

Post-adoption of the candlenut agroforestry in Central Sulawesi, Indonesia

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Abstract. This research examined the contribution and effect of socio-economic variables toward the post-adoption of the candlenut agroforestry by using Path Analysis to provide the magnitude and significance of the hypothesized causal connection between the variables. The target population in this research includes all farmers of the agroforestry in Sigimpu and Bakubakulu villages, Palolo sub-district, Sigi District, Central Sulawesi Province of Indonesia (315 farmers) out of which a number of 164 farmers were selected by using Isaac and Michael Table. The path model shows the magnitude of the direct effects to post-adoption was 48.8% and the total effect was 66.5%. The variable of satisfaction on agroforestry inheritance was greater than the variable of satisfaction on income from the agroforestry, while the variable of a number of candlenut trees was the biggest contributor to the exogenous variables. The statistical evidence indicates not only the satisfaction variables affected the post-adoption, but also they sign an important of land tenure security for along term of the management.

1. Introduction

Agroforestry is one of important land use systems that takes places in both tropical and temperate regions, producing wood and food for better life and food. It also improves livelihoods, alleviates poverty and promotes productive, resilient forest and agricultural environment [1]. Agroforestry in Indonesia can provide better environmental services by maintaining hydrological function, biodiversity conservation and carbon sequestration although not as high as in a natural forest, but its economic values are higher than the forest own [2]. In surrounding research area in Central Sulawesi Province of Indonesia, agroforestry consists of agroforestry systems that range from low-intensity management with a high degree of shading to highly intensified with no shade cover [3]. To have an agroforestry system with a high degree of shading, the payments for environment services required for inducing the adoption of more sustainable agroforestry with more shading trees [3,5].

Agroforestry adoption has been developed in the form of farm forestry in Indonesia. It is a kind of private forests in which the intervention of the government is minimized. Despite the existence of the debate on the role of a free market on forestry, Indonesia government has been encouraging forest-owning families and communities, or those with secure rights to state-owned forests, referred to as locally controlled forestry. This system could be key players in potentially tackling some issues in



Indonesia such as forest degradation, poverty, livelihoods, and climate change. Farm forestry in Indonesia is in accordance with the state law. According to Law No. 41 Year 1999 on Forestry Article 5 paragraph (1b) is replaced with the term forest land for forest rights in the clarification section called community forests. Meanwhile, according to the Decree of the Minister of Forestry No. 49/Kpts-II/1997 about funding and community forest enterprises, these forest are owned by the people with a minimum of 0,25 ha with canopy closure and timber plants or other types of more than 50% and or plants in the first year as a minimum of 500 plants/ha.

Candlenut trees have been growing in Indonesia community environment by serving both economic and ecological benefits. The trees can grow in a productive rotation period of 20 years on 40–60 years of biological rotation [6]. Considering a number of socio-economic factors, the sustainability of candlenut management falls into the category “sustainable with some considerations” based on “Lembaga Ekolabel Indonesia” standard due to bad management of the stand [7]. Moreover, trends in Indonesia where farmers prefer agricultural systems that have economic productivity rather than ecological functions [8].

Economic consideration is always in the behind of motivation to achieve a satisfaction in establishing and maintaining a farm forestry such as what the farmers of South Konawe conducting the teak forest management [9], farmers in Gunung Salak who keep their agroforestry system including fruit tree system and timber tree system [10], as well as in Sweden by which the farmers as the owners of the small-scale forestry proposed four motivation to pursue the management that are satisfaction, amenities, conservation, and economic efficiency [11]. Event non-farm income and agroforestry adoption are substantial reasons of farmers in Northwest Ethiopia to convert their cereal crops into agroforestry systems as well as to diversify their incomes [12]. Species richness of trees, fungi, invertebrates, and vertebrates did not decrease with yield [13]. The further explanation that moderate shade, adequate labour, and input level can be combined with a complex habitat structure to provide high biodiversity as well as high yields.

Beside economy satisfaction, we proposed a satisfaction based agroforestry as an inheritance for the children as one of the important factors influencing society participation in planting and maintaining of trees in the agroforestry system. It is the case of the candlenut agroforestry by which it has been in end years of the rotation. Are the owners will readopt the agroforestry? The paper will answer the question by having developed our insight that agroforestry as the inheritance and the capital will grow up on a secure individual or family rights. Contrary, in a system which is uncertain, leads to reluctance in planting trees as requirement of an agroforestry system and this can occur in a tenure right of communal land or state one.

2. Theoretical framework

Agroforestry technology of farm forestry could be changed to represent social strategies that redistributed resources. It is dunked in social relations and often needs more resources for employment and maintenance. Agroforestry farmers have other priorities because they may be caught in the food imperative and the health imperative. It has been reported that in 1990 there were more than 30 million hectares of agroforestry in Indonesia, and in 2010 the agroforestry areas were falling toward 20 million hectares [2]. We proposed that the basis of continued usage of agroforestry (post-adoption) is satisfaction, while dissatisfaction may cause agroforestry farmers to discontinue the agroforestry in their lands. Not only in Indonesia, in Europe also as well as we can find elsewhere of the world, the area under agroforestry has been declined over the year due to the increased mechanization that led to the development of the increasingly specialized crop, animal and wood production systems [14].

Even though the agroforestry can make contribution in delivering multiple benefits and in the same time to mitigate climate change, agroforestry adoption is still slow due to a difference between the ontology of global policies focusing on the merits of agroforestry with one of everyday practices and strategies, especially in subsistence agriculture [15]. An adoption will start usually with the recognition that a need exists and moves to searching for a solution, then making an initial decision for an implementation [16,17]. They explained furthermore that innovation is a dynamic process and

implementation that depends on leadership, operational size and structure, innovation fit with norms and values, and motivation. It has been explained that in the implementation stage of innovation, it brings the newness in which some degrees of uncertainty is involved in diffusion [18]. It has been explained that time is very important factor in innovation adoption and diffusion [19], while another result of a research showed that timeliness and method of training are the effective factors for adoption of improved crop production [20]. It can be said that there is a series of technological generation in function of time and other variables that bring the growth in the level of demand, acceptance, or use in the diffusion of innovations [21,22]. The adoptions than consist of early adopters and late adopters by which they are different. They must be able to cope with a high level of uncertainty and may not be respected by other members of the social system. This theory is available as well as for candlenut agroforestry as one of land use technologies in which uncertainty about the outcome of the innovation still can be a problem at the more than 30 years of implementation. Thus, the farmers as implementers of the farm forestry based candlenut agroforestry as the innovation itself may need any assistance to reduce the degree of uncertainty in order to ensure not only the sustainable of management but also the sustainable of the farm forestry based candlenut agroforestry.

Post-adoption is the confirmation stage of the Rogers' theory, the innovation-decision process. We consider two conditions in the post-adoption that are continuance and discontinuance, which are influenced by dissonance. When a farmer feels dissonant, he will ordinarily be motivated to reduce this condition by changing his knowledge, attitude, and action toward the agroforestry. If he abandons the agroforestry, he may start to examine another technology of land uses at the same time in order to substitute the agroforestry. We have Figure 1 to illustrate the candlenut agroforestry post-adoption through a management cycle to the next one as follow:

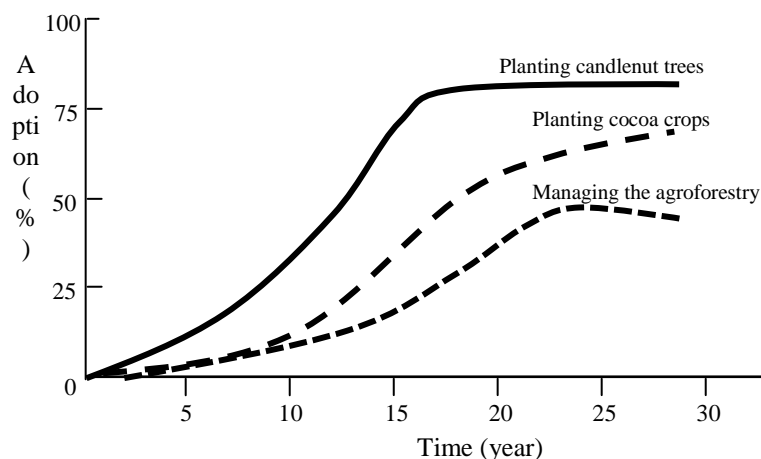


Figure 1. The curves depict the process by which the agroforestry is in the lack of management affecting post-adoption.

A methodology that is commonly used for a satisfaction and post-adoption survey consists of first identifying the most important attributes of a system, and second, asking the respondents to rate the attributes on a symmetrical one-dimensional scale. Nearly fifty percent of the 706 articles published in the Journal of Agricultural Education from 1995 to 2012 reported quantitative research with at least one variable measured by Likert Scale [23]. On this scale, the lowest value indicates the highest dissatisfaction with an attribute, and the highest value represents the greatest satisfaction, while the midpoint indicates neutrality. Likert Scale was applied to measure level of satisfaction on candle nut agroforestry that consists of five levels, which are 1 (very dissatisfied); 2 (dissatisfied); 3 (insure); 4 (satisfied); and 5 (very satisfied). To have a Likert Scale, a series of verbal statements was written that expressed a range of positive expression, view, sentiments, claims or opinions about the candle nut

agroforestry that ranged from mildly positive to strongly positive and then the same relative to a range of negative statements [24].

3. Research method

An interview instrument was developed with three main variables that are agroforestry post-adoption, farmer's satisfaction toward income from the agroforestry, and farmer's satisfaction toward agroforestry inheritance. The instrument also comprises of other variables as being explained previously (X1, X2, X3, and X4).

The population analysed in this research consisted of farmers from two villages (Sigimpu and Bakubakulu) who have been managing farm forestry based candlenut agroforestry. The two villages, within the Palolo sub-district of Central Sulawesi Province, were selected for analysis because they have been implementing candlenut agroforestry among farmers in these areas for around three decades. List of the farmers within the villages was collected from the village governments. From the list containing 315 farmers, by using Isaac and Michael Table, a total of 164 farmers were decided as a sample size and randomly selected for being interviewed. Prior to data collection, a pilot survey was undertaken to pre-test the questionnaire, targeting 10 farmers from the villages, not on the interview list. We adopted pre-test items from previous studies for many constructs, we hoped with modification to make them relevant to the post-adoption survey on the candlenut agroforestry.

We would like to inform to the readers that you should be aware of certain limitations of this research before considering the results. A survey method of data collection was applied, thus the results we have here is a snapshot of the post-adoption on the candlenut agroforestry. Another constraint on our present research is the use of only present agroforestry farmers but did not take into consideration the potential agroforestry farmers. Even though the research presents the limitations, but we hope that the readers will have a good impact or influence in well interpreting the research finding, anyway. Before doing the path analysis of the data we have collected, we look closely at the data to determine the best method of organizing it by using spread sheet Excel and SPSS that tend to be easily accessible.

Path analysis was employed to determine whether or not the multivariate set of our data fits well with the causal model (see figure 2). The path analysis has been operated as a hierarchical multiple regression analysis by which each endogenous variable we conducted a multiple regression analysis predicting variables Y and Z from all variables which are hypothesized to have a direct effect on them. We have not included in the analysis any variables which are hypothesized to affect Y and or Z only indirectly (through one or more intervening variables). For each path to an endogenous variable, we computed a path coefficient, p_{ij} , where "i" indicates the effect and "j" the cause. We squared each coefficient to have the proportion of the affected variable's variance that is caused by the causal variable. The coefficient may be positive (increasing the causal variable causes increases in the dependent variable if all other causal variables are held constant) or negative (increasing causal variable decreases dependent variable).

Although the analysis has been used for years in many fields as diverse as econometrics and biology, there are few examples of its application in investigating multiple-cause behaviours in agroforestry post-adoption. Path analysis is a type of causal modelling for investigating postulated relationships among variables. Among the most important of these are the assumptions that the occurrence of one event is sufficient for the occurrence of a later event, and that the cause and effect variables covary so that a change in the level of the cause variable alters the effect variable.

4. Results

The main result of the research was a Path Model describing both correlation and path coefficients between the variables (figure 2). A correlation coefficient does not relate to the gradient beyond sharing its positive or negative sign. It is a measure of linear relationship. The existence of a strong correlation did not imply a causal link between the variables. For example, we cannot imply that X2 causes X4 or vice versa. Correlation Analysis was an important step to determine the inter-relationship

among the variables in order to have a better understanding of both the direct and indirect effects of the specific components can be attained. There were two types of relationships can be specified in the path model: causal and unanalysed. A causal relationship is represented by a straight line arrow pointing from the cause to the effect; it can be direct or indirect. The model, depicting post-adoption, Y1 (satisfaction toward income from the agroforestry) and Y2 (satisfaction toward agroforestry as a bequest) directly lead to Z (post-adoption), while all X variables indirectly cause the post-adoption through their effects on Y1 and Y2. The model also depicts unanalysed relationships, represented by the curved double-headed arrows among X variables. Unanalysed means that there is an ambiguity about the relationship. In the model, X1 (number of candlenut trees) and X4 (cocoa production) for example were related to one another, but it was uncertain whether the relationship was causal or spurious. The implications of the model are that the farmer's socio-economic variables (X1, X2, X3, and X4) directly affected the satisfaction toward income from the agroforestry (Y1) and the satisfaction toward agroforestry as a bequest (Y2) of the farmers. These, in turn, indirectly affected post-adoption of the farmers (Z). Our diagram as well as indicates that Z was directly affected by Y1 and Y2. We regressed Z on these two causal variables and obtained $R^2 = 0.731$ $\rho_{Y1Z} = 0.420$, $\rho_{Y2Z} = 0.544$. The path coefficient for extraneous variable was 0.51. We see that Z was more strongly caused by Y2 than by Y1, and that extraneous variable exert great influence.

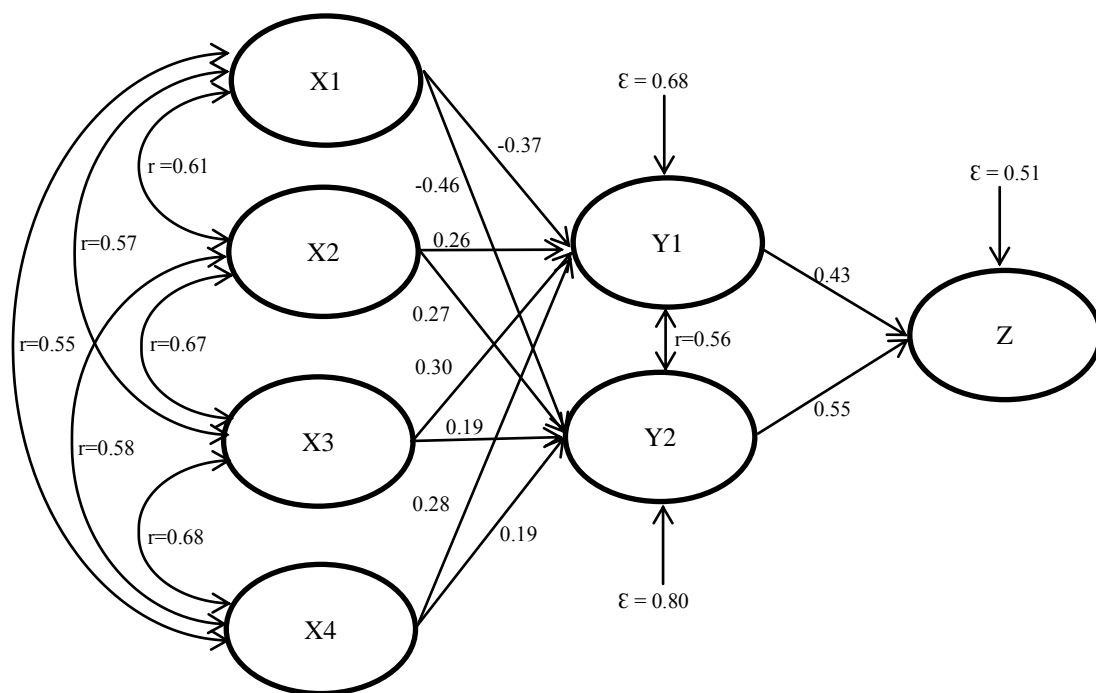


Figure 2. Path coefficients in the diagram of the agroforestry post-adoption.

To explain the causal effects in the model, it is about the effects that go directly from one variable to a second variable (direct effects) and effects between two variables that are mediated by one or more intervening variables (indirect effects), we divided the model into three sub model: sub-model 1, sub-model 2, and sub-model 3. And we have the sub-model equation as follow:

Equation of sub-model 1:

$$Y_1 = -0.37X_1 + 0.26X_2 + 0.30X_3 + 0.28X_4 + 0.68\varepsilon_{Y1} \quad (1)$$

Equation of sub-model 2:

$$Y_2 = -0.46X_1 + 0.27X_2 + 0.19X_3 + 0.28X_4 + 0.80\varepsilon_{Y2} \quad (2)$$

Equation of sub-model 3:

$$Z = 0.48Y_1 + 0.55Y_2 + 0.51\varepsilon_Z \quad (3)$$

We can take the utility of path analysis here by decomposing the source of a correlation between the independent variable and a dependent variable (table 1). The primary rule of the analysis states that the correlation between an independent and a dependent variable is the sum of the direct effect and all indirect effects.

Table 1. Results of decomposing the correlations between variables in different sub-models.

Sub-model	Independent variables	Dependent variable	Direct effect	Indirect effect	Total
Sub-model	X1	Y1	-0.37	0.93	0.56
	X2	Y1	0.26	0.22	0.48
	X3	Y1	0.30	0.09	0.39
	X4	Y1	0.19	0.23	0.42
Sub-model2	X1	Y2	-0.46	0.45	-0.01
	X2	Y2	0.27	0.04	0.31
	X3	Y2	0.19	-0.04	0.15
	X4	Y2	0.19	0.11	0.30
Sub-model3	Y1	Z	0.43	0.28	0.71
	Y2	Z	0.55	0.22	0.77

We can quantify the reasons for the correlation between Y1 and Y2 by using the tracing rules, starting with Y1 and ending in Y1. The result was four direct pathways, one for each independent variable. The direct pathway for X4 went from Y2 to X4 and directly from X4 to Y1. The magnitude of this path was $0.19(0.28)=0.05$. This quantifies how much the direct effects of education were responsible for the correlation between Y1 and Y2. The second direct effect went through X3 and equals $0.19(0.30)=0.057$. The third was $0.27(0.26)=0.07$, and the last direct effect went through X1 and was $-0.46(-0.37)=0.170$.

To calculate all the indirect ways by which Y1 and Y2 may be correlated, we consider in first the indirect effects that pass the two independent variables X4 and X3. These two variables influenced the correlation between Y1 and Y2 comes about because X4 directly influenced Y2, X1 was correlated with X3, and X3 directly provided Y1. We started in Y2, went to X4, than to X3, and then to Y1. The pathway here was $0.19(0.68)(0.30)=0.04$. The model proposes another pathway reflecting a similar indirect mechanism. X3 had a direct effect on Y2, X3 was correlated with X4 and X4 had a direct effect on Y1. This path started at Y2, went to X3, thence to X4, and finally to Y1, or $0.19(0.68)(0.28)=0.0362$. Thus, the results of the indirect effects of X4 and X3 on the correlation between Y1 and Y2 were the sum of these two pathways, or $0.0387 + 0.0362 = 0.0749$. We did the rests with this logic until we had exhausted all the indirect pathways between every pair of independent variables (Table 2). Table 2 shows a result of trace paths from Y1 to Y2 through residuals. The magnitude of this was $0.8(0.33)0.68 = 0.17$ and this was an illustrative comparison of the amount that the independent variables contribute to the correlation with the amount that the residuals contribute. If the independent variables explained a large percentage of the correlation between Y1 and Y2, then the residual correlation should go toward 0.

Table 2. Decomposition of the correlation between Satisfaction Y1 and satisfaction Y2.

Type	Source	Amount	Total
Direct	X1	$-0.046(-0.37) = 0.01$	
	X2	$0.27(0.26) = 0.07$	
	X3	$0.19(0.30) = 0.05$	
	X4	$0.19(0.28) = 0.05$	
	Total direct		0.1
Indirect	X4&X3	$0.19(0.68)(0.30)+0.19(0.68)(0.28) = 0.07$	
	X4&X2	$0.19(0.88)(0.26)+0.27(0.88)(0.28) = 0.11$	
	X4&X1	$0.19(0.55)(-0.37)+-0.46(0.55)(0.28) = 0.16$	
	X3&X2	$0.19(0.67)(0.26)+0.27(0.67)(0.30) = 0.08$	
	X3&X1	$0.19(0.77)(-0.37)+-0.46(0.77)(0.30) = 0.16$	
	X2&X1	$0.27(0.61)(-0.37)+-0.46(0.61)(0.26) = 0.13$	
	Total indirect		0.7
Residual		$0.8(0.33)0.68 = 0.17$	0.2
Total			0.9

In the full model, we had no direct effect of X variables on post-adoption (Z). They contributed only indirect effects channelled through Y1 and Y2. Different with that, satisfaction variables (Y1 and Y2) show both direct and indirect effects. One of the direct effects on the satisfactions (Y1 and Y2) via the investigated characters was negative in X1 (number of candlenut trees), while the rest variables were positive in X2, X3, and X4. We can see as well that direct effects of Y1 and Y2 on Z were stronger than their indirect effect. The magnitude of the direct effects to post-adoption were 48.8% and the total effects were 66.5%. The Y2 contribution was greater than Y1, while X1 indirect effect was the biggest of exogenous variables. F and t-tests show significant effects of Y1 and Y2 on Z.

5. Discussion

The above results show the contribution of satisfaction toward income from agroforestry (Y1) and the contribution of satisfaction toward agroforestry as a bequest (Y2) on the agroforestry post-adoption (Z) in which we find that Y2 shows greater contribution than Y1. It means that the agroforestry farmers as parents keep an idea of inheriting their agroforestries to their own children. Most farmers spoke of bequest (value) as a gift carrying responsibility and it is a good part of sustainability of the agroforestry. In another word, the bequest value will be as a key for the post-adoption of the sustainable management of the lands. Inheritance system should be a good indicator of sustainable management. Even it could be as an instrument of increasing land right and certain in forest and land management. Land and tenure right on agroforestry system in Sumatra, Indonesia increases motivation and certain in tree plantation [25]. A bequest represents a moral of altruistic value in the management of the agroforestry. It can be stated that altruistic concern is a reasonable assumption for parents transferring resources to their children [26]. Nevertheless, an economic theory of altruistic transfer has resulted many counter intuitive conclusions. When we explain the bequest from the theory perspective, it could be predicted that inheritances will compensate for earning differences between siblings as well as between parents and children.

Agroforestry as a bequest is an important factor for the sustainability, directly in the term of short and medium time scale. The factor is believed to have a correlation with the bio-ecological factor for a long-term sustainability. In other words, it can be stated that high level of personal land ownership has probably contributed to the long-term adoption of agroforestry [27, 28]. However, to make the majority of households in a village adopt agroforestry practices requires involvement and efforts beyond the village level by developing increased levels of trust among farmers and other stakeholders representing different societal sectors and administrative levels [29]. Thus, the awareness and recognition of the stakeholders to the inheritance value becomes very important for strengthening the agroforestry system through the involvement of the parties. This will result in outcomes in long-term

sustainability of agroforestry management which is still rarely found in agroforestry implementation projects.

To persuade of scaling-up agroforestry to sustainably increase the productions and maintain environmental services, it is important to address three key issues, they are creating a need for local adaptation of any variation in social, economic and ecological context; developing appropriate service delivery mechanism, markets, and institutional contexts, as well as technologies; and appropriating research design to enables co-learning amongst different actors [30]. Local adaptation on socio-economic contexts of the post-adoption with its two determinant factors should take not only income from the agroforestry but also inheritance. An economic perspective such as income, access to capital and incentive is socio-economic condition influencing agroforestry adoption [31,32]. While inheritance with a high level of agroforestry ownership will be a determinant factor for the adoption in long-term, event through the next rotation by replanting trees in a tenure security.

6. Conclusions

This study provided statistical evidence that long term sustainable management of the next rotation of the candlenut agroforestry needs land tenure security under the local inheritance system, as well as the satisfaction toward income from the agroforestry. Involving other factors surrounding these two factors could be as a promising step toward satisfied economic and tenurial institutions. It is widely believed that land tenure unsecured brings a socially inefficient resource allocation.

Considering the satisfaction toward income from the agroforestry as the second factor after the inheritance could be as an internal factor of keeping the agroforestry with lower production under a medium shade of the candlenut stand. This circumstance could be as an opportunity to the farmers to have any incentive from the agroforestry services.

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