Estimating Land Expectation Value of Smallholder Farmers’ Eucalyptus Woodlot Products in Wogera District, Northern Ethiopia

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ABSTRACT

Background*: The area of Eucalyptus plantations has expanded greatly and the species dominates many rural and urban landscapes as it suits the limited resources of smallholder farmers, yields higher income than other tree crops and increasing demand for woodlot products. The study conducted in Wogera District within three purposively selected kebele administrations. Smallholder farmers at the study area are converting their crop land to Eucalyptus plantation. Therefore there should need to deal the pushing factors for the allocation of Eucalyptus. This study aims at identifying the factors influencing decision of land allocation for eucalyptus woodlot production, and estimating the land expectation value.*

Method*: Cross sectional data was collected through semi-structured interview schedule. Data analysis employed descriptive statistics and Faustman formula.*

Results*: The results of the household survey revealed that land degradation and neighbor influence are the main factors for smallholders' land allocation decision for Eucalyptus plantation. Therefore, as per the results, most of the crop land has been converted to Eucalyptus plantation. However, this a rapid land conversion issue made a threat on most farmers in related to losing of indigenous crops so as it leads them to be food insecured.*

***Conclusion**: Farmers in the study area are rational in their land allocation for production of either annual or perennial crops including Eucalyptus woodlots. Finally the study recommends government intervention in the separate land management issue is mandatory to make balance in production of both Eucalyptus and crops.*

Key words: land expectation value, Faustman formula, land management

Background

Africa has 675 million hectares of forest and 350 million hectares of wooded land together covering 35 percent of its total land area (FAO, 2010). This includes tropical moist forests primarily in Central and West Africa, tropical dry forest, mostly in East and Southern Africa, including the miombo woodlands in Tanzania and Mozambique, and Mediterranean forests and woodland in North Africa.

In Ethiopia natural forests and woodlands are shrinking while population and wood demands are rapidly increasing. The common response to this problem has been establishment of plantations of fast-growing tree species (Lemenih and Bongers, 2010). From the second half of the nineteenth century, successive governments in Ethiopia have attempted, to varying degrees, to promote plantations to compensate for the declining supply from the natural forests (Pukkala and Pohjonen 1990; Bewket 2003; Mekonnen *et al.,* 2007).

However, reforestation and aforestation in the country is very slow compared to deforestation (Bekele 2003; Achalu 2004; Lemenih *et al*., 2008). Furthermore, most of the reforestation efforts were driven by the State, NGOs and aid agencies, and most of these agents retreated from promoting plantations after the mid-1980s. Instability of rural institutions and forest related policy constraints was not also encouraging to tree plantings outside homestead plots (Kassa *et al*., 2011). Despite this fact, smallholder farmers are nowadays taking the lead in expanding tree planting in the form of farm forestry (Achalu 2004; Mekonnen *et al*., 2007; Duguma and Hager 2010).

In Ethiopia, several *Eucalyptus* plantation projects were established in the 1980s with support from United Nation' Sudano-Sahelian Office (UNSO), Danish International Development Agency (DIDA), Finish International Development Agency (FIDA), World Bank and the African Development Bank. These plantations were established to supply fuel wood for the towns of Debreberhan, Dessie, Gondar, Bahirdar, Nazret and Addis Ababa. In Debreberhan alone UNSO invested over 3 million USD to plant 2600 ha of *Eucalyptus* (Pohjonen and Pukkala 1990). The other most important *Eucalyptus* growers in Ethiopia are smallholder farmers in the highland areas including the Amhara Regional State.

The current trend of *Eucalyptus* woodlot expansions in the highlands of North Gondar and Wogera District may indicate the popular acceptance of forest plantations as an attractive business for smallholder farmers in the region. The economic potentials of exotic tree species could be the driver that led to expansion of *Eucalyptus* woodlot plantations not only on marginal lands but also conversion of crop lands to woodlots (Yitaferu *et al*., 2013; Lemeneh and Kassa, 2014; Tadesse *et al*., 2015). This study evaluates the factors determining the land allocation decision and profitability of woodlot production in Wogera District.

The shift from natural to planted forests has changed traditional land use decisions and had a major impact on subsistence agricultural practices. The changes in land use patterns have important economic, social, and environmental impacts that should be considered when developing land use policies. Shifts away from crop production toward a mix of forest and perennial agricultural output have both positive and negative externalities associated with food security, household income, and land quality (Mekonnen *et al.,* 2007, Kebebew and Ayele, 2010; Mujawamariya and Karimov, 2014). These impacts are increasingly important as smallholders realize the possibility for higher financial returns by converting their most productive croplands into wood fiber production.

Over the last two decades *Eucalyptus* woodlots have expanded at an extraordinary rate across the highlands of Ethiopia (Ewnetu 2008; and Lemenih 2010). For instance, out of the 92,000 ha of land covered with *Eucalyptus* plantations in Amhara Regional State of Ethiopia, about 67% is farm forestry developed by smallholder farmers in the last two decades (Lemenih 2010). Wood scarcity to meet own demands, declining farm productivity, need for increased sense of land security, and better adaptive capacity of the species on degraded plots are often mentioned as major factors inspiring farmers' to convert farm plots to *Eucalypt* woodlots (Achalu 2004; Mekonnen *et al*., 2007).

Some scholars argue that the financial profitability and income potential of plantations is the most driver. However, a comprehensive study identifying the key factors affecting the smallhlder farmers' decision of land allocation and land expectation value is lacking particularly in Wogera District where there is recent expansion of *E. globulus* plantations.

Thus, this study was designed to fill this gap and contribute to better understanding of the push and pull factors towards the expansion of *Eucalyptus* woodlots in the highlands of North Gondar. The comprehensive analysis of the profitability and land allocation decision of smallholder farmers can also support informed decision of policymakers striving to bring rural development based on natural resource based production systems.

The key research question: what drives smallholder farmers' conversion of fertile crop lands to *Eucalyptus* woodlot plantations in the highlands of North Gondar Ethiopia especially the target area Wogera District? and what will be the estimated land expectation value of *Eucalyptus* woodlots at the study area?

Research Methods

Description of the study area

The study was conducted in Wogera Districts of Amhara Regional state in 2016/2017 because it is potential area for *Eucalyptus* woodlot production. Wogera is one of the administrative districts in North Gondar Zone of Ethiopia. The District's capital city, Amba Giorgis, is 36 km far from the zonal capital, Gondar town. According to the District's Agricultural office (2016) it has a population of 268,833, of which 137,057 and 131,776 male and female, respectively. The religions of people are 95% Orthodox Christians and the remaining 4% Muslims. Similarly, there are two largest ethnic group in the districts namely Amahara, Qemant and others which taken the percentage of 90.48%, 9.24% and 0.28%, respectively.

The altitude of Districts ranges from 1100m to 3040 m.a.s.l while the minimum annual temperature ranged between 14 ^{o}c and 33 ^{o}c. Daily temperature becomes very high during the months of February to May, where it may get to as high as 38 ^{o}c and it becomes very low during the month of October to the end of December and it may get below 0 ^{o}c. Mean annual rainfall for the districts ranges from about 500 to around 1200 mm. The rainy months extend from June until the end of September. However, most of the persistence rainfall is received during the months of July and August.

The total area coverage of Districts is 182,126 ha of which the cultivated land (46.1%), grazing land (22.7%), forest land (11%), building (4.42%), rivers and gorges (2.73%) and others (12.85%). Most of the forest area is covered by *Eucalyptus*. The soils types in the District have predominantly brown and black colors. The area is characterized by mixed farming system (i.e. crop and livestock production). The main crops produced in the District are wheat, barley, teff, maze sorghum, and leguminous crops like bean, peas and lentils. Likewise, it is known by high area coverage of *Eucalyptus Globulus*. Furthermore, the District is known by livestock production such as oxen, cows, goat, sheep, mule, horse, poultry, donkey, bull, heifer and calves (WDAO, 2016). The bellow figure shows map of the study area (Fig:1).

Data collection and sampling procedure

Both Quantitative and qualitative data was collected from both primary and secondary data. Primary data was collected from sample *Eucalyptus* producer households and community leaders through house hold interview, key informant interview and focus group discussions. The interview schedule consisting of both open and close-ended questions was prepared and administered. The content and face validity of interview schedule was reviewed. The secondary data was collected from published and unpublished materials to get general overview. When come to the sampling procedure, three stage sampling technique was used for the sample selection. First, The Wogera District was selected purposively due its potentiality in *Eucalyptus* production. In the second stage three more potential *Eucalyptus* producer Kebeles namely Kosoye, Yisak Debir and Ambagiworgis Zuria was selected purposively out of 41 total kebeles of the District. Then, using the household list of sampled kebeles, 119 sample *Eucalyptus* producer households were selected using systematic random sampling technique. The sample size determined using Yemane formula (Yemane, 1967).

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

Where n = sample size, N = total target population in the study area equals to 2686 and e = the level of precision. The minimum level of precision is acceptable at 10%.

Analytical framework

The survey data collected from the various sources was edited, coded, and cleaned to ensure consistency, uniformity, and accuracy. Data processing tools were Excel, SPSS and STATA computer programs. Using the collected data, descriptive statistics, and Faustman Model were applied.

Descriptive statistics

Under this method, Objective one (identifying land allocation decision criteria) and other household socioeconomic descriptions were done.

Faustman model (LEV) analysis

The Faustman model is well accepted in economics (Samuelson 1976, 1983), and it has a ‘‘myriad’’ of applications (Chang 2001) with high practical relevance worldwide (Tahvonen *et al.,* 2001) LEV represents the maximum amount that could be paid for a tract of land. Furthermore, the LEV calculation applies to a forest with a predictable periodic timber yield. As LEV simply calculates the value of bare land in perpetual timber production, it is based on the standard discounting formula for the present value of a perpetual periodic annuity (Boettke *et al.,* 2007).

$$PV = \frac{a}{(1+i)^{t-1}} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (eqn\ 2)$$

Where: PV = Present value of a perpetual periodic annuity

a = Value received every t years in perpetuity

t = Years between annuity payments

i = Interest rate, expressed as a decimal

This is actually a standard discounted cash flow (DCF) calculation, but with several critical assumptions:

1. The values of all costs and revenues are identical for all rotations. All costs and revenues are compounded to the end of the rotation to get the future value of one rotation. This value will be the amount received every t years.

2. The land will be forested in perpetuity.

3. The land requires regeneration costs at the beginning of the rotation.

4. Land value does not enter into the calculation. Land value is what it was calculated.

5. The cash flow will be the same in perpetuity, what means that it will always be cultivated the same species, for the same purpose, and that

6. The relative prices will remain constant along time; land only has value for wood production.

The value calculated is the present value (PV) for a perpetual series of rotations. Many timber companies and pension funds do not buy timberland with the intention of holding it to perpetuity. The LEV does give the value of bare land in permanent forest production, however, and is the standard forestry DCF calculation. Because it is a standard DCF calculation, it can be applied to single or multiple rotations on a consistent basis. The calculation is involves two steps. First, each cost and revenue is compounded to the end of the first rotation. The net value at rotation represents the dollar amount available at the end of each rotation in perpetuity. Second, the PV of the birr amount is calculated on a perpetual periodic basis using equation (Tahvonen, 2004). To compute LEV, following the next steps is necessary:

1. Determine all of the costs and revenues associated with the first rotation. These values should include initial costs of planting, site preparation, and so on, as well as all subsequent costs and revenues.

2. Place the costs and revenues on a timeline and compound all of them to the end of the rotation. Subtract the costs from the revenues.

3. Use the PV of a perpetual periodic series formula to calculate the PV of an infinite series of identical rotations. (Divide by $(1 + i)^t$ where t is the rotation length

Thus, the formula for LEV is simply;

$$LEV = \frac{NFV}{(1+i)^{t-1}} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (eqn\ 3)$$

Where: LEV = Land expectation value

NFV = Net future value of one timber rotation

t = Length of timber rotation

i = Interest rate expressed as a decimal Then the NFV can be calculated as;

$$NFV = \sum Rn(1+i)^{t-n} - \sum Cn(1+i)^{t-n} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (eqn\ 4)$$

Where: NFV = Net future value of one rotation at year t

Rn= Revenue received in year n

Cn = Cost incurred in year n

t = Rotation length in years

n = Year of a particular revenue or cost

i = Real discount rate, expressed as a decimal

Note that the LEV formula uses Birr and a real interest rate. The LEV calculation can include prices or costs adjusted for real price increases by using the formula for a geometric series of cash flows (cash flows that increase or decrease by a fixed percent from one time period to the next). Of course, the annual percentage increase must be less than the discount rate or the LEV will tend towards infinity.

LEV is the theoretically correct criterion for valuing bare land in timber production, for evaluating the value of various forest management alternatives or even for determining the age of final timber harvests (rotation age). It is so widely recognized as the standard criterion, appraisers certainly ought to include it in their "menu" of valuation techniques of an investment (Tahvonen, 2004).

Result and discussion

Smallholder Farmers' Land Allocation Decision Criteria for *Eucalyptus* Plantation

Farmers set some conditions for allocation of their land and available resources economically. The smallholder *Eucalyptus* producers were asked to list and rank their criteria for the allocation of their parcels of land to *Eucalyptus* woodlot. The selection criteria obviously vary among the need and objective of the farmer. Figure 3 below presents graphically the smallholder Farmers' criteria for the allocation of lands for *Eucalyptus* production. The production potential and level of degradation of their land, economic attractiveness of *Eucalyptus* plantations, neighbors influence, ownership of excess land, easiness of Eucalyptus plantations and their combinations were the key criteria for the allocation of lands for *Eucalyptus* production.

As illustrated in the chart, the smallholder farmers are rational in their decision to allocate their land for *Eucalyptus* production. They tend to allocate degraded and marginal lands for *Eucalyptus* as indicated by about 45% of the respondents (Figure 3). This implies that the production capacity of their land is an important factor for their land use decision to *Eucalyptus*. The farmers don't simply plant *Eucalyptus* on their fertile land as for crop they do. As farmers expressed in group discussion, most of the time the land which is degraded and more acidic is less productive for agricultural crops and needs more input for agricultural crop production. In line with this the participants of the group discussion indicated that *Eucalyptus* woodlots generate high income on marginal and degraded lands. For example, a 0.25 ha degraded land with low crop productivity (even might not compensate the costs of inputs) can generate revenue from *Eucalyptus* up to 60 thousand birr in a 5 to 7 years rotation period. Therefore, in this case farmers consider *Eucalyptus* plantation as a best alternative production system when their land is degraded.

Economic attractiveness and neighbor influence were equally important variables in the decision of land allocation for *Eucalyptus* as indicated by 10.1% for the respondents. Farmers influenced by neighboring plantations surrounding their lands even if their land is productive for agricultural crops. It is generally accepted by the farmers in the study area that *Eucalyptus* plantation is financially profitable than agricultural crop production as it needs less labor and other inputs, the cash income comes in a lump-sum at once, and the woodlots can be used as insurance, collateral for credits and saving accounts. Farmers are also forced to plant *Eucalyptus* on their farmlands if their neighboring lands are planted with *Eucalyptus*. This is mainly due to the shading effects and root competition for nutrients and water which affects the productivity of crops on the nearby lands (Figure 2). That indicates that the expansion of *Eucalyptus* in the study area is not only because of the economic attractiveness and with full acceptance of the land owners, but also forced by the neighboring land uses for *Eucalyptus*. In figure 2 one can see the vast area of crop plantation lost by eucalypt allopathic effect. Farmers might not want to plant *Eucalyptus*. But such farmers who face such problem have no any choice rather than *Eucalyptus* (see the bellow fig 2).

The other factor, Owner ship of excess land and easiness to produce are also affecting the decision criteria for farmers' land allocation criteria equally (1.7% for each). As discussed in the above house hold characteristics, farmers with owner ship of large land, have the tendency and opportunity to allocate for *Eucalyptus*. Additionally, *Eucalyptus* doesn't require routine farming activity like crop production. Therefore, farmers especially old aged and with shortage of family labor are influenced to plant *Eucalyptus* to reduce their burden.

The other case is, farmers decision don't only affected with one factor. For instance, as shown in the above, the decision which influenced with land degradation can be affected by economic attractiveness at the same time with 16.8%. This is the most dominant factor next to land degradation. Farmers know their land fertility through experience and relate the land type with suitable crop type. Then, if they have excess land, even all their land is not fertile, they put priority with respect to land fertility and the most degraded one allocated to *Eucalyptus*.

Land degradation and neighbor influence in combination affect land selection criteria by 4.2%. Farmers might want to plant crops even though their land is degraded. This may be due to land shortage. So, they consider as it can give good yield with special treatment. But as they are in this situation, their nearby neighbors plant *Eucalyptus*. Then there is no option to not plant *Eucalyptus*. Economic attractiveness and easiness to produce holds 3.4% to affect the decision. Land degradation and easiness to produce, excess land economic attractiveness, land degradation and excess land affect the decision with equal percentage (1.7%) for each pair.

Other factors like (need for traditional Plaughing tools, for fence, for self sufficiency in fire wood consumption, to prevent flood …) affect the decision criteria by 2.5%. Farmers forced to allocate from their piece of land for *Eucalyptus* plantation in order to fulfill thus wants (see fig 3).

Estimating Land Expectation Value (LEV) of Eucalyptus woodlot products

Note that all costs and revenues are discounted back to year 1 and based on the survey data focus group discussion, average harvesting period for first seedling *Eucalyptus* is 5 years. After harvesting of first seedling, the coppice reaches to harvest at 4th year. They also replied that production after 3rd coppice becomes decline. So, farmers decide to re plant a new stand after 3rd coppice has been harvested. Additionally as researcher Luckert (2008) as cited in Karimov (2014) recommend that the coppicing period is recommended to be 3- 4 rotation period after this, it is better to replant new seedling. The length of the project assumed to be 17 years with 5 years first seedling and 3 coppice rotation each coppice rotation takes 4 years. It is assumed replanting new stand will occur after 3 rotations at year 17. All revenues and costs must be compounded to the end of first rotation (year 5). The calculation for the net future value (NFV) of one rotation was done.

LEV represents the maximum amount that could be paid for a tract of land and still earn the required interest rate. A buyer could pay 203,174.71 per hectare for the tract and earn 5% on the investment, assuming that the land is used to grow timber according to the management schedule outlined. LEV is always greater than NPV, because it doesn't consider land value.

The other situation takes place when net timber revenue occurs on a periodic basis—say, as this survey informed the coppice harvested every four years for 3 rotation period. The standard LEV calculation is appropriate in this case. Such a forest is said to have "cutting cycles," where a "reserve growing stock" is permanently maintained, and growth from this constant reserve is cut periodically. This is analogous to maintaining the principal in a savings account and periodically withdrawing interest. Note that annual management and property tax costs are subtracted from net timber revenue using the future value of a terminating annuity formula:

The below table (Table 1) Presents Costs and benefits of *Eucalyptus* that could use to compute the LEV. All the costs are taken on average and described in terms of Ethiopian birr with interest rate of 5%.

Conceptual Model for Explaining the Expansion of *Eucalyptus*

The Faustman Model in timber land appraisal considers the following scenarios. As the result of this thesis implied that *Eucalyptus* is profitable than crop production, there need to discuss with different scenarios related to profitability

- Price of wood with Land allocation

Higher price attract new farmers to engage in *Eucalyptus* planting *Eucalyptus*. So this leads to *Eucalyptus* Expansion; due to this Crop profitability decreases.

- Labour availability or minimum wage with *Eucalyptus* expansion as well its profit

If there is large family labor or minimum wage salary; farmers tend to produce crop rather than *Eucalyptus*. This is due to crop production is labor intensive than *Eucalyptus* plantation. Therefore, crop production will increase. As per the group discussion in the study area, farmers need crop even though *Eucalyptus* profitability is high, because they consider the economic value of their own crop and livestock than financial values. Figure 4 below presented the Faustman model conceptual graph based on few scenarios.

Description of symbols: C1, initial Crop production level, C2, next crop production level after a certain change; E1, initial Eucalyptus plantation level and E2, next Eucalyptus plantation level after a certain change (see the below Figure 4).

CONCLUSION

From the empirical finding of the research the following conclusions can be drawn that will have policy and development implications related to the smallholder Eucalyptus plantation land allocation decision criteria and land expectation value.

Farmers in the study area are rational in their land allocation for production of either annual or perennial crops including *Eucalyptus* woodlots. The production potential of their land is used as main criteria for allocation of land for *Eucalyptus* production. So, mostly if their land becomes marginalized, their unique decision could be planting Eucalyptus at that degraded land.

The other is Land expectation value (LEV). This method used to inform the future expectation value of land covered with Eucalyptus. Land cost is not considered, because Faustman assumed that all benefit and cost values to be calculated are the value of land.

Recommendation

As per the results, most of the crop land (even fertile lands) has been converted to Eucalyptus plantation. However, this a rapid land conversion issue made a threat on most farmers in related to losing of indigenous crops so as it leads them to be food insecured. So, Policy should intervene in the separate land management issue to make balance in production of both Eucalyptus and crops.

Abbreviations

Br: Birr (Ethiopian national currency); DIDA: Danish International Development Agency; FIDA: Finish International Development Agency; LEV: Land Expectation Value; NFV: Net Future Value; NGOs: Nongovernmental Organizations and UNSO: United Nation' Sudano-Sahelian Office

Authors' contributions

YSD developed the proposal; developed research questionnaire, performed data management, coding, wrote the report and preparing the manuscript. GAA prepared research questionnaire, analysis, editing and evaluating the manuscript. All authors read and approved the final manuscript.

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Competing interests

The authors declare that they have no competing interests.

Availability of data and materials

The author wants to declare that they can submit the data at any time based on publisher’s request. The datasets used and/or analyzed during the current study will be available from the author on reasonable request.

Consent for publication

The authors have agreed to submit for Environmental Systems Research journal and approved the manuscript for submission.

Ethics approval and consent to participate

Ethical clearance letters were collected from University of Gondar research and community service directorate and North Gondar Zone administrative office to care for both the study participants and the researchers. Before data collection and field visit, each districts and sub districts have got official letters. The study area was already informed the reason why the study has done and by whom. There was high clarity of objectives and other study issues for all study participants and others. Because of that the research was done without compromising anybody’s interest.

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Figures

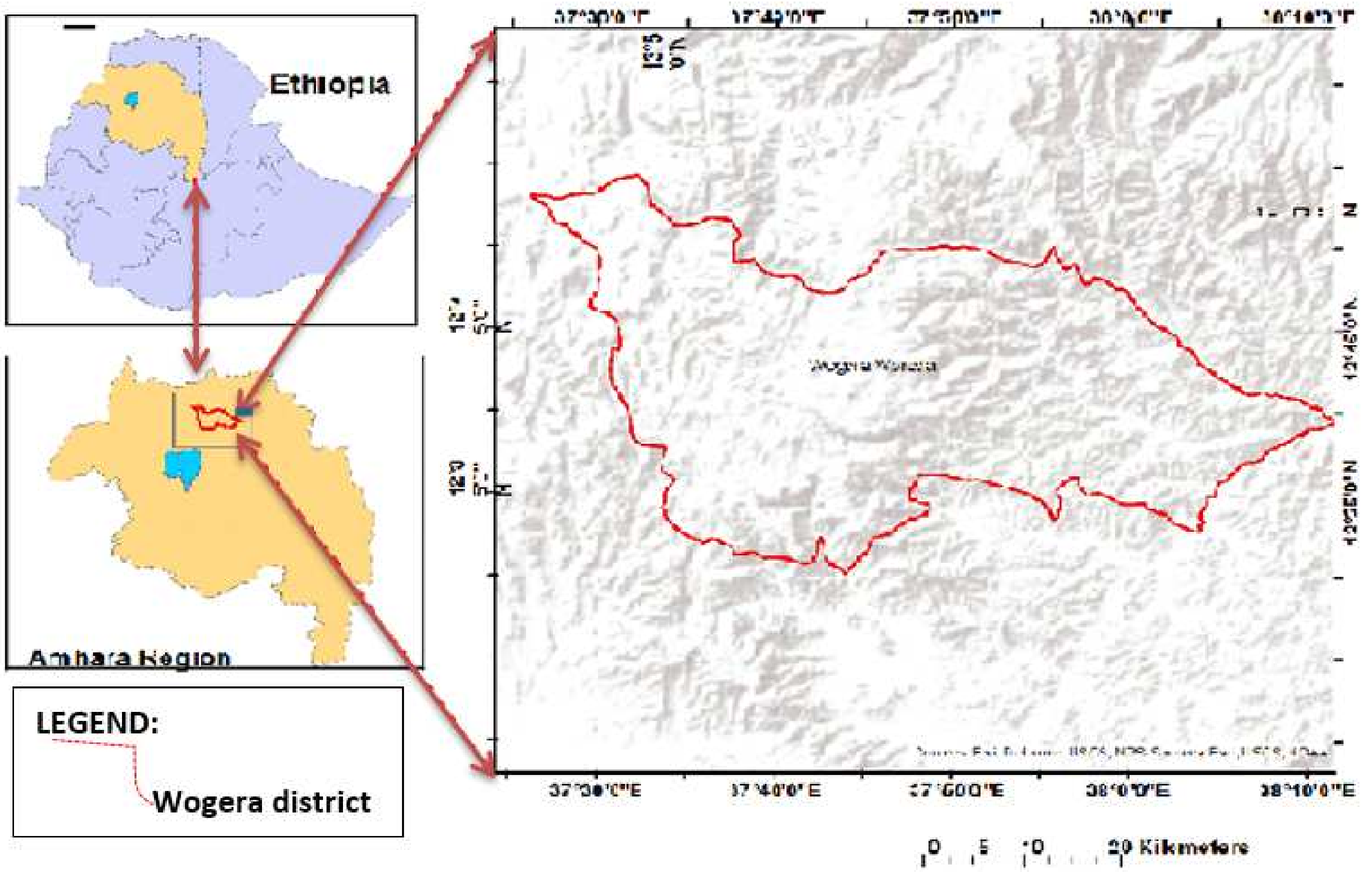

Figure 1

map of the study area Note: The designations employed and the presentation of the material on this map do not imply the expression of any opinion whatsoever on the part of Research Square concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. This map has been provided by the authors.

Figure 2

crop with nearby Eucalyptus that affects farmers land allocation

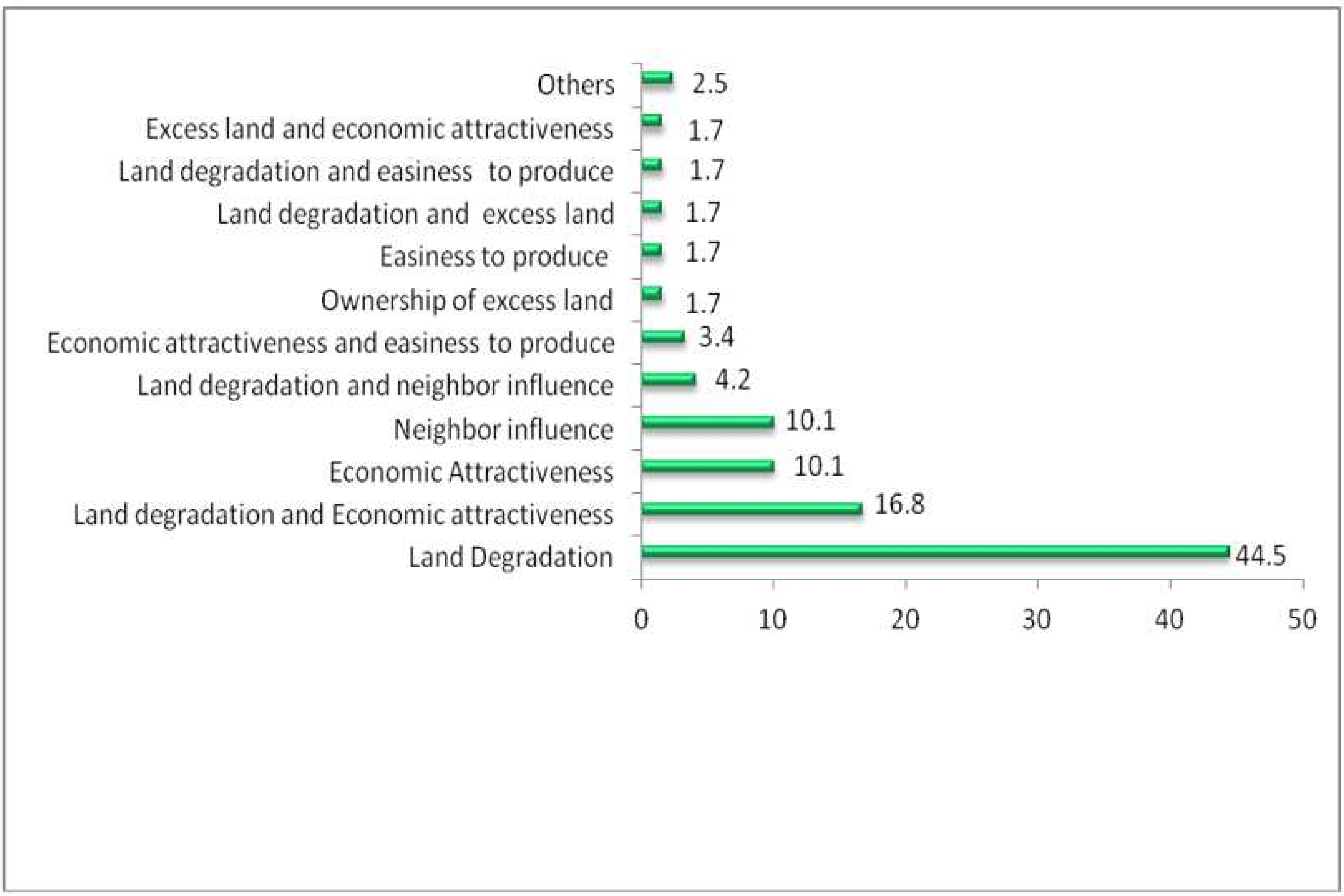

Figure 3

Smallholders farmers’ land selection decision criteria for Eucalyptus plantation

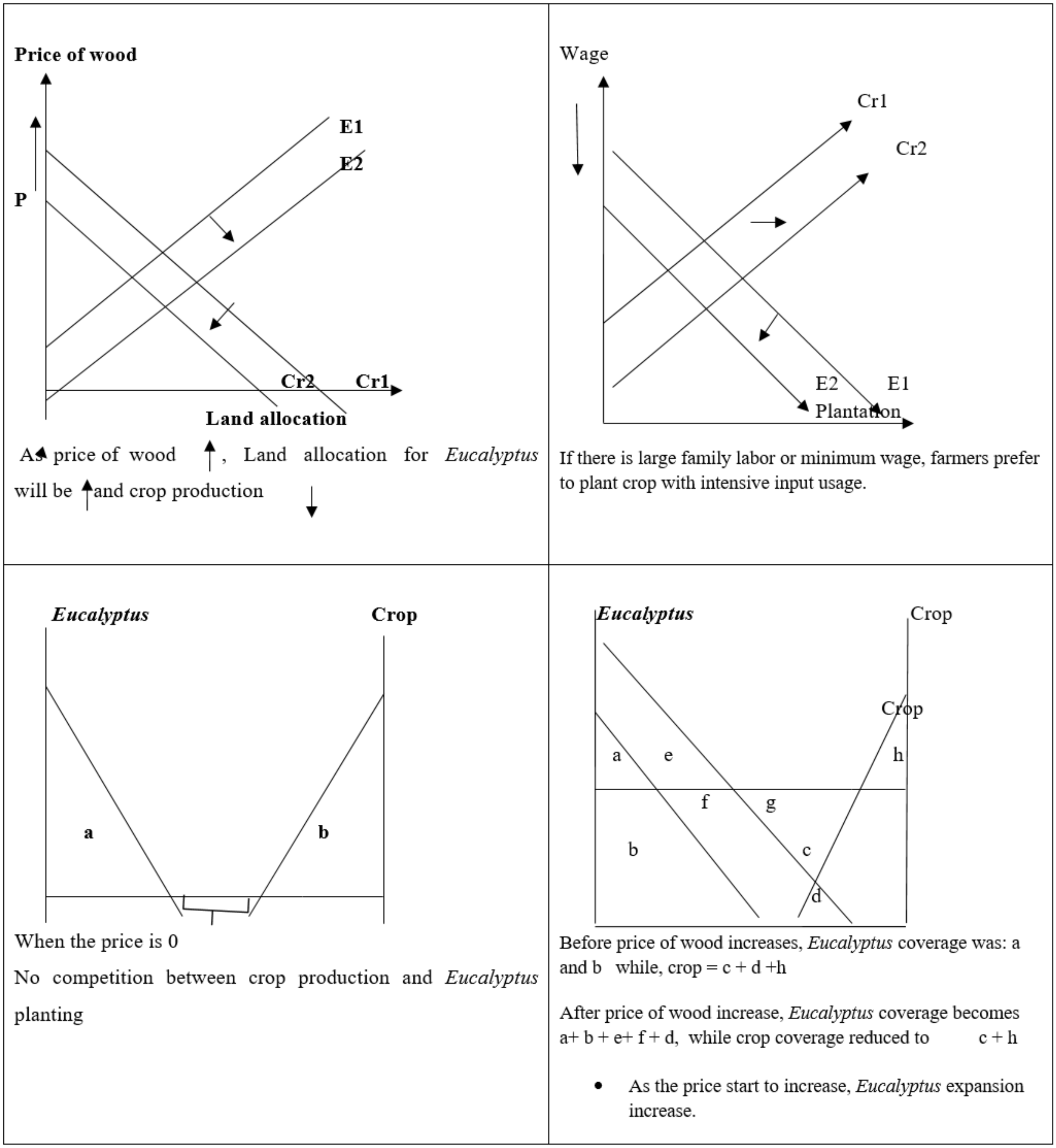

Figure 4

Conceptual graphic presentation of Faustman model

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- Yorrowdata.xlsx