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# Is Sustainable Intensification Possible? Evidence from Ethiopia

**Vine Mutyasira [1,*], Dana Hoag [2], Dustin L. Pendell [3] and Dale T. Manning [2]**

1 Department of Agricultural Economics and Extension, University of Zimbabwe, Harare, Zimbabwe
2 Department of Agricultural and Resource Economics, Colorado State University, Fort Collins, CO 80523, USA; Dana.Hoag@Colostate.Edu (D.H.); Dale.Manning@Colostate.Edu (D.T.M.)
3 Department of Agricultural Economics, Kansas State University, Manhattan, KS 66506, USA; dpendell@ksu.edu
* Correspondence: vinemutyasira@gmail.com; Tel.: +1-263-773-097-640

Received: 30 August 2018; Accepted: 11 November 2018; Published: 13 November 2018

**Abstract:** This paper explores the sustainable intensification possibilities facing smallholder farmers in Ethiopia. We examine the internal consistency of jointly achieving "sustainable" "intensification" by exploring the factors that lead to complementarity or tradeoffs in the outcomes. A cross-sectional survey of farms was examined in multiple regions of Ethiopia's Highlands. The results show that some farmers can achieve both sustainability and intensification, while many do not, or cannot achieve both at the same time. We found that some actions have a common impact on both sustainability and intensification, while other factors only affect one outcome. Access to agricultural loans and farm mechanization significantly increases the likelihood of succeeding in sustainable intensification. Access to land will be critical for agricultural sustainability while access to farming information and technical services will drive agricultural intensification. Overall, opportunities to improve both sustainability and intensification are weak, but the opportunity to improve one without sacrificing the other are realistic. The results contribute to the ongoing debate on sustainable intensification and help policy makers explore alternatives for managing different intensification and sustainability scenarios to achieve agricultural development goals.

**Keywords:** environmental sustainability; Ethiopia; smallholder agriculture; social sustainability; sustainable intensification

## 1. Introduction

Sustainable intensification (SI) of agriculture is receiving growing attention as a viable pathway to addressing the challenge of feeding a rapidly growing world population in the face of a changing climate and increasing environmental concerns [1–5]. While there is no commonly agreed upon definition, SI generally refers to a system aimed at enhancing agricultural productivity while simultaneously reducing the negative impact of farming on the environment, and not increasing total cultivated land [6–8]. The correspondence between these goals is not always clear: are they complementary or does implementation require the sacrifice of one to achieve the other?

Perhaps there is no more important place to understand the synergies and tradeoffs from SI than smallholder farming systems. The cost of undesirable tradeoffs can be more devastating due to the already vulnerable positions of many smallholder farmers. Studying these complex systems, however, requires some way to track and manage multiple dimensions of sustainability and intensification, while simultaneously accounting for individual preferences over outcomes among those people managing the smallholder farms. Therefore, a framework is developed to assess the sustainability and intensity of smallholder farmers in Ethiopia simultaneously. First, we define and measure sustainability and agricultural intensification on individual farms. Using this information, we examine the observed relationship between intensity and sustainability. Finally, we characterize the attributes of smallholder farms that affect intensification or sustainability and examine which factors can increase both simultaneously.

Although widely viewed as the new paradigm for agricultural development in Africa [9], a number of studies have argued that the quest for SI will involve trade-offs in economic, social and ecological goals [2,10]. The subjectivity introduced by tradeoffs has fueled an ongoing debate on what really constitutes SI of agriculture [11–14]. There are also concerns that environmental goals tend to be overwhelmingly emphasized [15,16], while other developmental aspects, such as food and nutrition security [10], welfare of farm animals and wellbeing of farm workers [16], as well as equity and distributive justice [17,18], are not given equal prominence.

Within the SI discourse, the largest debate is centered on the relationship between agricultural intensification and sustainability [6,16]. From an economic perspective, agricultural intensification involves increasing the use of variable inputs to produce higher agricultural output, or value, per hectare [19]. However, several papers have expressed concern that some types of intensification, such as increased use of chemical fertilizers, are detrimental to the environment [1,20]. Parallel to these arguments are concerns that calls to reduce levels of input usage may reduce farm productivity and undermine competitiveness [21]. The goals of intensification and sustainability are often viewed as incompatible [16]. Studies have highlighted cases where intensification of production systems has led to negative environmental and social outcomes [1,11], as well as lost ecosystem services provided by agriculture [22]. However, some scholars instead argue that intensification can support ecological goals, especially in cases where land-sparing gains from intensification-induced productivity growth could reduce the need for land expansion [14,23,24]. Generally, the relationship between intensification and sustainability is not always clear-cut [15,25]. Accordingly, understanding the synergies and tradeoffs between agricultural intensification and sustainability, as well as the relationships between different sustainability dimensions, will be crucial to crafting appropriate policies to support SI of agriculture within any given context.

## 2. Data

### 2.1. Study Area

The study is carried out in Tigray, Amhara, Oromia and the Southern Nations, Nationalities and Peoples (SNNP) regions of the Ethiopian highlands. The Highlands are characterized by relatively steady rainfall, averaging an annual range of about 600 mm to over 2000 mm, while average annual temperatures range from 20 to 22 °C in the lower elevations to 10–12 °C in the higher elevations [26]. However, climatic conditions vary across regions. For instance, the Tigray region, which lies in northern Ethiopia, is characterized by frequent droughts. On the other hand, the Oromia region, located in the central and southern part of Ethiopia, receives rainfall ranging from 200 mm to 2000 mm annually. This is the region where most of Ethiopia's coffee is grown. Oromia and the SNNP regions, which make up the south-west highlands, also have relatively good agroecological potential [27]. The Amhara region, located in the central and north-western part of Ethiopia, receives annual rainfall ranging from 300 mm in the east to over 2000 mm in the west [28]. However, despite the agricultural potential, these areas face productivity and soil degradation issues, attributable to limited investments in soil and water conservation measures [29].

### 2.2. Data Collection

A cross-sectional survey of 600 smallholder farmers in each of Tigray, Amhara, Oromia and the SNNP regions of the Ethiopian highlands was conducted from March through May of 2015. To ensure that relevant information was collected, participating households owned some agricultural land and had planted and harvested crops over the previous 12 months. Most respondents made production and marketing decisions on the farm, unless it was a spouse of the household head who was aware of most operational decisions on the farm. Households were randomly selected from farmer lists provided by government extension officers in the respective wards (*woredas*). The surveys were carried out by government extension officers, field facilitators and agricultural research officers from the International Livestock Research Institute, who were selected based on their familiarity with the study areas and ability to speak the local language. Survey teams comprised of five enumerators and a supervisor in each of the four districts, who were all subjected to an intensive three-day training session prior to data collection.

## 3. Materials and Methods

### *3.1. Conceptual Model*

Sustainable intensification is largely seen as balancing trade-offs between intensification and sustainability across its key dimensions [30]. Given that the relationship between intensification and sustainability is not always known with certainty, a framework for analyzing conditions under which tradeoffs or synergies exist is vital for understanding the critical drivers that may contribute to different SI outcomes. Different SI pathways and outcomes are likely to develop, depending on the variations in agro-ecological, socioeconomic, and institutional conditions [26], the nature of existing farming systems [31], and farmers' circumstances [32], as well as access to markets, infrastructure and agricultural potential. The type of intensification path that emerges in a given context will have implications for sustainability [33]. Sustainable intensification paths will therefore vary between locations, farming systems and individual farms. Figure 1 provides a conceptual framework depicting the likely cases. Farms can be plotted in this space, as we do later in the paper. Sustainability and intensification can be complements, where both can be bettered or worsened; or substitutes, where one goal will be improved (diminished) at the cost (benefit) of the other.

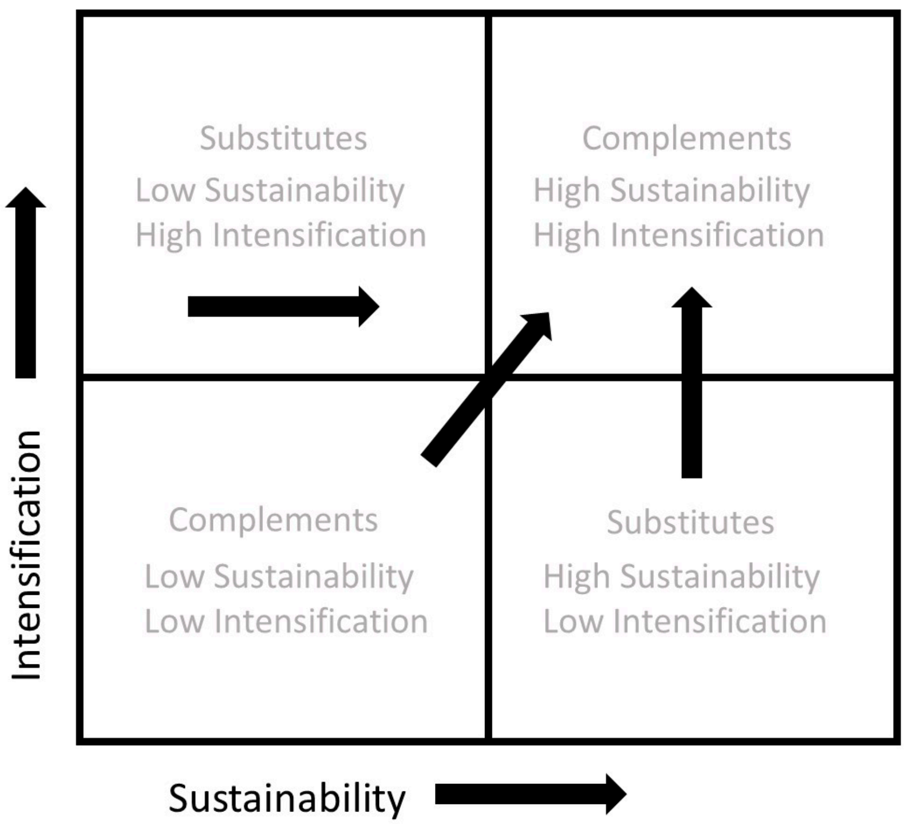


**Figure 1.** Conceptual pathways for agricultural intensification and sustainability.

For simplicity, intensification in Figure 1 is measured in gross value of crop output per hectare, from lowest to highest. Conditional on a value of crop productivity, sustainability can range from high to low. When both are high, or both are low, intensification is synergistic or complementary to sustainability. However, when one is high and the other is low, they may be antagonistic. Four broad farm pathway possibilities are presented in Figure 1. Farms in the lower left quadrant have low social and environmental sustainability (LS) and low intensification (LI), which is undesirable for both farmers and policy makers alike. This is a typical case of resource-constrained households, with very limited investments in both productivity-enhancing inputs and in soil fertility management. This scenario likely depicts systems where farmers operate with very low levels of net farm income [34]. Farms in the upper right quadrant display a high level of sustainability (HS) and intensification (HI). These farms demonstrate circumstances where SI is supported. Farms in the upper left, and lower right quadrant display circumstances where SI is not supported; there are tradeoffs between agricultural intensification and sustainability. Some of these farms have low-input sustainable agriculture systems [21], which typically involve use of fewer chemical inputs and more ecological management practices. Farms with high intensity and low sustainability have limited investments in environmentally friendly practices and land improvements. The key question we address is what circumstances support SI and which work against it.

### *3.2. Measuring Intensfication and Sustainability*

The first step in our analysis was to develop measures of agricultural intensification and relative social and environmental sustainability. Agricultural intensification refers to an increase in the output per hectare, usually achieved through increases in the use of inputs such as labor and/or capital on land already under cultivation [2,6]. An increase in the gross value of agricultural output can occur through an increase in yields per hectare, increasing cropping intensity per unit of land or shifting towards high-value crops [2]. In this study, the gross value of crop output per hectare was used as a measure of agricultural intensification at the farm level. This was obtained by summing all the main crops produced, multiplied by average producer prices. The producer prices for the crops were obtained from the Ethiopian Central Statistical Agency.

Agricultural sustainability is closely related to the concept of sustainable development, which aims at enhancing current production goals without compromising the ability of future generations to attain their own goals. Sustainable production systems generally minimize the unnecessary use of external inputs, use production practices and technologies with less adverse impacts on the environment promote agro-ecological processes, as well as promoting positive impacts on natural, social and human capital [2]. Sustainability is generally multidimensional [35] and typically involves several indicators. A measure of relative social and environmental sustainability was obtained by aggregating five indicators of the social dimensions of sustainability (household wealth, membership to associations, gender roles and family labor) and 6 indicators of the environmental dimensions (inorganic fertilizer use, use of chemicals, livestock density, erosion control, crop rotations and organic manure use). A complete description of the study can be found in [36]. Using production data from surveyed farm households, Mutyasira et al. [36] derived a synthetic index of social and environmental sustainability using a data envelopment analysis (DEA). This allowed the authors to examine the technical efficiency of each farm by creating the non-parametric production frontier that identifies the most efficient farms, which are assigned a score of unity. The efficiency scores for each farm were taken as relative measures, benchmarked against the most efficient farms, and given a relative sustainability score between 0 and 1 for each farm. The basic assumption of their model was that each farm maximizes its composite sustainability subject to the level of priority given to each of the sustainability indicators. The indicators for each sustainability characteristic were derived from the Framework for Assessing the Sustainability of Natural Resource Systems [37] and a series of key informant interviews. This DEA methodology has been widely adopted as a way of deriving endogenous weights for aggregating indicators [38–40]. Indicators of the economic dimension of sustainability were excluded from our sustainability index, as they are likely correlated with agricultural intensification. Farmers were then assigned a sustainability and an intensification score and these were plotted, consistent with Figure 1, to examine their relationship.

### 3.3. Drivers of Agricultural Intensification and Sustainability

To answer the question as to whether SI is possible in the smallholder farming context, regression models of intensification and sustainability were estimated as a function of farm and household characteristics. To identify which variables would similarly influence intensification and sustainability, we considered the effects of characteristics on each of the two outputs. If effects have the same sign, that variable can contribute to both sustainability and intensification. A set of household demographic, socioeconomic, institutional and agro-ecological variables were considered in the analyses. See Table 1 for a list of independent variables used in the analysis.

**Table 1.** Description of variables used in regression analyses.

| Variable | Category | Description |
|---|---|---|
| Dependent variable | | |
| Agricultural intensification | Continuous | Gross value of crop output per hectare (Ethiopian Birr). |
| Agricultural sustainability | Index | A relative measure of sustainability, obtained by aggregating social and environmental indicators. |
| Independent variables | | |
| Land size | Continuous | Total land owned by the household (ha) |
| Distance to markets | Continuous | Total distance, in kilometers, to the nearest village market. |
| Age of household head | Continuous | Age of household head in years |
| Demonstration plots visits | Continuous | Number of times the farmer visited agricultural demonstration plots during the cropping year. |
| Asset index | Continuous | An index of productive assets, constructed through Principal Components Analysis (PCA). |
| Household size | Continuous | Total number of household members |
| Mechanization | Binary | Measure of weather production processes are mechanized |
| Off farm income | Binary | Measure of whether household has access to off farm income |
| Agricultural loans | Binary | A measure of whether the household had access to agricultural loans |
| Oromia dummy | Binary | 1 = Oromia region<br>0 = otherwise |
| Tigray dummy | Binary | 1 = Tigray region<br>0 = otherwise |
| Amhara dummy | Binary | 1 = Amhara region<br>0 = otherwise |

The explanatory variables shown in Table 1 include a mixture of household and farm characteristics, institutional factors and agro-ecological variables. Household and farm characteristics are represented by the age of the household head, the principal decision maker, as well as off-farm income, livestock ownership and farm size. The farmer's age may have an ambiguous influence on SI. While younger farmers have a higher propensity to adopt new technologies [41], older people are more likely to invest in soil fertility and land improvements, probably because they have relatively higher savings and greater farming knowledge [42]. Households' off-farm income is expected to provide an important source of income for the liquidity-constrained rural households, and thus positively affect the odds of SI. Livestock ownership, measured by tropical livestock units, will positively affect both agricultural intensification, through increased availability of draught power, and sustainability, through manure for organic farming. Farm size will likely have an ambiguous effect on the odds of SI. Smaller farms in developing countries tend to be more intensive and highly productive, consistent with the inverse productivity hypothesis [43], while larger farms have a higher propensity to invest in sustainable farming practices and soil fertility management. However, farm size could have varying impacts on agricultural technology use depending on the characteristics of the technology in question and other institutional factors such as tenure arrangements [44].

Institutional factors are represented by the distance of the household to the nearest market, frequency of access to extension services, as well as number of times the farmer participated in government extension services. Distance to markets is a proxy for market access; hence, the odds of SI are likely to fall as distance to markets increases. The number of farmers' visits to demonstration plots is expected to increase the likelihood of both agricultural intensification and sustainability, since farmers are exposed to improved technologies and sustainable farming practices. Improved access to extension services will help farmers adapt the technological packages to their own farms hence increasing the odds of SI. Three regional dummies are included represented Tigray, Amhara and Oromia regions, while the SNNP region is treated as the reference group. These binary variables will act as proxies for differences in agroecological conditions and are expected to influence both intensification and sustainability. For instance, Ehui S et al. [45] observed differences in total factor productivity across Tigray, Amhara and Oromia regions of Ethiopian highland regions, due to differences in climate and other biophysical determinants of agricultural potential.

## 4. Results

In this section, we present and discuss the key results of the study. The first part of this section explores the relationship between agricultural intensification and sustainability, with a goal to identify where the two are competing or complementary. Farmers are classified according to their levels of intensification and relative sustainability performance. The second part investigates the key drivers that are likely to shape SI trajectories and pathway clusters in Ethiopian smallholder systems.

### *4.1. Classifying Agricultural Intensification and Sustainability*

The average gross value of output per hectare, our measure of intensification, was 11,421 Ethiopian Birr (ETB), which is roughly US $571 per hectare. Intensification varied considerably by farm sizes and across the four regions. The average gross value of output per hectare was 16,650 ETB (US $832) on small farms, 9838 ETB (US $492) on medium farms, and 9304 ETB (US $665) on relatively larger farms. Intensification was highest in the Tigray region, with an average gross value of crop production of 15,707 ETB (roughly US $785). The average gross value of crop production per hectare were 11,733 ETB (roughly US $587), 10,885 ETB (roughly US $554), and 7393 ETB (roughly US $370) in the Amhara, Oromia and SNNP regions, respectively. Farms were grouped into high- and low-intensification categories depending on whether their gross value of output per hectare were above or below the sample average; 37.7% of the farms were in the high-intensification category while 62.3% of the farms were in the low-intensification category. Moving on to the relative measures of social and environmental sustainability, based on the sustainability index computed by a DEA model, only 2% of the farms had perfect scores of social and environmental sustainability indices (index = 1). However, when classifying farms into high and low relative to the sample mean, consistent with Figure 1, the results indicated that 51.7% of the farms were in the high-sustainability category while 48.3% of the farms had scores lower than the average sustainability scores, and hence classified into the low-sustainability category. Figure 2 shows the distribution of farms vis-à-vis intensification and sustainability.

Overall, 47.8% of the farms in total were on pathways where sustainability and intensification are perfectly complementary (low intensification/low sustainability (LILS) and high intensification/high sustainability (HIHS)). About 29.2% of the farms were LILS pathway cluster (low intensification and relatively low sustainability), while only 18.6% of the farms were in the HIHS pathway cluster (high intensification and relatively more sustainable). On the other hand, 52.2% of the farms show a complete conflict between sustainability and intensification (low intensification/high sustainability (LIHS) and high intensification/low sustainability (HILS)). Approximately 33% of the farms were low intensification but exhibited relatively high sustainability levels (LIHS cluster), while 19.1% of the farms were high in intensification but relatively less sustainable (HILS cluster).

As shown in Figure 2, farms are generally clustered towards a high level of social and environmental sustainability, while the opposite is true of intensification. Smallholder systems in Ethiopia under consideration tend to perform relatively better in social and environmental sustainability than agricultural intensification [36], perhaps because low-intensity systems are correlated more closely to environmental objectives than intensive systems. Productivity levels are generally low due to limited use of inorganic fertilizers, which tends to favor environmental sustainability. Interestingly, there seems to be wide dispersion of sustainability for similar productivity levels. This implies that sustainability can vary without substantial changes in intensity. Around the mean sustainability score of about 0.6, there is also variance in intensification (plotting vertically), suggesting that there is room to increase intensity without significantly decreasing sustainability. Generally, farms with very low, or very high sustainability, do not have particularly high intensification. Another observation is that there is not any substantial upward sloping trends, implying that few farms have both high sustainability and high intensification. It appears that sustainability varies more than intensification and that higher intensification does not necessarily reduce sustainability. There is also a large cluster of farms in the middle, around 0.3 on intensification and 0.7 on sustainability, which implies there may be a natural central tendency. It is possible that people can be moved up or to the right, but it is not so easy to do both.

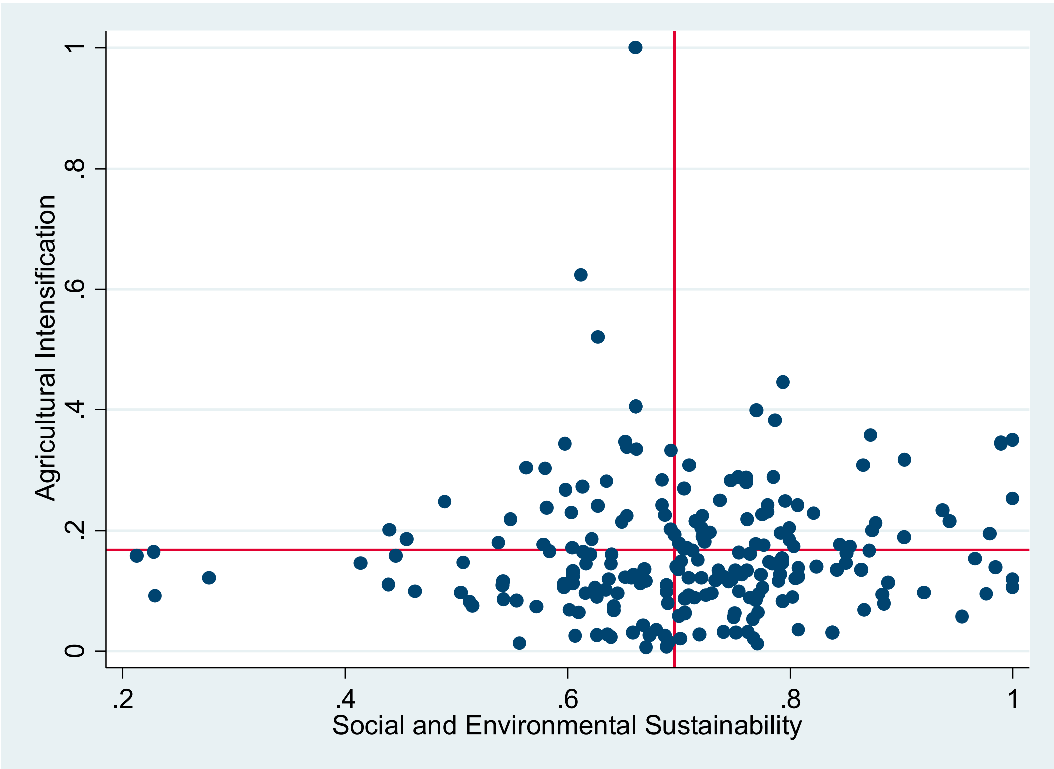


**Figure 2.** Scatter plot of normalized intensification and sustainability (n = 229).

### *4.2. Drivers Shaping Sustainable Intensification*

To examine the key drivers of sustainable intensification, two linear regression models were estimated using ordinary least squares, where normalized values of agricultural intensification and sustainability were regressed against a set of household demographics, socioeconomic, institutional and agroecological variables (results presented in Table 2). The objective was to identify variables that improve both intensification and sustainability, as well as those that might increase one but not the other. The regression results are presented in Table 2 and include regional fixed effects. Therefore, coefficient estimates, excluding the regional fixed effects, are average effects, conditional on the region that a farm is in. The final model returned results for 229 in Stata, taking into account cases that had missing values on some variables and indicators used in the analysis.

Variables found to influence both intensification and sustainability were access to agricultural loans, farm mechanization, farm asset ownership (asset index) and agroecological conditions (captured by the regional fixed effects). Access to agricultural loans was associated with higher levels of agricultural intensification and relative social and environmental sustainability, indicating that the availability and accessibility of agricultural loans increases the likelihood of farmers embarking on more sustainable paths of agricultural intensification. This is consistent with several other studies emphasize the importance of addressing liquidity constraints among smallholder farmers who are often faced with imperfect rural credit markets. Agricultural loans could provide the much-needed capital for smallholder farmers to invest in land improvements [33], as well as purchase complimentary inputs required for sustainable farming. Most of the technologies promoted under the banner of sustainable intensification tend to involve considerable upfront investment costs [46]. Access to loans will be important for sustainable agricultural intensification in Ethiopia and most sub-Saharan Africa, where a combination of imperfect credit markets and limited access to private financing imposes significant constraints on smallholder farmers.

**Table 2.** Linear model regression results.

| | **Sustainability** | **Intensification** |
|---|---|---|
| **Variables** | **Model** | **Model** |
| Land size | 0.0238 ***<br>(0.00623) | −0.00482<br>(0.00568) |
| Distance to market | −0.00295 *<br>(0.00168) | 0.000714<br>(0.00153) |
| Age of household head | 0.00121 *<br>(0.000733) | −0.000906<br>(0.000668) |
| Demonstration plot visits | 0.00110<br>(0.00337) | 0.00649 **<br>(0.00308) |
| Assets index | 0.0336 ***<br>(0.00582) | 0.0227 ***<br>(0.00531) |
| Family size | −0.00278<br>(0.00312) | −0.000376<br>(0.00285) |
| Mechanization | 0.133 ***<br>(0.0375) | 0.0661 *<br>(0.0342) |
| Off farm income | 0.0164<br>(0.0154) | −0.0188<br>(0.0141) |
| Agricultural loans | 0.0413 **<br>(0.0185) | 0.0305 **<br>(0.0169) |
| Oromia | 0.0406<br>(0.0373) | 0.0579 *<br>(0.0340) |
| Tigray | 0.0282<br>(0.0243) | 0.109 ***<br>(0.0222) |
| Amhara | 0.0433 *<br>(0.0226) | 0.0631 ***<br>(0.0206) |
| Constant | 0.364 ***<br>(0.0801) | 0.0341<br>(0.0731) |
| Observations | 229 | 229 |
| R-squared | 0.350 | 0.251 |

Standard errors in parentheses; *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

The results show that systems with higher degrees of farm mechanization were associated with higher levels of agricultural intensification and relative social and environmental sustainability. Production mechanization is important for addressing draught power constraints and labor bottleneck, as well as reducing drudgery in critical farm operations. Farm mechanization is also likely to enable farmers to implement soil management measures such as contours, which help preserves soils and improve environmental sustainability in general. This result is also complemented by the positive impact of the production asset index on the likelihood of increasing agricultural intensification along with social and environmental sustainability. Affordable and tailored small scale mechanization will, therefore, be an important innovation for promoting sustainable intensification of smallholder farming systems in Ethiopia.

Agro-ecological factors were also significant predictors of intensification and sustainability categories. The results showed that households located in Amhara regions were much more likely to exhibit higher levels of both agricultural intensification and relative farm sustainability, compared to the SNNP region. The significance of these regional binary variables underscores the importance of geographic targeting as an effective strategy for both encouraging and enhancing sustainable intensification in smallholder farming systems.

As previously discussed, these variables can increase both sustainability and intensification simultaneously, but based on the discussion in Figure 2, that may be difficult. The relative size of the coefficients for each of these variables can help explain why these data in Figure 2 show that a change is more likely to increase one of the objectives with less influence on the other. For example, the coefficient on farm mechanization is twice as high for sustainability as for intensification. The trends seen in Figure 2 appear consistent with a weak ability to increase both objectives simultaneously when combined with the factors that can influence only one objective at a time.

Moving on to variables that are likely to influence either one of intensification or sustainability but not the other, the results show that land size, distance to market and age of household head were drivers of sustainability but not intensification. The results indicate that bigger farms are likely to be more socially and environmentally sustainable. This is generally consistent with studies that have shown that larger farms are associated with more environmentally sustainability because they tend to implement more extensive productive techniques [47] and have a higher propensity to participate in agro-environmental programs [48]. Access to more land also increases crop and livestock enterprise diversification, which promotes both social and environmental outcomes. Also, with bigger landholdings, there are opportunities for land sharing and increased women's participation in crop production. The results also show that the age of the household head increases the social and environmental sustainability of farms. On the other hand, access to agricultural demonstration plots positively influenced agricultural intensification, but its impact on relative social and environmental sustainability was not significant. Most farming technologies are knowledge-intensive by nature, requiring considerable skills and knowledge from farmers [6,49,50]; greater access to farmer-managed demonstration plots and field schools will be crucial in shortening the farmers' learning curves and ensuring that technologies showcased at demonstration plots are adapted to farmers' fields for increased productivity.

## 5. Conclusions

The contributions of this work to the current sustainable intensification (SI) discourse are twofold. First, the paper provides evidence of both synergies and conflicts of SI in an empirical setting with data from more than 229 Ethiopian farmers. Secondly, the framework can help identify policies and contexts in which both objectives are compatible and when they conflict. These results can help policy makers offer effective incentives and instruments for nudging farmers towards more sustainable paths of agricultural intensification as described in Figure 1, or at least helping those farmers that can do one without sacrificing the other. We were able to classify farmers according to levels of agricultural intensification and relative social and environmental sustainability. We generally observed that farms displaying high levels of intensification and sustainability were characterized by relatively larger landholdings, higher levels of crop incomes and livestock ownership. These farms had the highest agricultural production assets indices, which also translated into high cropping intensity.

To the question "does intensification lead to, or away from, sustainability", we find that it depends. We found that only 18.6% of our sample had the best of both worlds, high intensity and high sustainability. Generally, the proportion of higher sustainability scores tended to rise with intensification, but there are many exceptions within each typology group. Based on policy priorities, identifying these clusters could help in targeting interventions and development of technological innovations that are tailored to specific farmer profiles and current performance vis-à-vis intensification and sustainability. One important observation is that where we observe a large increase in intensification relative to the means in Figure 2, we do not observe a large reduction, or increase, in sustainability. So, in part, the answer to our question is that you can increase intensification without sacrificing sustainability, which may be a more realistic goal for SI.

Based on the analysis from this study, the essential ingredients of a SI strategy for Ethiopia, and for smallholder farming systems in general, appear to be enhancing farmers' access to agricultural loans off-farm income, through increased integration into the non-farm rural economy and addressing liquidity constraints through appropriate rural financing schemes and smallholder-tailored credit facilities; improvements in agricultural mechanization services and careful geographical targeting. If agricultural intensification is the primary focus, increased access to agricultural training and technical services should be emphasized. Finally, improved access to productive land through measures to address revolving land ownership and tenure security questions should help improve the social and environmental sustainability of current production systems. Policy makers can increase SI by improving any of these parameters and by understanding where sustainability and intensification work together or at cross purposes. Achieving SI may also require coming up with 'nudges' and appropriate measures and incentives to encourage farmers that are already highly intensive to adopt sustainable farming practices.

**Author Contributions:** D.H., D.P. and D.M. supervised V.M.'s Ph.D. research work from which this research paper was developed. V.M. took the lead in the data collection and analysis, and original draft preparation. All authors participated in reviewing the paper and discussing the research results.

**Funding:** This research was supported by the USAID Africa Rising project (ILRI); The Norman E. Borlaug Leadership Enhancement in Agriculture Program; as well as Colorado State University, Department Agricultural and Resource Economics.

**Acknowledgments:** The authors would like to acknowledge the International Livestock Research Institute (ILRI) for kindly supporting the data collection process in Ethiopia. Specifically, we want to thank Kindu Mekonnen, Peter Thorne and Girma Tesfahun Kassie for their technical support and helping supervise the data collection activities in Ethiopia.

**Conflicts of Interest:** The authors declare no conflict of interest.

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