clearly highlight that a significant number of households lack adequate land holdings. Moreover, this issue is compounded by the fact that these small landholdings are divided among multiple parcels situated far apart.

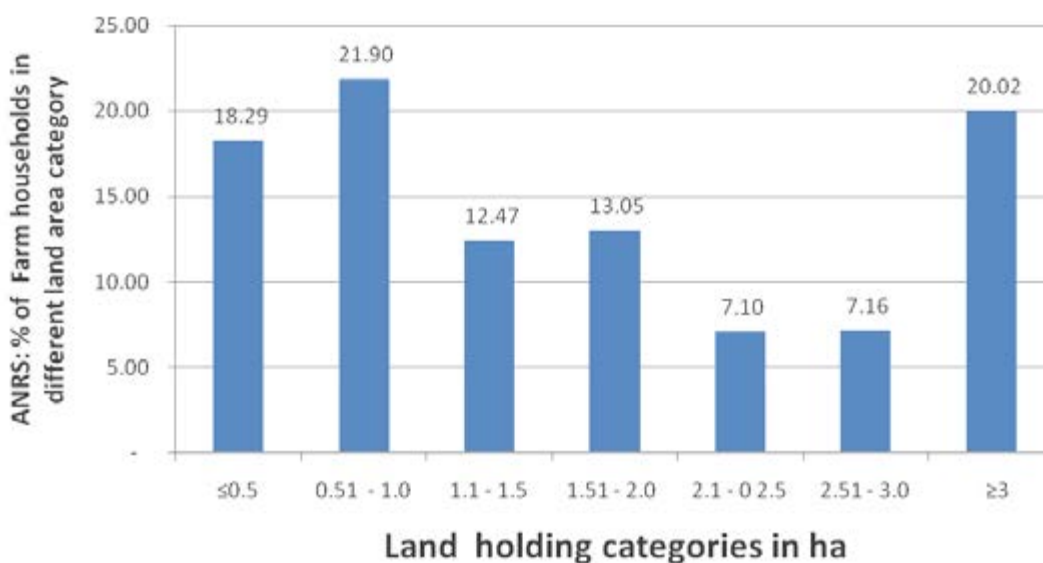


Figure 3. ANRS: Percent of farm land holders in different land holding category (ha).

Table 9 ANRS: Percent of farm land holders in different parcel holding category

Category		Percent of households having 1-2 parcels	Percent of households having 3-5 parcels	Percent of households having 6-8 parcels	Percent of households having 6 or more than 8 parcels
Percent of households in different parcel category across Zones	Waghemra	39.43	43.43	14.82	2.32
	W. Gonder	46.46	41.08	10.95	1.52
	N. Shewa	25.73	35.93	22.64	15.59
	W. Gojjam	26.24	45.42	22.99	5.34
	S. Wollo	24.63	27.83	21.69	25.85
	S. Gonder	24.78	47.00	20.95	7.18
	N. Wollo	30.52	36.04	20.36	12.78
	N. Gonder	29.49	46.59	19.575	4.345
	E. Gojjam	29.84	43.68	20.22	5.87
	C. Gonder	39.21	41.18	15.77	3.82
	Awi	34.55	46.65	15.81	2.99
	Total	31.90	41.35	18.71	7.96

7.1.2 ANRS: Farmland fragmentation analysis

The land fragmentation analysis revealed that, at the regional level, households hold an average of 4.2 parcels, with variation across zones ranging from 2.93 in West Gonder to 5.72 parcels in the South Wollo zone (Figure 4). The regional average parcel area was recorded at 0.49 hectares, displaying variability from 0.32 hectares in South Wollo to 2.47 hectares in West Gonder.

The average number of parcels held by farm households across zones indicates a significant degree of land fragmentation. This fragmentation poses a considerable challenge in regions where landholdings per household are already small, further impeding farmers' ability to enhance productivity on their farms.

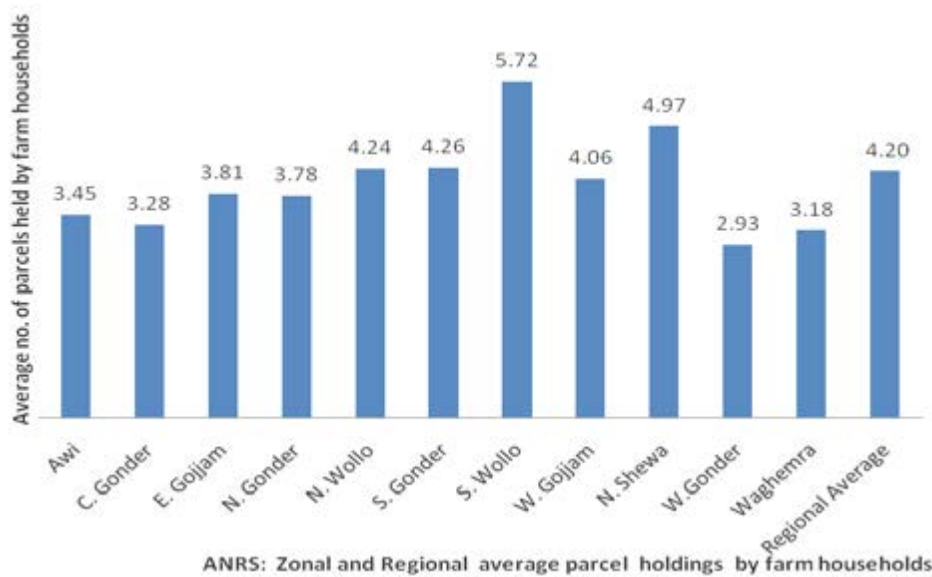


Figure 4: ANRS: Average number of parcels held by farm households across zones and the regional average

A detailed analysis of parcel holdings reveals that approximately 32% of households possess 1-2 parcels, 41.35% own 3-5 parcels, and roughly 26% have 6 or more parcels (Figure 5, Table 9). These percentage distributions underscore the necessity of developing a land consolidation strategy. It appears crucial to prioritize farm households with a higher number of parcels for a land consolidation process.

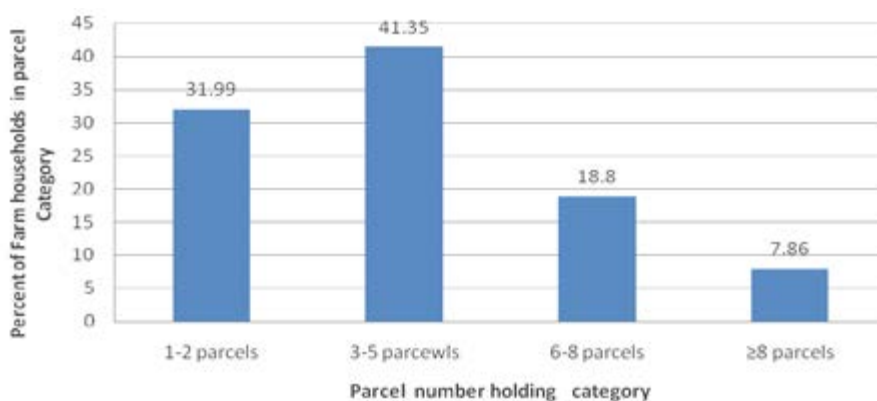


Figure 5: ANRS: Percentage of farm households in different parcel holding categories

The analysis of parcel areas across zones highlights the average parcel areas varying from

0.32 hectares in the South Wollo zone to 2.47 hectares in the West Gonder zone. Notably, a significant portion of the average parcel areas across zones falls below 0.5 hectares (Figure 6). The prevalence of small parcel sizes serves as a compelling indicator to commence farmland consolidation initiatives.

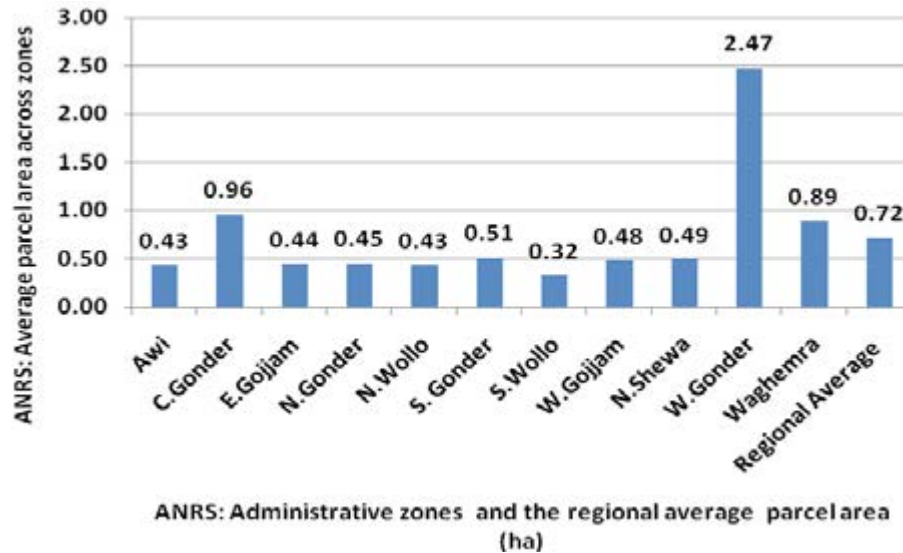


Figure 6. ANRS: Average parcel area across zones and the regional average (ha)

7.2. Oromia Region: Analysis on land holding per household across zones and the region based on land data compiled at woreda level

The study on landholding and farm land fragmentation in the Oromia region encompassed 17 Administrative Zones, comprising 124 Woredas (Figure 7), and spanned across 2,612 Kebeles. This region accommodated a total of 1,972,474 farm households. The study recorded a total of 6,791,411 parcels, covering an area of 6,791,411 hectares. A detailed analysis and summary of data, delineating information on study zones, woredas, farm households, land holdings, and land fragmentation in the region, is presented in Table 10.

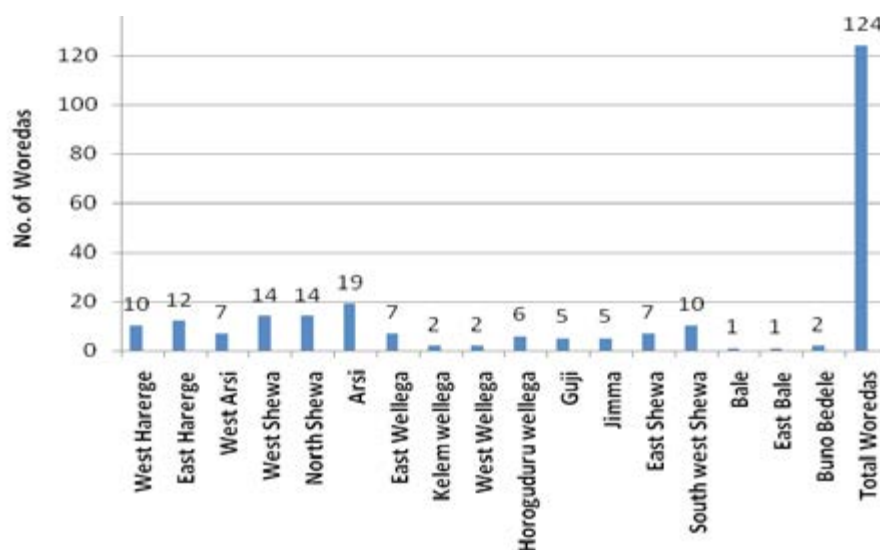


Figure 7: Oromia region: Distribution of study woredas across administrative zones (See Annex 2).

Table 10: Oromia Region: Summary of data on study zones, woredas, kebeles, farm households, land holdings and number of parcels

Category	No. of woredas	No. of rural kebeles	No. of parcels	No. of farmland holders	Farmland Area (ha)	Average land holding per farm household (ha)	Average No of parcels held by a farm household	Average parcel area (ha)	Minimum parcel area	
Percent of households in different land holding categories across Woredas	Buno Bedele	2	32	38,312	12,090	33,577	2.78	3.17	0.88	0.0851
	East Bale	1	18	42,818	10,234	38,181	3.73	4.18	0.89	0.0514
	Bale	1	21	45,214	47,218	48,171	1.02	0.96	1.07	0.0479
	South-West Shewa	10	215	474,867	108,362	329,606	3.04	4.38	0.69	0.05166
	East Shewa	7	199	503,668	128,907	304,988	2.37	3.91	0.61	0.0300
	Jimma	5	83	148,175	57,785	126,578	2.19	2.56	0.85	0.39982
	Guji	5	73	102,865	23,295	119,239	5.12	4.42	1.16	0.01618
	Horoguduru Wollega	6	83	180,866	47,100	169,700	3.60	3.84	0.94	0.022
	West Wollega	2	27	20,559	4,701	8,232	1.75	4.37	0.40	0.004
	Kelem Wollega	2	40	55,673	12,968	18,539	1.43	4.29	0.33	0.002
	East Wollega	7	98	244,626	97,313	302,882	3.11	2.51	1.24	0.02
	Arsi	19	380	1,202,057	291,551	898,902	3.08	4.12	0.75	0.030
	North Shewa	14	262	1,340,749	239,956	734,303	3.06	5.59	0.55	0.010
	West Shewa	14	286	859,394	244,505	596,432	2.44	3.51	0.69	0.02335
	West Arsi	7	142	261,185	123,312	245,201	1.99	2.12	0.94	0.06
	East Harerge	12	352	818,596	275,229	492,057	1.79	2.97	0.60	0.0592
	West Harerge	10	301	451,787	247,948	365,593	1.47	1.82	0.81	0.0255
Total	124	2,612	6,791,411	1,972,474	4,832,189	2.45	3.44	0.79	0.05	

7.2.1 Oromia: Average land holding analysis

At the regional level, the average landholding per farm household stands at 2.45 hectares, with variations across zones ranging from 1.02 hectares in the Bale zone to 5.12 hectares in the Guji zone (Figure 8). Notably, in nine zones within the study region, the average landholding exceeds 2.5 hectares. This serves as a promising indicator for the potential to engage in commercial farming activities following land consolidation.

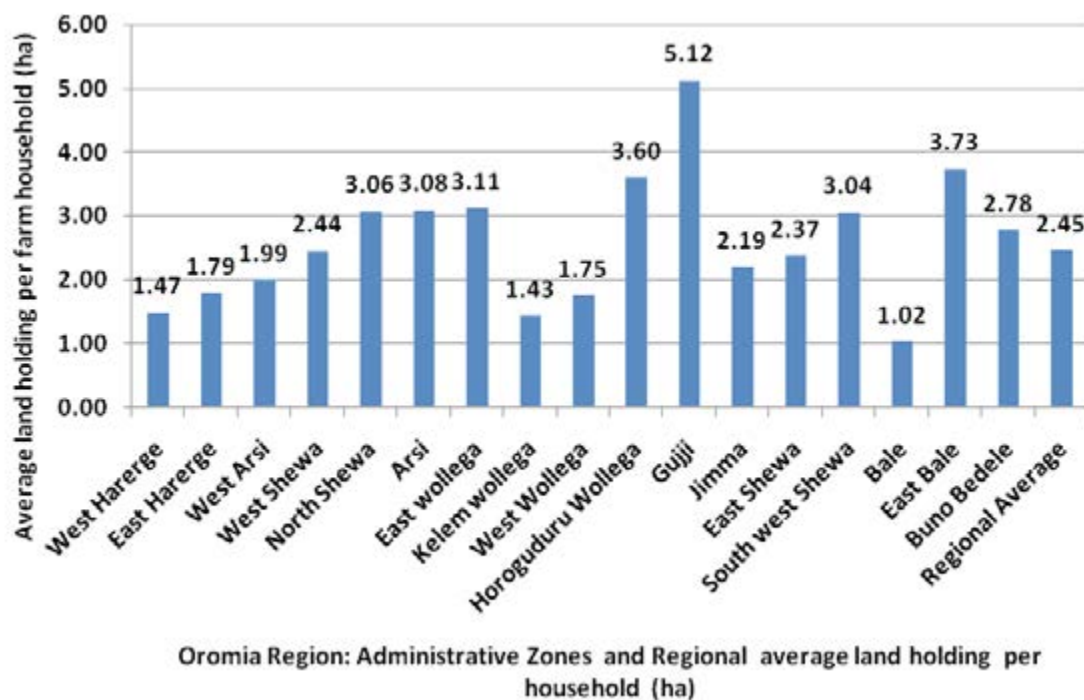


Figure 8: Oromia Region: Average farm land holding per household across administrative zones and the regional average (ha). (The details are attached in Annex 3 & 4)

The analysis on the percentage of farm households in different landholding categories reveals that approximately 81.35% of the households in the Oromia region own less than or equal to one hectare of land. Additionally, around 5.9% possess land ranging from 1.1 to 2 hectares, while the remaining few own more than 2 hectares (Figure 9). This data, as presented in Table 11 distinctly illustrates that the majority of farm households in the Oromia region own 0.5 hectares or less, signaling a severe land shortage. Furthermore, these small landholdings are divided into multiple parcels, exacerbating the issue.

Table 11. Oromia Region: Summary of percent of households in different land holding categories

Category		% of HHDs having up to 0.5 ha	% of HHDs having 0.51 to 1.0 ha	% of HHDs having 1.1 up to 1.5 ha	% of HHDs having 1.51 to 2.0 ha	% of HHDs having 2.1 ha to 2.5 ha	% of HHDs having 2.51 to 3.0 ha	% of HHDs having more than 3 ha
Percent of households in different land holding categories across Woredas	Buno Bedele	44.99	27.74	8.42	5.73	2.69	2.28	8.14
	East Bale	45.02	28.74	9.42	6.24	2.80	2.21	5.56
	Bale	57.78	26.17	6.23	3.77	1.55	1.12	3.38
	South-West Shewa	57.78	26.17	6.23	3.77	1.55	1.12	3.38
	East Shewa	57.83	26.80	6.13	3.66	1.48	1.10	3.00
	Jimma	47.57	25.67	10.74	5.58	2.46	2.03	5.95
	Guji	50.91	20.48	7.18	5.71	3.00	2.63	10.09
	Horoguduru Wollega	54.32	26.34	6.66	4.25	1.89	1.48	5.06
	West Wollega	79.11	13.14	2.88	1.86	0.67	0.59	1.75
	Kelem Wollega	78.94	13.33	3.26	1.76	0.68	0.55	1.48
	East Wollega	51.22	21.34	7.05	5.39	2.74	2.40	9.86
	Arsi	60.71	23.86	5.59	3.46	1.51	1.17	3.70
	North Shewa	70.95	18.94	4.04	2.44	0.99	0.76	1.86
	West Shewa	60.46	22.39	5.77	3.85	1.74	1.39	4.40
	West Arsi	40.79	31.91	9.81	6.52	2.97	2.24	5.76
	East Harerge	76.52	14.74	3.34	2.09	0.86	0.62	1.82
	West Harerge	57.42	22.89	6.65	4.60	2.04	1.70	4.70
	Total	58.37	22.98	6.43	4.16	1.86	1.49	4.70



Figure 9. Oromia Region: Percent of farm in different land area holding land holders category

7.2.2 Oromia Region: Farmland Fragmentation Analysis

The analysis of farm land fragmentation reveals that, at the regional level, households hold an average of 3.44 parcels, with variations across zones ranging from 0.96 in the Bale zone to 5.59 in North Shewa (Figure 10). The considerable variation in the average number of parcels held by farm households across zones indicates substantial land fragmentation. This fragmentation poses a significant challenge for farmers in a region where landholding sizes per farm household are already small, further impeding their ability to make their farms productive.

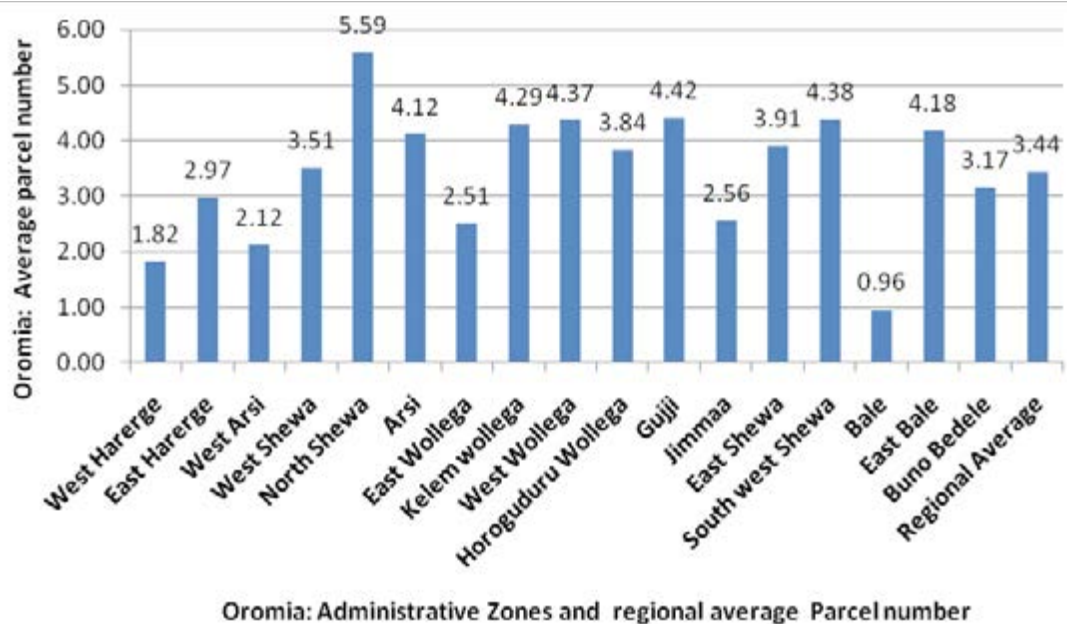


Figure 10. Oromia Region: Average number of parcels held by farm households across zones and the regional average.

The regional average parcel area was recorded at 0.79 hectares, displaying variability from 0.33 hectares in Kelem Wellega to 1.24 hectares in East Wellega zone (Figure 11). Notably, a majority of the average parcel areas across zones exceed 0.5 hectares. It is crucial to protect these larger parcels from further fragmentation to ensure their preservation and maintain their productivity.

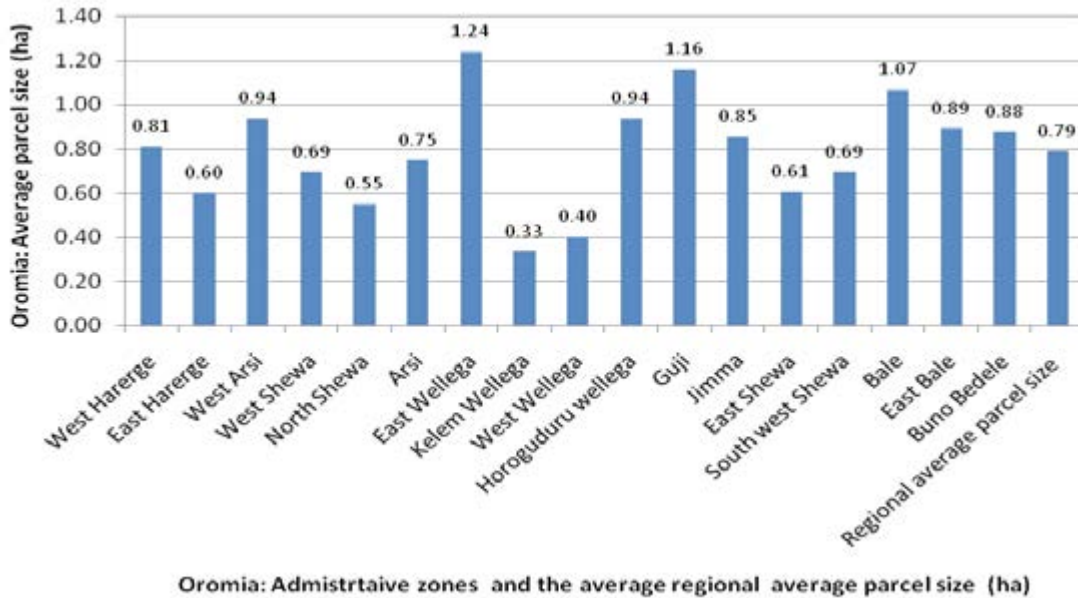


Figure 11: Oromia Region: Average parcel size across administrative zones and the regional average

The analysis of land fragmentation at the regional level further reveals that approximately 34.64% of farm households possess 1 to 2 parcels, while about 64.44% own 3 to 8 parcels (refer to Figure 12 and Table 12). The significant presence of a large group of farmers holding more than 3 fragmented parcels indicates a pressing need to initiate farm land consolidation efforts.

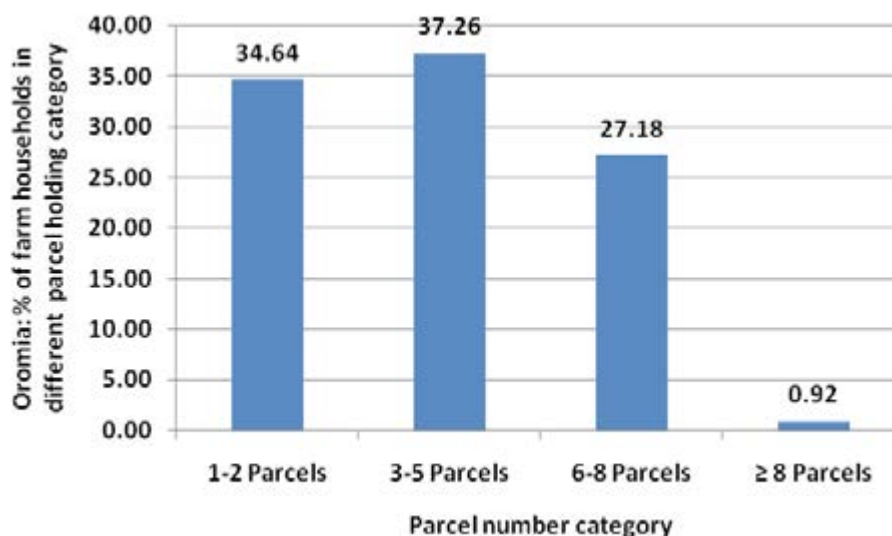


Figure 12. Oromia Region: Percent of farm households in different parcel number holding category

Table 12. Oromia: Percent of farm land holders in different number of parcel holding category

Category		Percent of households having 1-2 parcels	Percent of households having 3-5 parcels	Percent of households having 6-8 parcels	Percent of households having 6 or more than 8 parcels
Percent of households in different parcel category across Zones	Buno Bedele	36.00	36.00	27.50	0.50
	East Bale	23.00	42.00	35.00	0.00
	Bale	25.50	38.20	35.00	1.30
	South-West Shewa	25.50	38.20	35.00	1.30
	East Shewa	26.71	36.71	35.14	1.43
	Jimma	40.00	42.40	17.60	0.00
	Guji	39.8	41.8	18.4	0.00
	Horoguduru Wollega	35.00	37.33	27.33	0.33
	West Wollega	37.50	38.00	24.50	0.00
	Kelem Wollega	37.00	42.50	20.00	0.50
	East Wollega	38.00	37.86	23.57	0.57
	Arsi	26.79	36.95	34.79	1.42
	North Shewa	22.57	35.79	38.79	2.86
	West Shewa	24.86	29.00	44.79	1.36
	West Arsi	27.57	39.86	31.29	1.29
	East Harerge	50.25	38.25	9.33	2.17
	West Harerge	72.76	22.66	3.99	0.60
Total	34.64	37.26	27.18	0.92	

7.3. SNNP: Analysis on land holding per farm household across zones based on woreda level land data

7.3.1 Land holding per household

The study on landholding and fragmentation in the SNNP region was conducted across 18 Administrative Zones, encompassing 104 Woredas (Figure 13), and spanned 2,104 Kebeles. This area accommodated a total of 2,005,381 farm households. The study recorded a total of 3,887,653 parcels, covering an area of 2,219,761 hectares. A comprehensive summary of data detailing information on study Zones, Woredas, farm households, land holdings, land fragmentation, and the subsequent analysis conducted in the region is presented in Table 13.

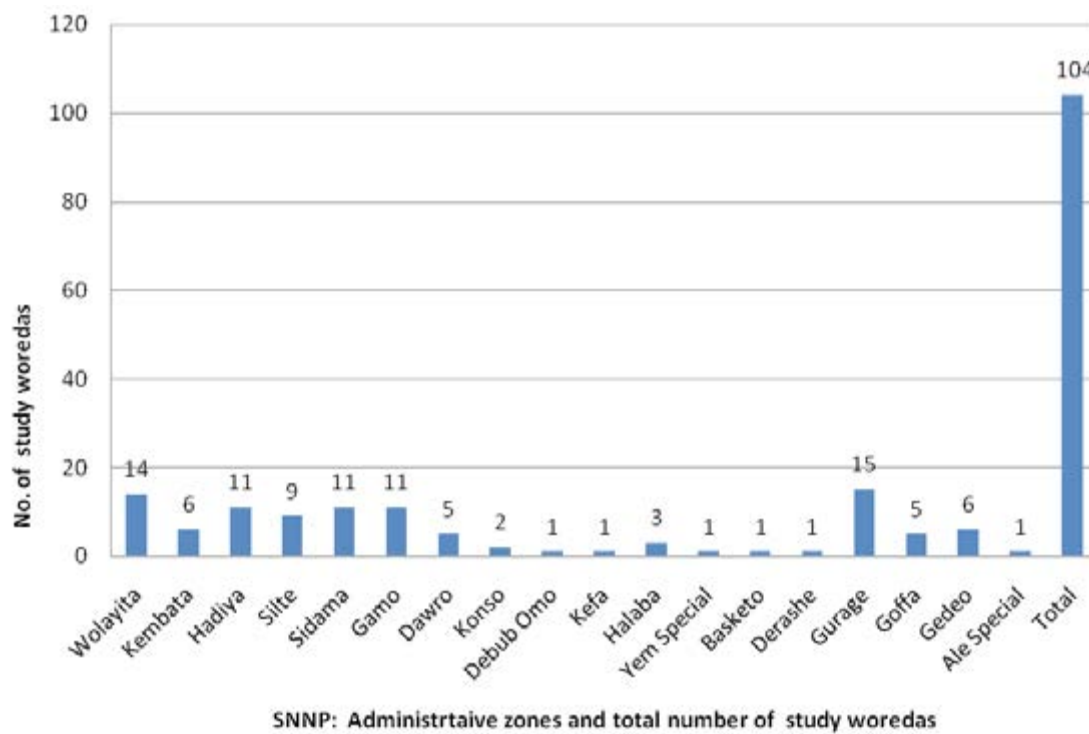


Figure 13: SNNP: Number of study woredas across administrative zones

At the regional level, the average landholding per farm household stands at 1.12 hectares, while the averages across zones vary significantly, ranging from 0.3 hectares in Kembata to 3.83 hectares in the Konso zone. The consistently low average landholding values across many zones indicate a prevailing shortage of farmland in the region (Figure 14).

Table 13. Table 13. SNNP: Summary of data on study Zones, Woredas, Kebeles, farm households, Land holdings and land fragmentation

Category	No. of woredas	No. of Rural kebeles	No. of parcels	No. of farmland holders	Farmland Area (ha)	Average land holding per farm household (ha)	Average No of parcels held by a farm household	Average parcel area (ha)	Minimum parcel area
Ale	1	16	53,134	27,461	39,303	1.43	1.93	1.43	0.0716
Gedeo	6	74	186,945	144,157	46,593	0.32	1.30	0.55	0.001
Goffa	5	129	219,976	112,464	165,433	1.47	1.96	1.54	0.009
Gurage	15	367	533,339	261,856	333,022	1.27	2.04	1.24	0.0012
Derashe	1	16	51,375	40747	38,912	0.95	1.26	0.95	0.008
Basketo	1	30	29,302	6,434	17,583	2.73	4.55	2.73	0.01
Yem Special	1	34	40,935	14,615	29,047	1.99	2.80	1.99	0.01
Halaba	3	71	83,920	50,459	69,043	1.37	1.66	1.42	0.02
Kefa	1	25	24,739	14,055	31,037	2.21	1.76	2.21	0.03
Debub Omo	1	33	41,323	22,455	23,658	1.05	1.84	1.05	0.01
Konso	2	25	122,048	24,763	94,878	3.83	4.93	3.83	0.002
Dawro	5	77	61,032	40,598	109,213	2.69	1.50	2.58	0.01
Gamo	11	244	711,178	240,144	317,382	1.32	2.96	1.26	0.002
Sidama	11	203	416,222	247,122	243,562	0.99	1.68	0.80	0.001
Silte	9	163	324,425	156,066	161,175	1.03	2.08	1.06	0.001
Hadiya	11	283	319,257	197,699	225,621	1.14	1.61	1.18	0.01
Kembata	6	79	334,253	202,145	59,641	0.30	1.65	1.03	0.005
WolaYita	14	235	334,250	202,141	214,656	1.06	1.65	1.24	0.06
Total	104	2,104	3,887,653	2,005,381	2,219,761	1.11	1.94	1.56	0.01

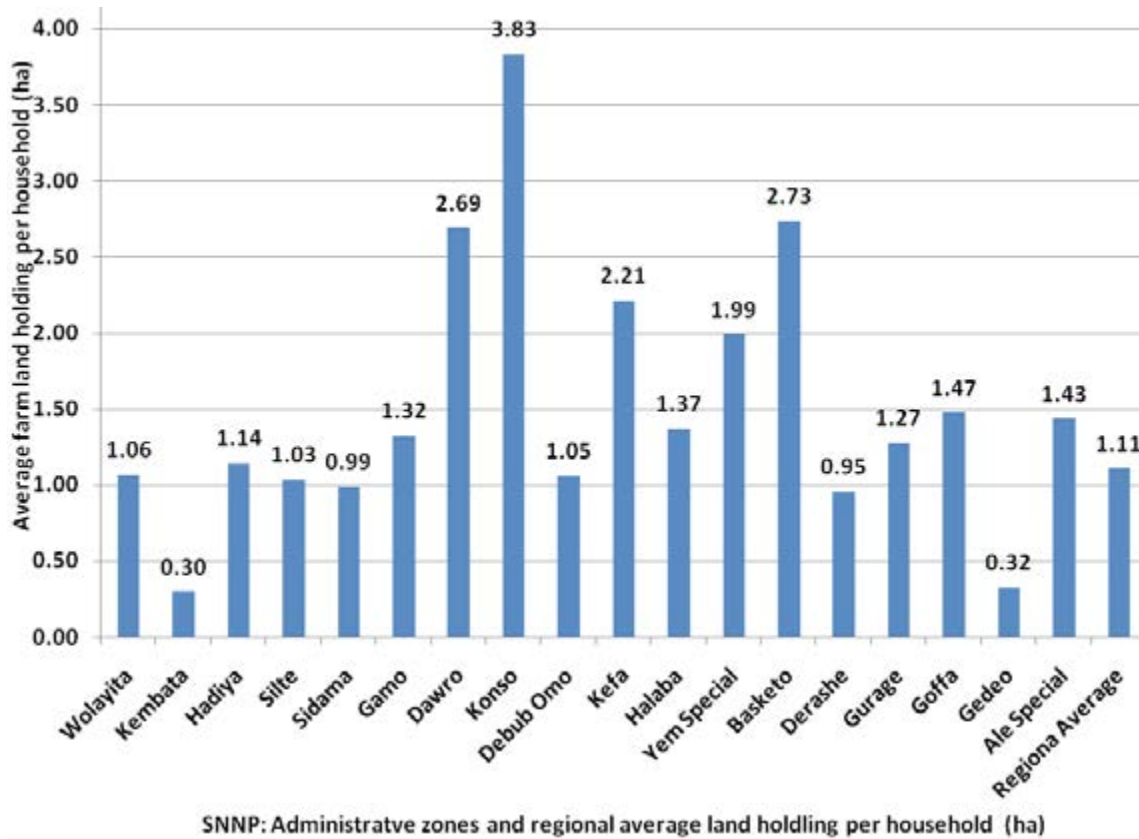


Figure 14: SNNP: Average farmland holding per HH across administrative zones & regional average (ha)

An analysis of the percentage of farmland holders in different land area categories (Table 14) indicates that approximately 37.61% of farm households possess less than or equal to 0.5 hectares of land. About 20.79% own land ranging from 0.51 to 1.5 hectares, while some 20.13% hold 1.51 to 2.5 hectares, and 8.91% possess over 2.5 hectares. These figures, as presented in Table 14 and summarized in Figure 15, clearly indicate that a substantial number of farm households in the SNNP region lack adequate land holdings. Moreover, these small landholdings are fragmented and situated far apart, exacerbating the situation.

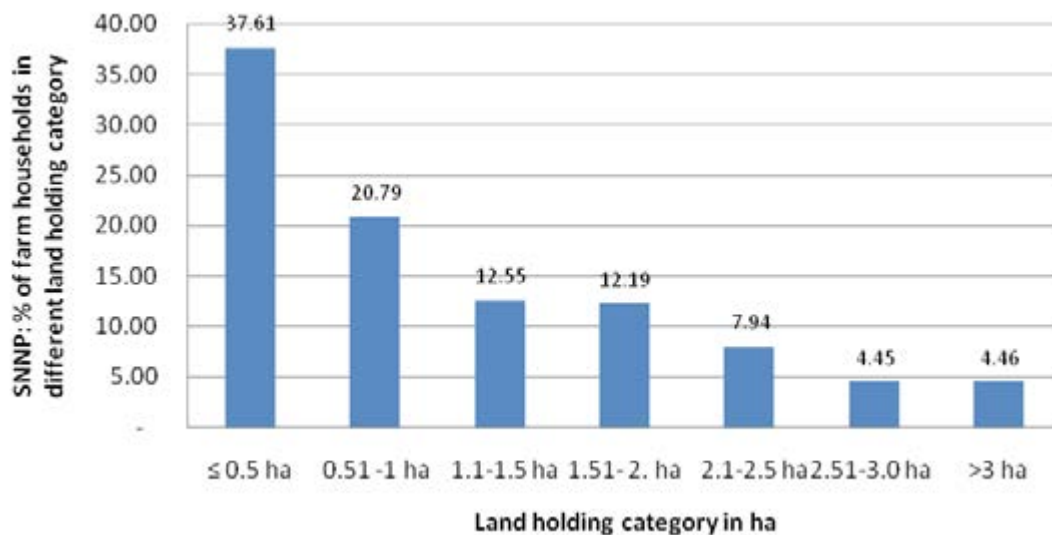


Figure 15: SNNP: Distribution of farm households in different land area holding (ha) in percent

Table 14. SNNP: Summary of percent of households in different land holding categories

Category		% of HHDs having up to 0.5 ha	% of HHDs having 0.51 to 1.0 ha	% of HHDs having 1.1 up to 1.5 ha	% of HHDs having 1.51 to 2.0 ha	% of HHDs having 2.1 ha to 2.5 ha	% of HHDs having 2.51 to 3.0 ha	% of HHDs having more than 3 ha
Percent of households in different land holding categories across Woredas	Ale	18.81	16.65	19.59	27.46	13.42	2.89	1.18
	Gedeo	80.20	9.63	4.14	2.65	1.50	1.18	0.70
	Goffa	29.29	22.23	17.20	12.67	7.51	5.31	5.79
	Gurage	29.62	26.73	14.58	11.42	7.46	4.85	5.34
	Derashe	52.69	23.57	7.61	7.36	2.26	1.84	4.67
	Basketo	8.75	18.82	19.16	26.96	13.38	8.56	4.38
	Yem Special	17.96	13.96	6.84	18.98	20.60	15.55	6.11
	Halaba	37.38	26.12	13.09	9.06	6.47	5.33	2.54
	Kefa	12.70	8.67	15.65	25.81	24.16	6.30	6.72
	Debub Omo	20.69	18.25	18.18	18.68	14.58	4.74	4.88
	Konso	62.32	19.91	5.75	3.82	1.79	1.49	4.92
	Dawro	30.07	24.83	12.27	7.77	4.42	3.85	16.79
	Gamo	41.42	28.28	11.17	8.13	4.50	2.81	3.68
	Sidama	79.16	15.22	2.64	1.41	0.50	0.35	0.72
	Silte	37.06	24.41	14.15	9.04	6.04	5.17	4.13
	Hadiya	22.44	23.87	19.13	14.58	9.47	6.55	3.96
	Kembata	45.35	29.63	13.87	6.84	1.87	1.50	0.94
	WolaYita	51.13	23.49	10.80	6.75	3.08	1.87	2.88
Total	37.61	20.79	12.55	12.19	7.94	4.45	4.46	

7.3.2 SNNP: Farmland Fragmentation Analysis

The analysis of land fragmentation revealed that, at the regional level, households hold an average of 1.94 parcels, while the average across zones varies from 1.26 parcels in Derashe zone to 4.93 parcels in the Knoso zone (as depicted in Figure 16). The relatively low average parcel number held by farm households across zones reflects the small land holdings per household. This level of fragmentation in a region where landholding sizes per farm household are already limited further hampers farmers' ability to make their farms productive.

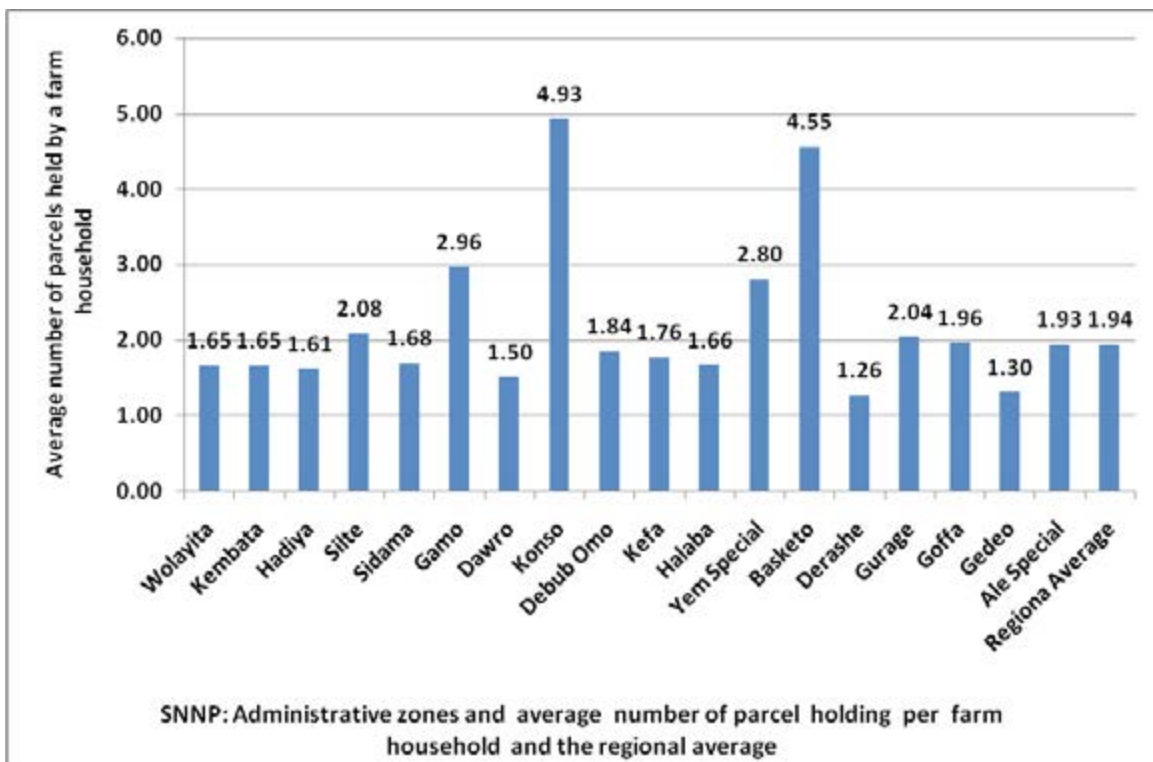


Figure 16. SNNP: Average number of parcels held by farm households across zones and the regional average

The analysis conducted on the area of parcels across zones revealed that the regional average parcel area stands at 0.71 hectares, with the average parcel area across zones varying from 0.18 hectare in Kembata zone to 1.79 hectares in Dawro zone. Notably, a majority of the parcel areas hover just over 0.5 hectares (as shown in Figure 17). It is important to note the prevalence of relatively larger parcels in Dawro and Kefa zones, presents a valuable opportunity that should be safeguarded from further fragmentation.

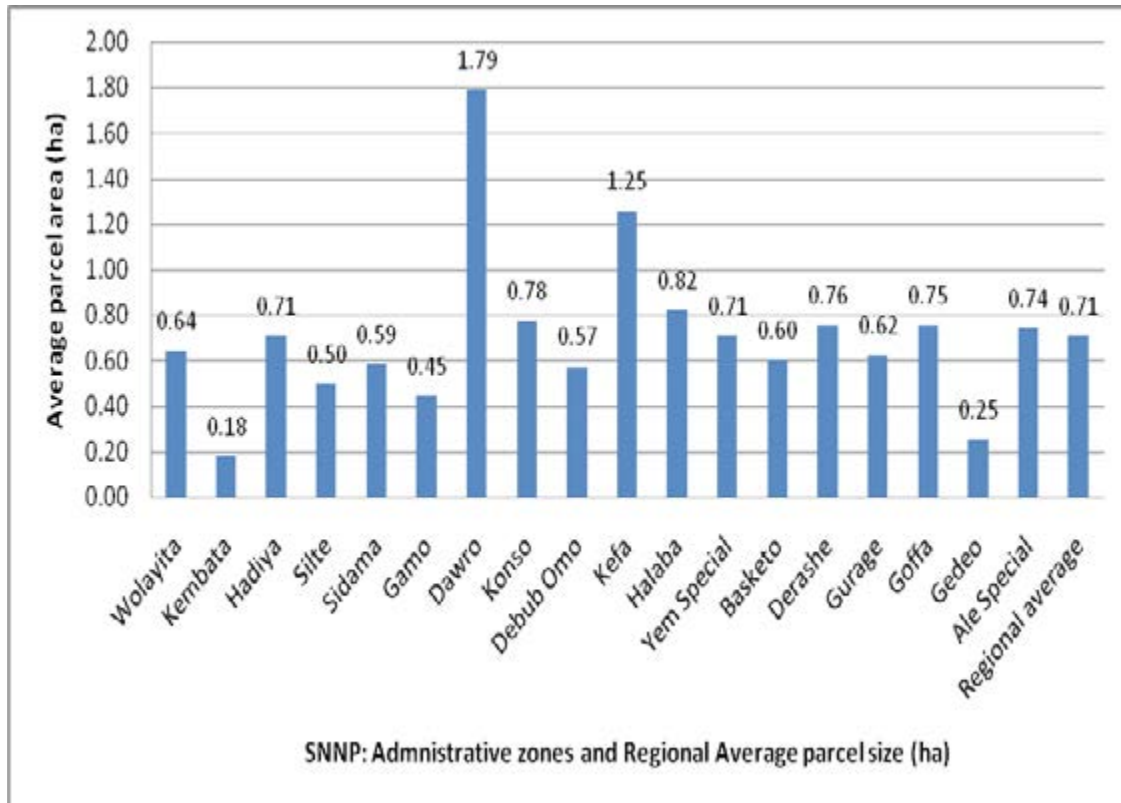


Figure 17: SNNP: Average parcel area across administrative zones and the Regional Average

The analysis of land fragmentation at the regional level further illustrates that the majority of farm households (62.16%) possess 1 to 2 parcels, while 28.59% hold 3 to 5 parcels, and 9.25% own more than 6 parcels (refer to Figure 18, Table 15). This substantial presence of a large group of farmers with fewer than three fragmented parcels serves as a valuable indicator to determine the group of households on which actions should be focused for the consolidation of farms.

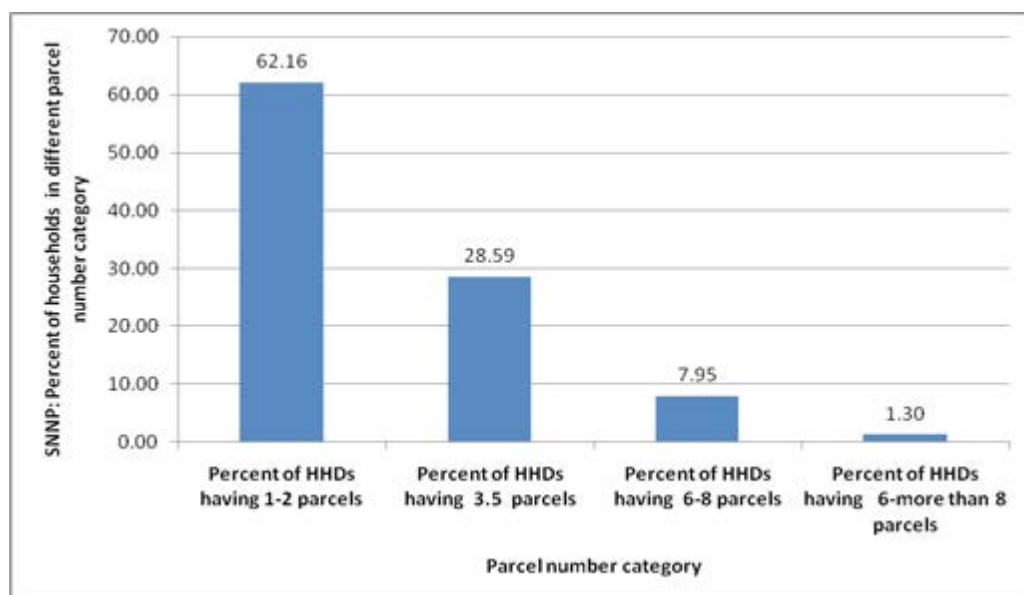


Figure 18: SNNP: Percent of farm households in different parcel number category

Table 15. SNNP: Percent of farm land holders in different parcel holding category

Category		Percent of house-holds having 1-2 parcels	Percent of house-holds having 3-5 parcels	Percent of house-holds having 6-8 parcels	Percent of house-holds having 6-more than 8 parcels
Percent of households in different parcel category across Zones	Ale	62.63	28.30	7.96	1.11
	Gedeo	69.54	25.36	4.82	0.28
	Goffa	68.61	23.97	5.62	1.81
	Gurage	56.53	29.11	10.64	3.72
	Derashe	81.92	13.47	3.65	0.97
	Basketo	81.92	13.47	3.65	0.97
	Yem Special	51.91	41.78	5.64	0.67
	Halaba	59.92	28.72	9.30	2.07
	Kefa	51.91	41.78	5.64	0.69
	Dehub Omo	67.66	30.15	2.15	0.04
	Konso	11.84	44.47	43.54	0.15
	Dawro	69.55	25.15	4.02	1.28
	Gamo	57.62	22.71	14.22	5.46
	Sidama	69.06	29.72	1.06	0.16
	Silte	53.25	35.91	8.45	2.39
	Hadiya	67.16	26.32	5.67	0.86
	Kembata	65.07	31.62	3.08	0.23
	WolaYita	72.76	22.66	3.99	0.60
	Total		62.16	28.59	7.95

8. Land holding and land fragmentation analysis across ANRS, Oromia and SNNP Regions

The analysis of average land holdings across the ANRS, Oromia, and SNNP regions reveals distinct patterns. Notably, the Oromia region displays a comparatively higher farm land area per household, standing at 2.45 hectares, followed by ANRS with 2.08 hectares and SNNP with 1.11 hectares. The national average is recorded at 1.88 hectares (see Figure 19). Furthermore, significant farmland fragmentation is observed across the regions, exemplified by 4.2 parcels in Amhara, 3.44 parcels in Oromia, and 1.94 parcels in SNNP. Nationally, farmers hold an average of 3.21 parcels. The average parcel areas differ among the regions, with ANRS, Oromia, and SNNP recording 0.5 hectares, 0.79 hectares, and 0.74 hectares respectively. The national average for parcel area is 0.68 hectares (Figure 19). These findings highlight a more pronounced land shortage in the SNNP region and substantial land fragmentation in the Amhara and Oromia regions. The data on land fragmentation across the 46 zones serves as a valuable indicator for future interventions in land consolidation.

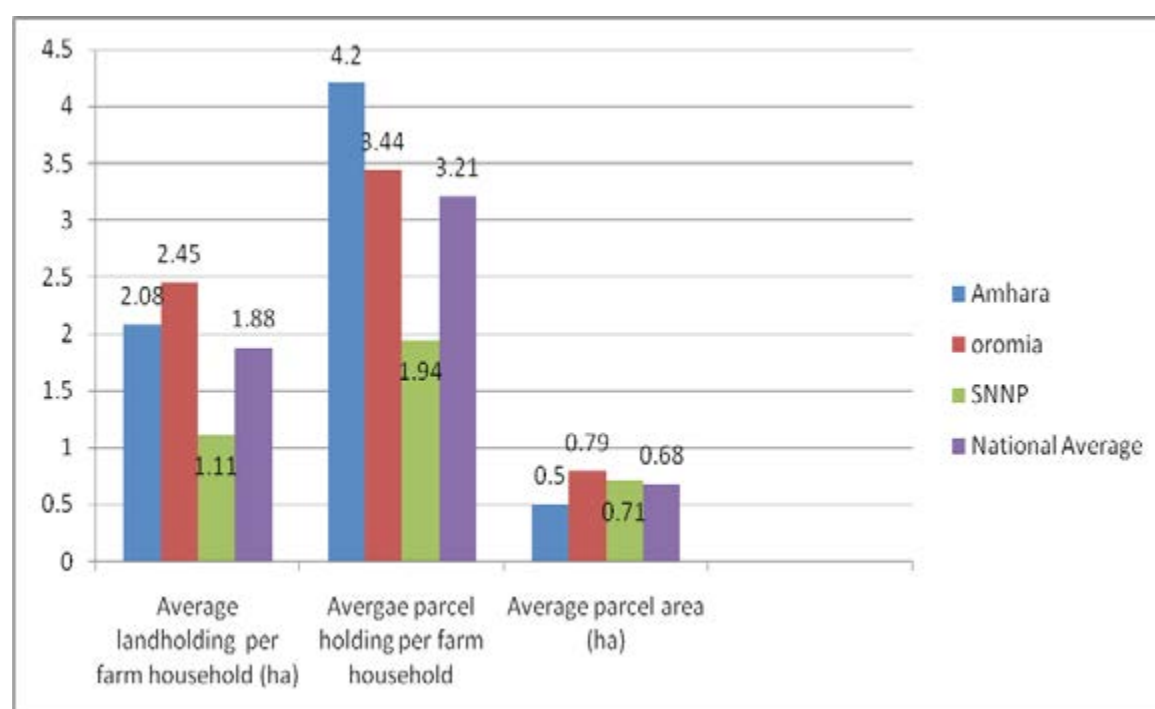


Figure 19: ANRS, Oromia, and SNNP and National average farmland and parcel holding per household and the National Average

Further scrutiny of farmland holders under different landholding categories reveals that in Oromia, the majority (58.37%) possess 0.5 ha or less, compared to 18.29% in ANRS and 37.08% in SNNP regions. At the national level of the total farmland holders included in this study (6,351,597 farm land holders), the majority (60%) own 1 hectare or less, and this small land holding is fragmented (Table 16).

Table 16. Percentage of farm households in different land holding categories across Amhara, Oromia, and SNNP Regions and the National Average

Land Holding categories	ANRS	Oromia	SNNP	National Average
HHDs having up to 0.5ha	18.29	58.37	37.08	37.91
HHDs having 0.51 to 1.0 ha	21.9	22.98	21.36	22.08
HHDs having 1.1 to 1.5 ha	12.47	6.43	12.16	10.35
HHDs having 1.51 to 2.0 ha	13.05	4.16	11.8	9.67
HHDs having 2.1 to 2.5 ha	7.1	1.86	8.08	5.68
HHDs having 2.51 to 3.0 ha	7.16	1.49	4.71	4.45
HHDs having more than 3 ha	20.02	4.7	4.81	9.84

Comparison of the percentage of farm households in different parcel holding categories revealed that the majority of farm households (64.54%) in the SNNP have 1-2 parcels, while the percentages for Amhara and Oromia regions are 39.11% and 34.64% respectively, and the national average is 46.10% (Figure 20). It was also noted that the majority of the farmland holders have three or more parcels, indicating the need for land consolidation.

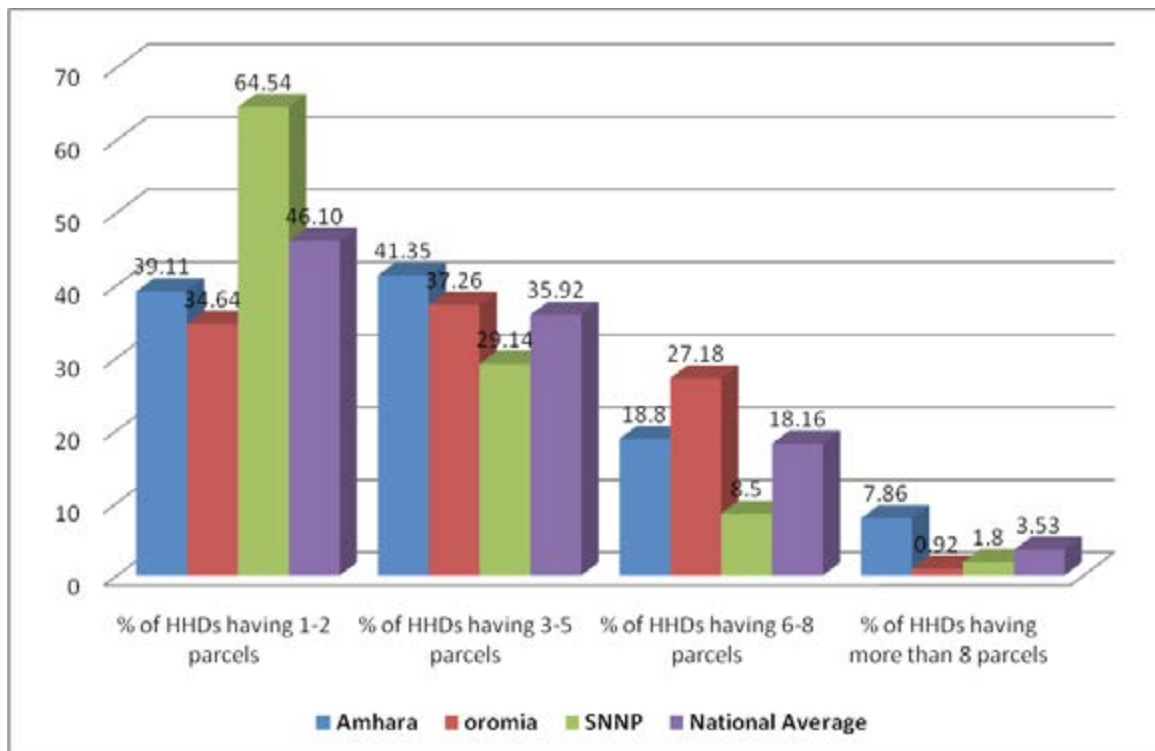


Figure 20: ANRS, Oromia, and SNNP percent of households in different parcel holding categories and the national average

Considering the small size of land holdings and significant variations across zones and woredas, it is prudent to assess land fragmentation levels in rural kebeles within each woreda utilizing the NRLAIS database. Conducting such assessments can contribute to informed decision-making regarding the strategic initiation of land fragmentation reduction strategies.

9. Other empirical evidence on trend analysis of land holdings and area of parcels held by farmers in the ANRS

In addition to the analysis conducted using land-holding data stored in the NRLAs, this study is complemented by a review of relevant empirical findings to substantiate the magnitude of land fragmentation and associated physical attributes. Accordingly, a land fragmentation study carried out in the Upper Lake Tana Basin, Dera Woreda, Amhara Region, which used a time series data collected from 1996/97 to 2018/19 on the land holdings of 193 sample households, revealed a significant decline in the average land holding and average parcel size per family member (Figures 21 and 22). The land holding per family member, which was 0.91 hectares in 1996, showed a substantial reduction to 0.261 hectares in 2018. Similarly, the average parcel size decreased from 0.285 hectares to 0.18 hectares per family member during the same period (Genreegziabher, 2018) (Figures 21 and 22). The study also determined that the average number of parcels per farm household in the same study area was 5.46. These findings underscore the alarming trend of land fragmentation and its implications for agricultural practices in the Upper Lake Tana Basin.

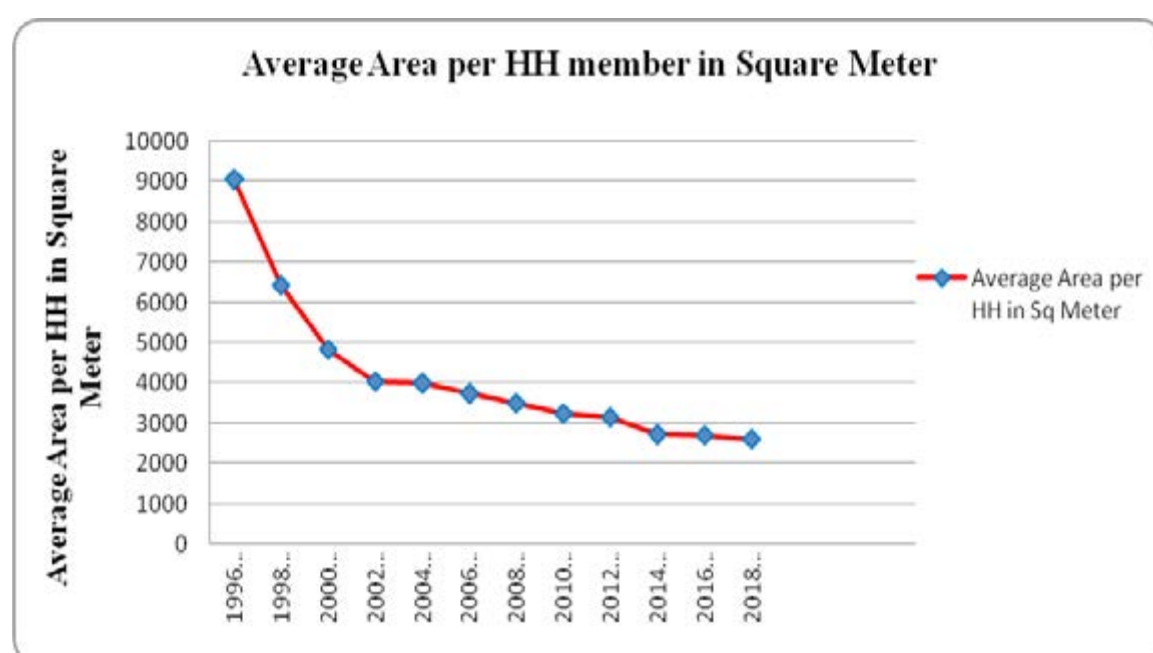


Figure 21: Average land holding per family member in Square meter (1996-2018)

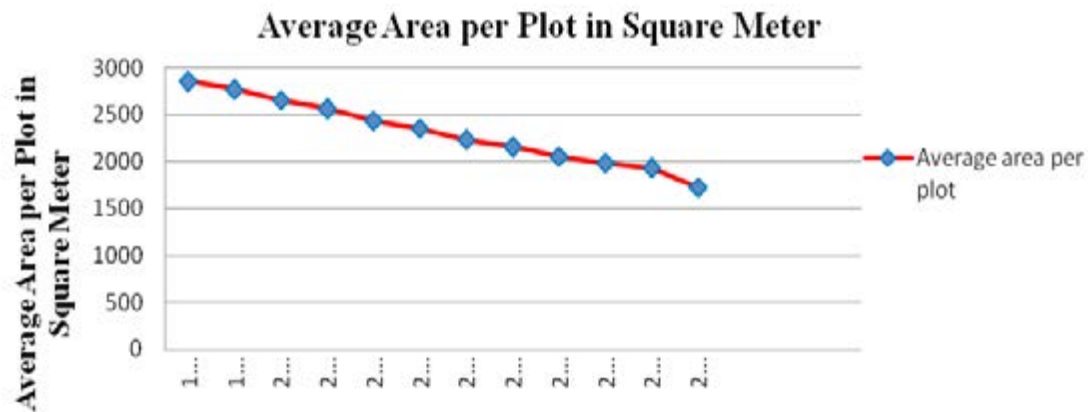


Figure 22: Average parcel area held by a household family member in square meter
(The years on the horizontal axis are those years indicated on the horizontal axis of figure 21)

Another study that focused on assessing land fragmentation in Merawi district, West Gojam, Amhara region, examined the land holdings of 96 sample households. The findings revealed that the average land holding per household is 1.53 hectares, with each household holding an average of 5.96 parcels. The number of parcels per household ranged from 2 to 11. A detailed breakdown of parcel holdings indicated that 7.5% of households have two parcels, 39.6% have 3-5 parcels, 36.8% have 6-8 parcels, and 15% have more than eight parcels. Parcel sizes ranged from 0.2 hectares to 0.75 hectares. In addition, a rural land holding cadastral map produced for the study area depicted the severity of land fragmentation, characterized by irregular shapes and dispersed locations of parcels in relation to homesteads. This observation is evident in the case of Mengistu Alemu, one of the respondents, who owns nine parcels identified by parcel number 0908 (Figure 23 and 24).

An analysis of parcel distances from homestead locations as a benchmark revealed that approximately 41.8% of households travel distances ranging from 2.5 km to over 4.4 km to access their parcels. Furthermore, 37.2% have parcels located within distances ranging from one km to less than 2.5 km, while the remaining 20.9% have parcels lying within less than one km (Yigremew Alemu, 2018). These findings underscore the challenges posed by land fragmentation in the study area, with implications for agricultural management and accessibility.

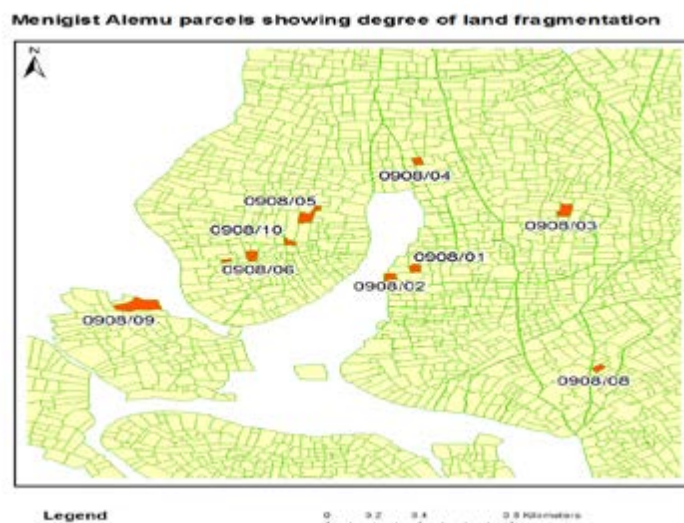


Figure 23: Cadastral map showing the location of a residence and distribution of parcels held by a single household, Merawi District, West Gojam, Amhara Region (Source: Yigremew Alemu, 2018)

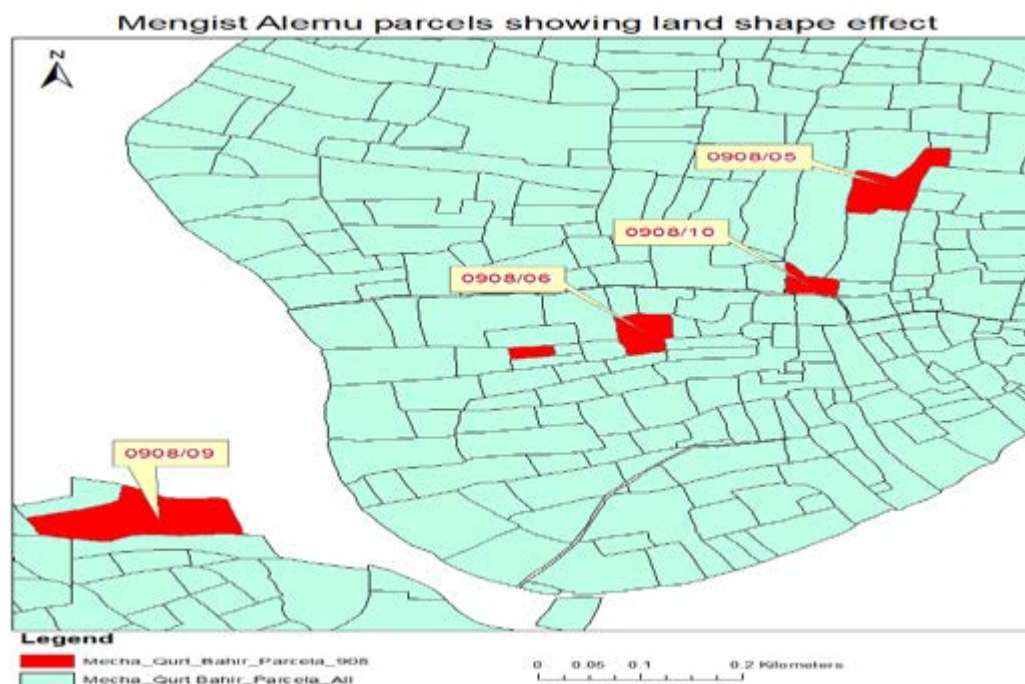


Figure 24: Cadastral map showing parcel shapes and boundaries, Merawi District, West Gojam, Amhara Region (Source Yigremew Alemu, 2018)

A study conducted in northwest Ethiopia on farmland fragmentation revealed that farmers may cultivate up to 14 scattered plots, with almost half of these plots measuring less than 0.2 hectares in size (Teshome, 2009). Similarly, research undertaken in Woreilu and Gozamen woredas, Amhara region, indicated that farmers in these regions cultivate between 5 to 15 plots. The level of fragmentation differs between the two woredas, with farmland being more fragmented in Woreielu (5.15 plots per household) compared to Gozamen (3.54 plots per household) (Girum and Stiem-Bhatia, 2019). A comprehensive comparison of these findings with the database of the pilot land fragmentation studies in the country could offer a clearer and more detailed understanding of the same topic.

10. Empirical evidence on costs of inaction on land consolidation

Globally, land is a fundamental asset for economic development. In Africa, land significantly contributes to its development, and approximately 60% of the population derives its livelihood and income from land directly or indirectly. The agricultural sector's contribution to the GDP in Sub-Saharan Africa is estimated to be between 25% and 40% (Belachew, 2009; Daniel, 2011). In the Ethiopian context, agriculture, which is predominantly rain-fed, has been the basic driver for the country's economy and a source of income for many people. The sector contributes about 43% of the GDP, generates about 90% of foreign currency earnings, and supplies approximately 70% of raw materials to the manufacturing sector (FDRE, 2007). It shall be reckoned that the dependency on land will remain inevitable in the years ahead. And,

the scenario demands giving due care to managing the land resources and devising strategies to maximize production from the scarce land resource.

One of the obstacles to promoting efficient utilization of land in Ethiopia, as discussed above, is the presence of fragmented land holding throughout the country. The ever-increasing population is one central cause of fragmentation. If we keep distributing land for the incoming generation, the impact will be reflected in agricultural productivity and may intensify the problems observed in economic development (Dafa Gudina, 2011). The following section deals with the Meta-analysis of land fragmentation to indicate the significant land fragmentation variables affecting crop productivity and the magnitude of the economic losses inflicted due to land fragmentation, and the lack of measures taken to implement land consolidation.

10.1 Meta-analysis of effects of land fragmentation on farmers' income

As clearly indicated in section 2.3, Meta-analysis is a powerful tool for increasing the amount of participant data available to answer a research question, increasing the reliability of the results, and providing summative answers to much-debated research questions. To this effect, several relevant studies carried out in Ethiopia were considered to prove or disprove the hypothesis that land fragmentation poses a negative impact on crop productivity.

The effects of land fragmentation were analyzed using Linear, Semi Log, and Log Log production functions. The semi Log functional form was chosen as the leading equation due to the Model's goodness of fit. The analysis showed that the coefficient of multiple determination was 0.7442, which implies that the independent variables, including farm size, the land fragmentation index, number of plots, distance of plots from homesteads, oxen power intensity, labor intensity, fertilizer, and age of the household head explained 74.42 percent of the variations in land productivity.

Accordingly, the Meta-analysis using the Model described in Section 2.3.1 has proved that land fragmentation has a far-reaching negative effect on promoting or transforming agricultural productivity. Among the variables considered in the different studies, land fragmentation variables, including Land Fragmentation Index, plot distance, and number of plots, were found to be important variables affecting crop yield productivity (Table 17).

Table 17. Result of Meta-Analysis Random or Mean effect Result from different studies

Variables	Coefficients	Std. Error	t-value
AGE	-0.901677009	0.061624474	0.24824277
PLOTSIZE	0.37959099	0.003823017	99.290961
LFINDEX	-0.20236424	0.002249424	-89.96269
PLOTDISTANCE	-1.679315822	0.220175	-7.62718666
NUMBEROFPLOT	-0.46551	0.014635405	-31.8071149
OXENPOWER	0.013293145	0.038341868	0.34670049
LABORINTENSITY	0.873835098	0.116927984	7.47327602
FERTILIZER	0.620255602	0.286924762	2.161736
EDUCATION	0.008810372	0.004985136	1.767328

10.1.1 Non-land fragmentation parameters and their impact on crop productivity

Labor Intensity: In this Meta-analysis, from a total of 20 selected papers, labor intensity was used as an explanatory variable in most of the studies, and it was found that it has a positive relationship with crop productivity. Most of the results are in line with the hypothesis that an increase in labor usage will lead to an increment in output value, holding other factors constant. The Meta-analysis also shows a positive relationship between labor and crop yield productivity.

Oxen Power Intensity: This refers to the total oxen power used in crop production during the study year divided by the total cultivated land area. This variable affected productivity positively. Holding all other independent variables constant, as oxen power intensity increases, the productivity of each plot increases.

Fertilizer: It was used as an explanatory variable in almost all of the studies and showed a positive relationship with technical efficiency. Most of the results are in line with the hypothesis that an increase in fertilizer usage will lead to an increment in crop productivity.

Education: In most of the studies, education was used as an explanatory variable, and it was found to have a positive relationship with crop productivity. Most of the results are in line with the argument that when farmers have access to better education, they may get better opportunities outside the farm sector to pursue other income-earning activities and to apply improved technologies that increase agricultural productivity.

10.1.2 Land fragmentation parameters and their effect on crop productivity

To quantify the degree of land fragmentation, various methods and indicators have been proposed. These include the number of plots, distances to plots, and an index capturing dissimilarities across farmed plots of land (i.e., Simpsons Index). The findings in the Meta-analysis related to the land fragmentation parameters and their effect on crop productivity are presented as follows.

- **Land Fragmentation Index (Simpson's Index):** Simpson's index is a parameter often used to quantify the degree of land fragmentation. It combines variations in areas among fragments with the number of fragments at the household level. The analysis showed that the coefficient of the land fragmentation index was negatively signed (Table 17), and in the Meta-analysis, holding all other independent variables constant, as the land fragmentation index increases by one percent, the productivity of each plot decreases by 0.91 quintals (91 kg). This implies that the greater the degree of fragmentation of the farmland, the less is the productivity. This conforms to the study of Solomon Assefa (2013) and Tenna et al. (2017), who reported that land fragmentation reduces the productivity of farms.
- **Number of Cultivated Parcels:** The number of cultivated parcels per household is one of the land fragmentation parameters. It has affected plot productivity negatively, which is significant at a 10% probability level. This implied that land holdings with fewer plots lead to optimal crop production. Similar results have been reported showing that there is a negative relationship between increasing number of plots cultivated and the yields of crops. The Meta-analysis result implied that as the number of plots increases by one percent, the quantity of productivity per plot decreases by 0.46 quintal (46 kg), keeping other variables constant.

- **Distance of Parcels from Homestead (Measured the Duration of Walk in Minutes):** The average distance of cultivated parcels from homestead was measured in adult walking time (in minutes) in the Meta-analysis. Land productivity was negatively affected by distance in walk minutes. The result indicated that other explanatory variables kept constant, as the distance of the farmers' residence from plot increased by one percent, the quantity of productivity decreased by 0.16 quintal (16 kg). This implies that the distance between homesteads and parcel wastes labor time, and it demands more time to transport inputs from homesteads to parcels and makes supervision and protection of the land difficult.

In sum, the overall finding in the Meta-analysis indicated that land fragmentation parameters have a negative effect on crop yields. Hence, the need for increasing the efficiency of small-scale farms calls for designing land consolidation programs considering economic, social, and environmental variables.

11. Empirical evidence on potential economic costs incurred due to land fragmentation

Land fragmentation has substantial implications for agricultural productivity levels. Altes and Im (2011) and Demetrious (2014) acknowledged, particularly in developing countries like Ethiopia, that the extent of rural land fragmentation plays a crucial role in national crop production. It affects both the technical and allocative efficiency of crop productivity and the overall environment of rural ecology, thereby influencing the sustainability of farmlands. Various factors, such as crop variety, soil fertility, the use of chemical and organic fertilizers, and agronomic practices, have been identified as influencing crop productivity (Kiflermariam et al., 2022). Research reports focusing on the impact of land fragmentation on crop yield have consistently demonstrated its adverse effects on agricultural output.

To highlight the economic implications of land fragmentation and substantiate the necessity for initiating land consolidation, this study reviews selected research findings on the effects of land fragmentation on crop productivity in different regions of Ethiopia and beyond. The insights derived from these studies underscore the significance of addressing land fragmentation for the enhancement of agricultural productivity and the sustainable utilization of farmlands.

11.1 National empirical evidence on effects of land fragmentation on crop yield

Upper Lake Tana Basin - Ethiopia

A study was conducted to assess the impact of land fragmentation on the productivity of teff, maize, wheat, and barley crops cultivated in the upper Lake Tana basin. The research involved 194 sample farm households, each possessing an average landholding of 1.5 hectares and subdivided into 1,059 plots. According to the findings reported by Gebreegziabher in (2019), the average number of plots per household was 5.46, with an average plot area of 0.245 hectares. The study results revealed that various land fragmentation parameters, including the land fragmentation index, number of plots, and distance, exerted a negative influence on crop yields. These findings suggest a potential link between increased land fragmentation and reduced agricultural productivity in the upper Lake Tana basin as indicated below.

- **Effect of Land Fragmentation Index on Crop Yield:** The analysis conducted in this study reveals a negatively signed and statistically significant coefficient for the land fragmentation index at a 5% level of probability. According to the model results, holding other variables constant, a 1% increase in land fragmentation is associated with a decrease in plot productivity by 0.02 quintals (equivalent to 2 kg per plot or 0.245 ha). This suggests that higher degrees of fragmentation are correlated with lower productivity levels. On a national scale, the total area dedicated to cereals in 2020 was estimated at 7.8 million ha (Kifflermariam et al., 2022). Calculations based on the estimated grain loss for this area indicate a total yield loss of 636,735 quintals (equivalent to 63,673.5 tons) at the national level. These findings underscore the substantial impact of land fragmentation on agricultural productivity, emphasizing the importance of addressing fragmentation issues for improved yield outcomes.
- **Effect of the Number of Plots on Crop Yield:** The number of parcels, identified as one of the land fragmentation parameters in this study, has been found to exert a detrimental impact on crop productivity. The model employed in the investigation indicates that for every 1% increase in the number of parcels, there is a corresponding decrease in yield by 0.01 quintal (equivalent to 1 kg per plot or 0.245 ha), keeping other variables constant. Considering the same cultivation area on a national scale, the estimated loss in crop yield stands at 318,367 quintals, equivalent to 31,836.7 tons.
- **Effect of Parcel Distance on Crop Yield:** The average distance of plots from the homestead, measured in adult walk minutes, was utilized to calculate the yield loss in the study. The model's findings suggest that for every 1% increase in the distance of parcels from the homestead, there is an associated yield loss of approximately 0.005 quintals (equivalent to 0.5 kg per plot, covering an area of 0.245 hectares). Consequently, the estimated national cereal crop yield loss is projected to be 159,184 quintals, equivalent to 15,918.4 tons.

North-western Highlands of Ethiopia

A study conducted by Gashaw et al. (2017) investigated the impact of land fragmentation on farmland productivity in the highlands of North Western Ethiopia. The researchers utilized cross-sectional data collected from 200 farm households, each possessing an average farmland holding of 1.25 hectares during the 2015/16 production season. The analysis employed Linear and Cobb-Douglas production functions. In the land productivity model, approximately 38% of the farmland productivity variation was explained by independent variables, including land fragmentation parameters. In this research, the scholars computed income losses attributed to walking time between parcels and increments in the number of parcels. The findings revealed that for every one-minute increase in the average distance of the parcel from the homestead, crop productivity decreased by 11.4 birr per hectare. Assuming the national estimated area covered by cereal crops is 7.8 hectares, the total income loss was calculated to be 88,920,000 birr. Furthermore, with each additional unit in the number of plots, income decreased by 13.98 birr per hectare, while holding other variables constant. This suggests that the total national loss amounted to approximately 109,044,000 birr. These results underscore the significant economic implications of land fragmentation on agricultural productivity and highlight the importance of addressing factors contributing to parcel dispersion for sustainable agricultural development.

South Eastern Ethiopia

A study on farmland fragmentation and its impact on food production in Southeastern Ethiopia, Oromia, was conducted by Dafa Gudina in 2011. The research utilized a sample of 92 farm households, each with an average landholding of 2.3 hectares, subdivided into an average of 3.34 parcels. The parcels, on average, measured 0.68 hectares each. The Cobb-Douglas model was employed for the analysis. The findings of the study revealed that the distance between plots has a significant negative effect on crop productivity. Holding other variables constant, the analysis demonstrated that an additional one-minute walking distance, on average, between two plots resulted in a reduction of approximately 16.96 kilograms of grain on 0.68 hectares. Extrapolating this to the national level, assuming the same area covered by cereals, the estimated crop yield loss is in the order of 194,541.1 tons.

These findings underscore the importance of considering farmland fragmentation and its associated factors in agricultural planning and policy formulation to mitigate reserve potential negative impacts on food production and overall agricultural sustainability.

Arsi Zone - Ethiopia

A recent land fragmentation study conducted by Teshome et al. (2022) in the Arsi Zone, Oromia region of Ethiopia, examined 314 households, revealing an average landholding of 1.6 hectares per household, subdivided into an average of 3.54 plots. Each parcel, on average, measured 0.45 hectares. The Multiple Linear Regression model analysis indicated that a one-unit increment in land fragmentation led to a decrease of 36.53 kilograms per hectare in total crop production. Extrapolating this finding to a national level, considering the estimated area covered by cereal crops at 7.8 million hectares, the total yield loss is estimated to be 284,934 tons.

Table 18 summarizes the outputs of the models employed in the three selected studies: Gebregziabber (2019), Gashan (2017), and Teshome et al. (2022).¹

Variables	Gebregziabber, 2019			Gashan, 2017			Teshome, 2022		
	Lin-Lin	Semi log	Log-Log	Multiple Linear	Log-Log	Multiple Linear	Multiple Linear	Log-Log	Multiple Linear
Intercept	Coefficient 4.92(***)	Coefficient 8.6(***)	Coefficient 4.09(***)	Coefficient 1151.03***	Coefficient 4.09(***)	Coefficient 1151.03***	Coefficient 57.113	Coefficient 4.09(***)	Coefficient 57.113
Area	2.1(**)	5.92(***)	0.61(***)	-125.84	0.61(***)	-125.84	-----	-----	-----
LF Index	2.85	-1.9(**)	0.44(**)	-----	0.44(**)	-----	-36.532***	-----	-36.532***
No of Plot	-0.87(***)	-1(*)	-1.06(***)	-13.98***	-1.06(***)	-13.98***	-----	-----	-----
Distance (Minute)	-0.0223	-0.5(*)	0.164(**)	-11.40***	0.164(**)	-11.40***	-----	-----	-----
Oxen Power Intensity	-0.0056	0.811(**)	-0.0094	28.42***	-0.0094	28.42***	2.220***	2.220***	2.220***
Capital Intensity	-1.9*10 ⁻⁴	-0.0215	-0.099	2.87***	-0.099	2.87***	9.997 ***	9.997 ***	9.997 ***
Labor Intensity	0.3227(**)	0.158	0.136	-0.23	0.136	-0.23	-720	-720	-720
Educational Status	0.0619(**)	0.0062	0.011(**)	1.548	0.011(**)	1.548	1.548	1.548	1.548
Age	-0.039(**)	-1.1(***)	-0.24(*)	-6.20*	-0.24(*)	-6.20*	218	218	218
R ² (goodness of fit)	39.22	74.42	52.12	0.42	52.12	0.42	0.359	0.359	0.359
Adjusted R ²	35.19	72.72	48.94	0.38	48.94	0.38	7.902***	7.902***	7.902***
F-Ratio	9.73(***)	43.87(***)	16.42(***)	5.56***	16.42(***)	5.56***	-----	-----	-----

¹ The results of the Meta analysis indicated in Table 18 are derived from the different land fragmentation studies carried in Ethiopia and summarized in Table 6.

11.2. International empirical evidence on the effects of land fragmentation on crop yield

In addition to the national research outputs, international empirical evidence on the effect of land fragmentation on crop yield was reviewed using studies carried out in Nigeria, Rwanda, Kenya, and India. The results in each case are presented below.

- **Nigeria:** The study conducted in Nigeria aimed to assess the impact of land fragmentation on smallholders' crop productivity in Imo State (Heke and Amaechi, 2016), involving a sample of 72 farm households. The variables examined included the number of plots, the Simpson index, and the plot area. The analytical approach utilized a Linear Semi-Log and Double Log model. The model's goodness of fit was determined to be 0.76, indicating that 76% of the variations in land productivity could be explained by the independent variables. The study findings indicated that the coefficient of the land fragmentation index was both negatively signed and statistically significant. This suggests that as the degree of fragmentation increases, crop productivity decreases. Furthermore, a 1% increment in the land fragmentation index was associated with a reported loss of 36 kilograms per hectare. The implications of these results underscore the importance of addressing land fragmentation issues to enhance smallholders' crop productivity in the region.
- **Rwanda:** A study conducted by Bizimana et al. (2004) investigated the impact of land fragmentation on economic efficiency in southern Rwanda, focusing on 200 farm households. The study employed various variables, including the number of plots, the operated area, and the distance between parcels and residences. The analysis utilized the two-stage least square (2SLS) method to assess the income loss attributed to these factors. Interestingly, the results indicated that while distance did not exhibit a significant effect, the number of plots demonstrated a noteworthy negative impact on net farm income per hectare, as evidenced by a coefficient of -0.223. In terms of cash, this effect translated to a substantial loss of 340.44 Rwandan Franc per hectare.
- **Kenya:** In Kenya, a study conducted by Kiplimo and Ngenov (2016) investigated the impact of land fragmentation on farm-level efficiency on 200 households engaged in maize cultivation. The analysis employed the Quantile Regression Model and Cobb-Douglas framework. The findings revealed that, with respect to the scale of production, farmers managing more fragmented land exhibited lower efficiency (58%). Conversely, farmers operating on larger farm sizes with fewer parcel numbers demonstrated a 70% efficiency in crop productivity.
- **India:** A study conducted in India examined the impact of land fragmentation on crop production efficiency, utilizing a sample of 14,980 households. The key variables under analysis included the Simpson Index, the number of fragmented plots, and distance. The findings revealed that a 1% increase in the Simpson Index led to a 4.7% reduction in net farm income. Additionally, with every 1% rise in distance, there was a corresponding decrease of 6.1% in net farm income (Daniel et al., 2010).

In summary, findings from studies conducted in Ethiopia and other nations consistently indicate that land fragmentation adversely impacts crop productivity. The results underscore the imperative for implementing a comprehensive land consolidation program in Ethiopia.

12. Strategies for land consolidation

The empirical findings within this study distinctly highlighted the prevalence of severe land fragmentation and small landholdings among farmers. Likewise, the literature reviewed in the preceding sections, along with the Meta-Analysis, underscores land fragmentation as a substantial obstacle to both agricultural productivity and environmental sustainability.

This study argues that land consolidation stands as a pivotal instrument capable of fostering more productive land utilization, sustainable societal development, and ecological stability. Thus, advocating for a comprehensive approach in land consolidation becomes imperative to steer balanced decisions concerning the sustainable use of land, aligning with societal, economic, and environmental needs.

Global experiences emphasize that successful land consolidation efforts should consider specific elements within the process. Incorporating these elements is crucial to ensure the effectiveness and success of the land consolidation program.

- **Awareness Creation:** Raising adequate awareness among landholders regarding the detrimental impacts of land fragmentation on agricultural productivity, coupled with highlighting the advantages of land consolidation, stands as a fundamental step in initiating voluntary farm land exchange while discouraging further fragmentation. The suggestion here underscores the need for comprehensive awareness-raising programs aimed at enhancing community understanding of land consolidation, fostering cooperation within communities to actively engage in the process. It is crucial to note that awareness creation shouldn't solely focus on the community; it should also target professionals and experts involved in the practical aspects of land consolidation. Ensuring their understanding and participation is vital in facilitating and executing successful land consolidation initiatives. This concerted effort toward awareness among both communities and professionals is pivotal in fostering a collective commitment toward effective land consolidation practices.
- **Effective Participation of Concerned Stakeholders:** Ensuring the involvement of all relevant stakeholders in the land consolidation process is imperative. In a democratic setting, the right to information, meaningful consultation, and active participation stand as a cornerstone. It is crucial for a democratic state to enable mechanisms that facilitate effective deliberation on the environmental, political, cultural, social, and economic implications of governmental decisions and laws at the community level. The evolution of participation in land consolidation processes, as seen in the Netherlands, showcases the importance of shifting toward more inclusive approaches. Initially, participation was limited to information sharing and consultation, but it later transformed into a co-creation model. In this model, landholders actively engage, discussing possibilities such as land exchange, ultimately leading to effective land consolidation. Considering Ethiopia's constitutional acknowledgment of the right to participation and consultation (FDRE Constitution, Arts. 43(2) & 89(6)), the subsidiary laws governing land consolidation should incorporate provisions for effective participation. This implies that when legislation for land consolidation is enacted, particular attention should be directed toward stakeholder participation. Detailed regula-

tions should outline the levels and methods of engagement, aiming to move beyond mere information sharing to a more robust level of participation. This goes in line with the need for inclusiveness both to the process and outcomes of land consolidation.

- **Start with Piloting the Land Consolidation Projects:** The initiation of land consolidation should commence through pilot projects and subsequently expand to encompass a broader scope. Targeting high-potential areas within their productive capacities is pivotal. Initially, the focus of land consolidation within pilot projects should be on irrigable areas. Ethiopia exhibits the potential to undertake land consolidation in each regional state, given the existence of potential areas suitable for initiating consolidation through pilot programs. Budget allocation stands at the core of this process. In Lithuania, as a response to severe land fragmentation, the commencement of land consolidation followed substantial international technical and financial assistance. A pilot area spanning 392 hectares involving 79 private landowners was selected. This pilot initiative was subsequently expanded, and adequate funds were allocated from the Rural Development Program with co-funding from the EU. Presently, a state land fund has been established to manage land consolidation, with several stakeholder institutions operating in coordination. The Lithuanian experience highlights that the introduction of land consolidation within a state need not be an excessively protracted process. However, it is expected that adjustments in legislation and procedures will be necessary based on experiences gained from initial projects, despite the earlier implementation of pilots (Hartvigsen, 2015). As evidenced in Albania, the implementation of pilot projects revealed numerous difficulties and obstacles, signifying that the pilot phase is an opportune time to comprehend the opportunities and challenges inherent in land consolidation. In Albania, among various issues, challenges related to the regime of property rights, particularly concerning the execution of property transactions and the procedural intricacies of registering these transactions, were encountered in the pilot phase (Republic of Albania Ministry of Agriculture, Food, and Consumer Protection, 2013).

These examples emphasize the importance for Ethiopia to commence land consolidation through meticulously designed pilot projects. The pilot stage should serve as a platform to understand various practical aspects of the land consolidation process. The lessons derived from these experiences serve to mitigate challenges and capitalize on opportunities during the extensive-scale implementation of land consolidation. It is imperative to acknowledge that land consolidation is not a one-time measure for an entire country. Therefore, the consolidation project should commence with a pilot program, recognizing that the process might span several years or more. For instance, in Turkey, the initial land consolidation project in 1961 marked the beginning of a transformative journey. Over the subsequent years, 87 projects were implemented, consolidating a land area of 58,000 hectares by 1980. The land consolidation process continued, and by 2006, the coverage expanded to 0.6 million hectares. Further land consolidation actions propelled the consolidated land to reach 3.2 million hectares by 2012. Notably, this momentum persisted, with the consolidated area expanding to 8 million hectares by the end of 2018; and it is anticipated to reach 14 million hectares by the year 2023 (Karaman and Gokalp, 2018). This progression underscores the importance of designing land consolidation in an incremental approach, taking into consideration the available resources and other variables that impact the implementation process. By adopting a phased strategy, countries can effectively navigate the complexities associated with land consolidation, ensuring sustained success over an extended period.

- **Comprehensive Land Consolidation:** Land consolidation necessitates a comprehensive approach, facilitating balanced decisions that align with societal, economic, and environmental needs for sustainable land use (Louwsma et al., 2017). Acknowledging the multifaceted nature of land—spanning social, political, economic, cultural, and aesthetic dimensions—our approach to consolidation should strive to harmonize diverse interests reflective of these dimensions. It is imperative to avoid prioritizing short-term gains over sustainable and long-term utilization of this resource. Contemporary trends indicate that beyond its predominant agricultural focus, land consolidation can serve nature conservation and climate change adaptation goals. Rather than purely economic gains, the emphasis should be on sustainable resource utilization, conservation, and environmental protection. Therefore, laws governing this domain should move beyond temporary fixes and instead provide a comprehensive, long-term response to land fragmentation (Louwsma et al., 2017). As much as possible, the advice is to consider the diverse dimensions of land throughout the consolidation process. The Dutch experience illustrates a comprehensive approach in their land consolidation program, addressing various objectives such as climate change mitigation, agricultural enhancement, landscape improvement, and nature conservation. Similarly, Finland, as a heavily forested European Union member with 86% forest cover, incorporated this aspect significantly into its consolidation efforts. This included targeting wetland protection and reducing CO₂ emissions. These examples underscore the need for Ethiopia's land consolidation project to adopt a comprehensive approach that encompasses the various dimensions of land, rather than focusing on a singular aspect.
- **Establishing and/or Identifying Responsible Institutions:** As a crucial response to land fragmentation and the nation's pursuit of sustainable development, the leadership of land consolidation should be vested in a responsible institution. Starting from the federal level and extending to the grassroots government structures, specific responsibilities should be allocated. Recognizing that land often represents local wealth (Marci, 2003), empowering local communities and administrations is prudent. Clearly defining the roles and duties of each administrative level and institution, along with outlining potential legal and administrative repercussions in case of failures, is paramount. Germany's model demonstrates this, with the majority of land consolidation responsibilities resting at the state (Länder) level, where the Ministry of Agriculture serves as the principal authority (Hartvigsen, 2015). In this endeavor, landholders themselves and the lowest administrative units (typically municipalities) have played a pivotal role from the outset.

In Ethiopia, the foundational legislation for land consolidation should be established at the federal level, while regional states may formulate their own land consolidation laws, preferably as regulations and directives, considering their unique contexts. This approach aligns with the division of powers concerning land in the federal constitution, where the national government enacts laws for land utilization and conservation, while states administer them within the framework of federal law (FDRE Constitution, Arts. 51/5 & 52/2/e). This allows for a standardized regulatory framework at the national level, which Ethiopia should emulate. Given the fundamental importance of land as a resource in the country, the federal government should determine the essential aspects of land consolidation provisions, leaving the specifics to regional states. In the pilot project implementation in the Republic of Albania, the role of local government units proved vital for successful project execution. Local governments were instrumental in providing pertinent documents, data, plans, urban planning maps, offering office space for the implementing entity's local project team, supporting project workshops and daily operations, and closely collaborating with the national-level Land Consolidation Commission (Republic of Albania Ministry of

Agriculture, Food, and Consumer Protection, 2013). Similarly, local-level administrations in Ethiopia can play substantial roles in the land consolidation process.

- Determination of the Nature of the Land Consolidation:** In Ethiopia, the decision regarding whether land consolidation should be implemented on a voluntary or compulsory basis will be determined through legislation. The German land consolidation framework presents a broad spectrum of possibilities and includes five types of land consolidation instruments: comprehensive, voluntary land exchange, accelerated, simplified, and land consolidation in cases of permissible compulsory acquisition (Hartvigsen, 2015). Ideally, land consolidation instruments should be built upon the consent of landholders, as observed in Lithuania where the approach was entirely voluntary (Louwsma et al., 2017). However, in practice, some or all landholders may resist participating in land consolidation, necessitating alternative instruments that compel adherence. Experiences from various states suggest that if landholders refuse to participate, relevant laws may lead to the expropriation of their land rights (Hartvigsen, 2015). In situations necessitating it, Ethiopia may also consider invoking land expropriation laws to displace resistant landholders, ensuring that appropriate compensation is provided. Hence, the strategy for the Ethiopian government should include considering various options for land consolidation, including the forceful eviction of opposing landholders, alongside the voluntary approach. Compulsory land acquisition often faces criticism due to its inability to sufficiently meet public space, infrastructure, and other land demands. It is a time-consuming, expensive, controversial, and potentially destructive process when it involves involuntary dispossession or forced eviction (Louwsma et al., 2017). Therefore, relying solely on forceful eviction for land consolidation might not yield intended results. Consequently, the primary approach to land consolidation in Ethiopia should prioritize securing the consent of landholders, with alternative methods considered only when voluntary consolidation proves challenging or impractical.
- Promoting Voluntary Land Exchange:** Another viable strategy involves promoting voluntary land exchange and formalizing its process, primarily through legal support and information updates. Research indicates that addressing issues of land fragmentation can be effectively tackled by instituting policies that endorse the formalization of land exchanges and encourage voluntary exchanges among landholders. This proactive approach assists rural landholders in alleviating the productivity limitations imposed by fragmented land holdings.
- Discouraging Further Land Fragmentation:** Achieving proper land consolidation involves strategically discouraging ongoing land fragmentation. One approach is to establish rules within rural land laws that define a minimum permissible land size, aimed at deterring further diminishment. Determining this minimum size should consider its correlation with achieving an economically viable farm size associated with higher productivity (Tenna et al., 2006). The rural land proclamations in the Amhara, Oromia, and Southern Nations, Nationalities, and Peoples' (SNNP) regions have specified minimum holding sizes, marking a commendable step in the ongoing efforts to reduce further land fragmentation. The economic value of a farm size is directly influenced by farm labor productivity and indirectly impacted by the availability of non-farm employment, which affects rural dependence on land and agriculture (Gebreselassie, 2006). Another specific strategy involves developing rural infrastructural amenities, crucial for fostering non-farm income sources, local product-based value-adding activities, and employment opportunities. Implementing these initiatives can help prevent further reductions in farm sizes and facilitate gradual land consolidation (Beyene, 2019).

- **Involvement of NGOs and International Development Agencies and other interested groups:** It is imperative that governments frequently take the lead in land consolidation interventions. In this endeavor, it is worth acknowledging that international development agencies, non-governmental organizations (NGOs), and other interested groups, whether formal or informal institutions, play a pivotal role, and their contribution is immense. Broadly speaking, depending on their financial resources and technical expertise, these involved parties can:
 1. Act as intermediaries between the government and landholders, facilitating cooperation among stakeholders.
 2. Provide the financial means and technical support necessary for both piloting and scaling up land consolidation efforts.
 3. Serve as conduits for convening power, organizing knowledge exchange activities, and disseminating lessons learned throughout the process of land consolidation.

In summary, the collaboration between governments and various external entities is crucial for the success of land consolidation initiatives, with each party contributing its unique strengths to ensure effective implementation and sustainable outcomes.

- **Incorporating Gender Issues:** In a developing agrarian economy where the majority rely on land, addressing women's land rights goes beyond governance, agricultural growth, and economic development—it encompasses agency, power dynamics, politics, and representation both nationally and locally (Peters, 2013). Ensuring land rights is pivotal for sustainable development, livelihood security, poverty eradication, democratization, good governance, and the realization of certain human rights (Deininger, 2003). For women, it extends to issues of gender equality, focusing on how to best support and strengthen their land rights and interests (Kaarhus and Dondeyne, 2015). It is crucial to integrate gender perspectives into the process. In many societies, women often find themselves as the de facto heads of households but lack decision-making power or a voice in community discussions. However, empowering women in land-related matters can enable them to capitalize on emerging opportunities, including those arising from land consolidation. Hence, given the substantial prevalence of women-headed rural households in Ethiopia, the approach to land consolidation should explicitly incorporate their participation in local institutions involved in the land consolidation process. This ensures that they have ample opportunities to actively engage in decision-making within the framework of land rights and consolidation efforts.
- **Integration between Land Administration and Land Consolidation:** Achieving an effective balance between the land administration system and the proposed land consolidation is crucial. A robust land administration system not only supports but also shapes the development and execution of land consolidation, and conversely, effective land consolidation efforts can enhance land administration. The definition of land tenure within the land administration system plays a pivotal role; any shortcomings in this aspect can impede the smooth operation of land consolidation. In the Ethiopian context, SLLC serves as a crucial prerequisite for the selection of pilot land consolidation areas. In the execution of land consolidation activities, it is imperative to engage technically and managerially competent, as well as energetic experts. These experts play a pivotal role in coordinating and expediting various tasks from the grassroots to upper levels. Consequently, the land administration system must proactively consider the necessary inputs right from the outset

to ensure the provision of efficient services. Additionally, it is essential to guarantee that the identified needs of responsible actors are comprehensively addressed in alignment with the established goals of land consolidation. Successful land consolidation initiatives within a state can significantly contribute to improved land administration and governance (Louwsma et al., 2017). It is imperative to recognize that land consolidation should not exist in isolation from a state's land tenure system. Consequently, the laws and regulations governing land consolidation must align with various rural land legislations enacted at both federal and regional levels. This alignment ensures that land consolidation efforts integrate seamlessly within the broader framework of land tenure and administration, fostering a more cohesive and effective land governance system.

- **Sharing Country Lessons:** Land consolidation has been implemented in various states worldwide, offering potential lessons applicable to Ethiopia. However, it is essential to approach these lessons with caution, recognizing that adopting models indiscriminately is impractical. Even when similar institutional and legislative frameworks exist, diverse circumstances often necessitate nuanced operational approaches (Watts, 2008). Factors like social, cultural, economic, and psychological contexts, as well as the level of development, significantly influence the applicability of lessons learned (Cruz, 1999). Land consolidation interventions need tailored approaches that suit specific contexts. Legislation, funding, cultural aspects, land utilization needs, administrative systems, institutional structures, and other elements tend to vary among states. This variation in socio-economic circumstances and institutional setups justifies the need for bespoke solutions in land consolidation and readjustment (Louwsma et al., 2017). Therefore, when drawing relevant lessons for Ethiopia, careful consideration must be given to assessing how these lessons align with Ethiopia's legal, social, economic, political, cultural, and institutional contexts. A fit-for-purpose approach is essential, emphasizing solutions that align with Ethiopia's specific circumstances rather than relying on one-size-fits-all solutions from other regions.

13. Conclusion and Recommendations

13.1 Conclusion

This study provides a comprehensive delineation of land fragmentation and land consolidation concepts while extensively reviewing diverse literature on factors precipitating land fragmentation. It delves into the economic, social, and environmental challenges posed by land fragmentation and indicates potential strategies for land consolidation. To furnish empirical evidence regarding land fragmentation in Ethiopia, the study meticulously analyzes the rural land holding cadastral database for Amhara, Oromia, and former SNNP regional state established through the National Rural Land Administration Information System (NRLAIS) and stored at the Federal Land Administration and Use Directorate (LAUD) of the Ministry of Agriculture. Furthermore, it provides a succinct overview of the country's land tenure systems across different regimes in relation to land fragmentation, reinforced by empirical evidence from various studies conducted locally and globally.

The various studies carried out on land fragmentation were analyzed using Meta-Analysis to prove the hypothesis whether land fragmentation has a negative impact on crop productivity or not and also to identify land fragmentation parameters having profound socioeconomic and sustainable land management implications. The factors driving land fragmentation are intricately linked to historical, institutional, and sociological elements. Particularly, recurrent land redistribution, inheritance, and donations as permitted by land laws exacerbate land fragmentation. Although current rural land laws in Ethiopia aim to discourage fragmentation, challenges persist due to a burgeoning rural population, land claims via inheritance by the landless, and inadequate enforcement of land laws at the local government level.

While acknowledging assertions about the positive aspects of land fragmentation in terms of risk aversion, the majority of research findings emphasize its substantial disadvantages over advantages. Factors such as small parcel size, increased number of parcels per farmer, spatial distribution and distance among parcels, irregular parcel shapes, and numerous parcel boundaries are identified as pivotal elements contributing to reduced yields, social conflicts, limited use of farm machinery, and hindrance to sustainable land management.

The analysis of farmers' land holdings across the three regions reveals generally low average land holdings, with a significant number of farmers operating on half a hectare or less, impeding sufficient grain production. Land fragmentation exacerbates this issue, as a majority of farm householders manage at least four fragmented parcels.

Meta-analysis indicates that land fragmentation unequivocally diminishes crop productivity. Specifically, variables like the Land Fragmentation Index, number of parcels, and distance between parcels substantially impact crop productivity. The examination of costs associated with land fragmentation in Ethiopia, coupled with the failure to execute land consolidation, projects an annual potential loss of hundreds of thousands of tons of grain, up to 284,934 tons. This significantly impacts the nation's food security efforts.

Despite the historical incidents that have induced land fragmentation and the diminution of parcel sizes in Ethiopia, the current regime appreciates the problems associated with land fragmentation. In this regard, the legal provisions across rural land laws in the three regions stand as robust ground to curb land fragmentation and spearhead land consolidations in the country.

The review of land consolidation aptly illustrates a gamut of options, including voluntary land exchange, cluster farming, land realignment, land banking, and land development. However, the effective implementation of these systems hinges on adequate resources, appropriate legal provisions, and institutional arrangements binding stakeholders toward the shared goal of improving livelihoods through productive agriculture and environmental sustainability.

Finally, the presence of reliable cadastral data highlighting the existence of severe land fragmentation and empirical evidence underscoring its adverse impact on crop productivity and land management substantiate the challenges associated with land fragmentation. These findings serve as critical markers to steer policy initiatives toward farmland consolidation.

13.2 Recommendations

Based on the findings gleaned from literature and landholding data analyses, the following recommendations are proposed to alleviate land fragmentation and initiate a policy discourse on land consolidation.

Land fragmentation is a widespread phenomenon in the study regions (Amhara, Oromia, and SNNP), posing a threat to agricultural transformation and food security efforts. Without curbing this trend, managing the environment and ensuring social stability become formidable challenges. Urgency lies in the hands of responsible authorities to exhibit political commitment and instigate land consolidation practices. The Ministry of Agriculture's LAUD, supported by development partners, should craft legal frameworks, drawing from global and national experiences, to persuade policymakers, land experts, and farmers. Using the available evidence, efforts should focus on cultivating awareness and a shared understanding that farmland fragmentation impedes national development. Hence, concerted action is imperative to achieve consensus on immediate interventions halting further fragmentation.

One primary factor exacerbating farmland fragmentation is the burgeoning rural population, which has resulted in the emergence of an enormous group of landless individuals and the prevalence of land inheritance practices. Inheriting descendants lead to decreased land sizes as divisions occur among heirs. To address this issue effectively, it is imperative to revisit existing land inheritance laws, establish minimum parcel division sizes, and devise frameworks that discourage land division among inheritors. These proactive measures are crucial steps to curb fragmentation and encourage joint operations on larger parcels. This effort should be complemented by economic and administrative development activities in the country to facilitate the movement of people from rural to urban areas. Such initiatives can help alleviate the pressure on land resources, contributing to a more sustainable and efficient land use system. By implementing these measures, we can work towards mitigating farmland fragmentation and fostering a conducive environment for agricultural sustainability.

For a meaningful land consolidation policy, the empirical findings in this study revealing the challenges posed by land fragmentation must be disseminated to raise awareness about the severity of the issue. This again has to be complemented by a reconnaissance survey to measure how land fragmentation problems are perceived by farmers and government bodies before

initiating the land consolidation idea. In this case, as it is currently being practiced in some districts of the country, many more project-based piloting of land consolidation intervention should be carried out to elicit the challenges and opportunities and design viable designs that could enhance land consolidation interventions.

Land consolidation stands out as a prominent measure employed to address the issue of land fragmentation. In order to garner the confidence of farmers and further promote the practice of land consolidation, it is imperative to place significant emphasis on well-organized awareness campaigns highlighting the drawbacks of land fragmentation while simultaneously publicizing the numerous benefits associated with land consolidation. This approach serves to strengthen the ongoing voluntary parcel exchange initiatives across various regions and encourages additional farmers to partake in similar endeavors.

Concurrently, concerted efforts should be directed towards identifying woredas and kebeles where land fragmentation is particularly severe, leveraging data from the National Rural Land Administration and Information System (NRLAIS). Prioritizing these areas for systematic land consolidation interventions becomes crucial in mitigating the challenges posed by fragmented land ownership. Policymakers must play an active role in endorsing the consolidation process, and relevant institutions should ensure the regular updating of their land registries to mitigate uncertainties surrounding land-holding rights. Furthermore, the formulation of incentives, such as agricultural extension support, mechanized services, or specialized credit arrangements, can serve as powerful motivators for farmers to willingly consolidate their farmland. This comprehensive approach not only addresses the immediate issues related to land fragmentation but also fosters a conducive environment for sustainable agricultural practices.

The transition towards land consolidation interventions necessitates the identification of responsible government institutions and engagement of other pertinent stakeholders to win their effective participation. Stakeholders must conduct a thorough analysis to discern the most suitable land consolidation approach, taking into account the prevailing realities in different regions. Gender issues must be seamlessly integrated into this process, given their significant relevance. As land consolidation demands substantial resources, concerted efforts should be made to secure the generous support of Non-Governmental Organizations (NGOs) and International Development Agencies. This collaborative approach ensures a comprehensive and sustainable strategy for land consolidation, fostering positive outcomes and addressing the multifaceted challenges associated with this endeavor.

The experiences in other countries demonstrate that addressing land fragmentation and promoting land consolidation necessitate the development of appropriate legal frameworks, the establishment of a comprehensive database on land holdings, assurance of land tenure security, and the creation of a functional organizational setup equipped with experts, physical facilities/computers, GIS facilities/ and financial support. The progression towards land consolidation in Ethiopia should, therefore, be assessed against these established standards. The government must identify existing gaps, and the approach should be meticulously designed, taking into account economic, social, and ecological variables. In this regard, the ongoing initiatives such as land registration, parcel cadastral maps production, and the issuance of second-level land holding certificates should be reinforced. Lessons gleaned from pilot land consolidation projects should be systematically compiled, as these constitute essential foundations for future interventions in land consolidation. It is imperative that the government strengthens these initiatives to ensure a robust and effective framework for addressing land fragmentation and promoting sustainable land consolidation in Ethiopia. References

14. Annexes

14.1 Annex 1: Meta-Analysis on farmland fragmentation parameters effect on crop productivity

	coef	se	si	si2	wi	yiwi		
Age	-1.1	0.07	0.07	0.0049	204.0816	-224.49	m	-0.86034748
	-0.5988	0.15407	0.15407	0.023738	42.12732	-25.2258	v	0.003274603
	-0.22	0.13	0.13	0.0169	59.1716	-13.0178	se	0.057224145
					305.3806	-262.733	t	-15.0346934
Labor Intensity	0.3227	0.131515	0.131515	0.017296	57.81618	18.65728	m	0.02069457
	0.02	0.005	0.005	0.000025	40000	800	v	2.49551E-05
	0.75049	0.2659	0.2659	0.070703	14.14371	10.61471	se	0.004995509
					40071.96	829.272	t	4.142635354
LF Index	-1.06	0.489	0.489	0.239121	4.181983	-4.4329	m	0.000506797
	-0.09	0.04	0.04	0.0016	625	-56.25	v	1.14126E-07
	0.00065	0.00034	0.00034	1.16E-07	8650519	5622.837	se	0.000337825
	-0.01	0.003	0.003	0.000009	111111.1	-1111.11	t	1.500176994
	0.29507	0.29507	0.087066	11.4855	-10.3495			
				8762271	4440.694			
No of Plot	-1.06	0.489	0.489	0.239121	4.181983	-4.4329	m	#VALUE!
	-13.98	0.1709	0.1709	0.029207	34.23859	#VALUE!	v	0.000214195
	-0.47581	0.014696	0.014696	0.000216	4630.221	-2203.11	se	0.014635405
					4668.641	#VALUE!	t	#VALUE!
Distance of the Plot	-56.6667	0.124179	0.124179	0.01542	64.84906	-3674.78	m	-178.22368
	-0.164	0.313	0.313	0.097969	10.20731	-1.674	v	0.048477031
	-11.40	0.220175	0.220175	0.048477	20.62833	-3676.46	se	0.220175
							t	-809.463747
Oxen Power	0.811	0.4	0.4	0.16	6.25	5.06875	m	0.019922129
	0.02	0.004	0.004	0.000016	62500	1250	v	1.58277E-05
	0.06	0.04	0.04	0.0016	625	37.5	se	0.003978409
	-0.69203	0.14291	0.14291	0.020423	48.96376	-33.8844	t	5.00756148
				63180.21	1258.684			
Plot Size	5.92	0.53	0.53	0.2809	3.559986	21.07512	m	0.044152747
	0.05	0.04	0.04	0.0016	625	31.25	v	0.000152772
	0.04	0.013	0.013	0.000169	5917.16	236.6864	se	0.01236008
					6545.72	289.0115	t	3.572205458
offfarm	-2.41	1.01	1.01	1.0201	0.980296	-2.36251	m	0.620255602
	1.71	0.97	0.97	0.9409	1.062812	1.817409	v	0.082325819
	0.79963	0.3146	0.3146	0.098973	10.10375	8.079261	se	0.286924762
					12.14686	7.534156	t	2.161736052
Educ	-0.18	-0.08	-0.08	0.0064	156.25	-28.125	m	0.008810372
	0.01	0.005	0.005	0.000025	40000	400	v	2.48516E-05
	-0.21	0.11	0.11	0.0121	82.64463	-17.3554	se	0.004985136
					40238.89	354.5196	t	1.767328431

14.2 Annex 2: Land fragmentation study data collection format

Summary of variables to be included for land holding and land fragmentation analysis

I: Households’ Average Land Holding Description at Regional Level

- 1: Region: Amhara/Oromia/SNNP
- 2: Average land holding by a household in the Region in ha.:
- 3: Average land holding by a household (ha) each zone in the Region:.....
- 4: Average land holding by a household in each Woreda in each Zone:
- 5: Average number of parcels held by a household in each zone of the Region:.....
- 6: Average number of parcels held by a household in each woreda of Zones:
- 7: Average number of parcels held by households at regional level:

II: Households’ Land holding description in different land holding size categories in percent in the Woredas of each Zone

1. Zone:..... Total Number of land holders
2. Name of the Woreda Total Number of land holders.....
3. Percent of households in the Woreda under each land holding category:
 - 3.1 Of the total land holders in the Woreda the percent of households having up to 0.5 ha:
 - 3.2 Of the total land holders in the Woreda the percent of households having 0.51 to 1.0 ha
 - 3.3 Of the total land holders in the Woreda the percent of households having 1.1 up to 1.5 ha :.....
 - 3.4 Of the total land holders in the Woreda the percent of households having 1.51 to 2.0 ha :.....
 - 3.5 Of the total land holders in the Woreda the percent of households having 2.1 ha to 2.5 ha
 - 3.6 Of the total land holders in the Woreda the percent of households having 2.61 to 3.0 ha.....
 - 3.7 Of the total land holders in the Woreda the percent of households having more than 3 ha

Based on the land holding data calculated for each woreda found in one zone , the data for each Zone can be summarized as follows:

III: Households’ Land holding description in different land holding size categories in percent across Zones in the Region:

1. Zone Total Number of households.....
2. Percent of land holders in each Zone under each land holding category:
 - 2.1 Of the total land holders in the Zone the Percent of households having up to 0.5 ha:
 - 2.2 Of the total land holders in the Zone the Percent of households having 0.51 to 1.0 ha
 - 2.3 Of the total land holders in the Zone the Percent of households having 1.1 up to 1.5 ha :.....
 - 2.4 Of the total land holders in the Zone the Percent of households having 1.51 to 2.0 ha :.....
 - 2.5 Of the total land holders in the Zone the Percent of households having 2.1 ha to 2.5 ha
 - 2.6 Of the total land holders in the Zone the Percent of households having 2.61 to 3.0 ha....
 - 2.7 Of the total land holders in the Zone the Percent of households having more than 3 ha

Based on the land holding data calculated at Zonal level the regional land holding data can be summarized as follows:

VI: Regional land holding size of households expressed in percent in each land holding category

1. Percent of households having up to 0.5 ha:
2. Per Percent of households having 0.51 to 1.0 ha
3. Percent of households having 1.1 up to 1.5 ha :
4. Percent of households having 1.51 to 2.0 ha :
5. Percent of households having 2.1 ha to 2.5 ha
6. Percent of households having 2.61 to 3.0 ha
7. Percent of households having more than 3 ha

IV: Calculations on Land Fragmentation:

- A. Percent of households in different number of parcel categories across Woredas in each Zone of the Region
 1. Zone :
 2. Woreda:.....
 3. Total Number of landholders in the Woreda
 4. Total number of parcels in the Woreda:
 5. Average number of parcels held by a household in the Woreda :
 6. Percent of households in parcel category in the woreda:
 - 6.1 Of the total land holders Percent of households having 1 to 2 parcels:
 - 6.2 Of the total land holders Percent of households having 3 to 5 parcels
 - 6.3 Of the total land holders Percent of households having 6 to 8 Parcels
 - 6.4 Of the total land holders Percent of households more than 8 parcels:

Based on the data on land fragmentation at woreda level the Land Fragmentation figures for each zone can be summarized as follows:

1. Zone:
2. Total No. of households in the Zone:
3. Total number of parcels in the Zone :
4. Average number of parcels held by a household in the Zone:
5. Percent of households in the zone across parcel category:
 - 5.1 Of the total land holders in the Zone Percent of households having 1 to 2 parcels:
 - 5.2 Of the total land holders in the Zone Per Percent of households having 3 to 5 parcels
 - 5.3 Of the total land holders in the Zone Percent of households having 6 to 8:
 - 5.4 Of the total land holders in the Zone Percent of households more than 8 parcels:

Based on the Zonal data on land fragmentation, the land Fragmentation level at Regional level can be summarized as follows:

VII: Region Level Percent of households in different number of parcel categories

- 1. Total number of Parcels in the Region:
- 1.1 Percent of households having 1 to 2 parcels in the region:.....
- 1.2 Percent of households having 3 to 5 parcels in the region
- 1.3 Percent of households having 6 to 8 parcels in the region
- 1.4 Percent of households more than 8 parcels in the region

VIII: Parcel Area Calculations

- 1. Average parcel area across woreda in each zone
- 2. Average parcel area across Zones
- 3. Average Parcel area at regional level

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