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# STRUCTURAL EQUATION MODELLING OF SOCIO-ECONOMIC DETERMINANTS OF MODERN TECHNOLOGY ADOPTION FOR SUSTAINABLE NATURAL RESOURCES MANAGEMENT IN ADJA AND NAGOT AREAS OF BENIN REPUBLIC

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## ABSTRACT

This paper evaluated data collected from 120 households in two areas of Benin Republic to identify socio-economic determinants of modern technologies adoption for sustainable management of natural resources. The methodological approach used is based on a structural equation modeling with latent variables. For the two areas, the results show that the participation in agricultural projects and frequent contacts with project agents were key factors of adoption. In fact, an increase in participation decision by 1 unit led to an increase in adoption decision by 1.28 units in Adja area and 2.05 units in Nagot ($p<0.1$). Likewise, socio-economic factors related to human capital, availability and access to production inputs and soil fertility determined participation in projects and adoption of technologies in Adja area. Conversely in Nagot area, socio-economic factors related to soil fertility did not influence adoption. These results suggest that agricultural policy should enhance the quality and efficiency of management of agricultural projects for both private and public initiatives in order to improve adoption of modern technologies for sustainable natural resources management in Benin Republic. The results have also revealed those factors that are vital for the promotion of adoption of technologies while implementing agricultural and natural resources management projects by government and donor agencies in Benin Republic.

**Key words:** Adoption, modern technologies, natural resources, Benin Republic.

## INTRODUCTION

According to Freud (1985), development projects are specific forms that have taken interventions of external helps in developing countries. They include finance, action, organization and coordination for economic growth. In the last decades, these interventions have put more emphases on the improvement of agricultural productivity and natural resource management in developing countries particularly in the Sub-Saharan African countries. Results of development projects evaluation have shown always undoubtedly that they have positive impacts on local population's livelihood (Doppler and Bothe, 1999; IFPRI, 2001). However, these impacts may remain sustainable only if farmers continue to get involved in development projects and to adopt modern technologies that they diffused for sustainable natural resource management. Thus, the long-term durability of the impacts is strongly related to the decisions of farmers to get involved in projects and to adopt modern technologies for natural resource management. Such natural resource management principles that were diffused in these communities include the use of fertilizers, manure, terracing as means of land management, minimum tillage, erosion control measures and planting of trees. The farming communities in Nagot and Adja areas of Benin Republic have over the years been exposed to participation in developmental projects that are agricultural related as well as other projects that are livelihood improving. However, factors influencing farmers' participation in these various project for sustainable agricultural production and environmental preservation have not been evaluated. The main objective of this study is, therefore, the evaluation of factors influencing farmers' participation in these various project in these two communities. These factors are both socio-economic in nature and adequate knowledge of these factors will be of great importance to the success of further interventions in these areas as well as other communities in Benin Republic both now and in the nearest future.

For this reason, it is important to identify socio-economic factors, which may be able to influence adoption of modern technologies for natural resource management and agricultural related management in the study areas. The purpose of this paper is, therefore, to contribute to this imperative through latent variables structural equation modeling in the evaluation of farmers adoption of modern technologies induced by projects interventions in Benin Republic.

## MATERIALS AND METHODS

### *Conceptual and theoretical frameworks*

According to GTZ (2000) and various development institutions, a development project is sustainable if it provides positive impacts, which remain for long-term even after the project termination. Therefore, the concept does not mean the project is implemented indefinitely, but during a planned time with positive impacts. Likewise, these positive impacts should remain for a long-time after the project termination. From these, sustainability of a project may depend on two interrelated aspects. First, through participation of local people and goal achievement, agricultural projects affect production systems, consumption pattern, institutional arrangements, natural resource management, human capital, and et cetera of beneficiaries. These impact on the local people are viewed as project positive impacts on sustainability of natural resource management and agricultural production and rural areas development since such impact could be seen with feasible manifestation. As feedback, the beneficiaries judge the projects from opinions of satisfaction with the impacts, and decide whether they could or not continue to participate and to adopt modern technology that are popularized and diffused. These two aspects are required simultaneously, and taking singly, any of them may be necessary, but not sufficient for sustainability of impacts of agricultural projects on natural resources management. For instance, an efficient project with little impact may not be sustainable if the beneficiaries will think that the project solve little of their resources management problems (soil degradation and fertility decline, deforestation, water pollution, *et-cetera*), and will thereby lower their participation. Likewise, high participation of local people may not necessarily lead to full goal achievement and positive impacts of a project. Actually, the system works like three cogged wheel training each other: (1) good design, management and monitoring, which provide high goal achievement are expected to induce positive high impacts, (2) the impacts are expected to enhance parti-cipation of beneficiaries and (3) continuous high participation is necessary for high efficient management and goal achievement to produce continuously positive high impact, and the system starts again until termination of the project. When failure occurs in one of the three processes, sustainability may never be achieved. From these, there are two important areas for analysis: (1) quality of design, management and monitoring, as well as goal achievement and impacts of the projects; and (2) identification of socio-economic factors that may affect participation and adoption decisions of beneficiaries, which is the target of this paper.

***Statistical considerations for modelling the determinants of modern technology adoption for Sustainable Natural Resources Management in Benin Republic***

Literature furnishes various methods authors used to estimate factors determining participation and adoption of modern technology. Earlier analyses consisted of suspecting that some factors were supposed to have influence on participation or adoption. There are studies in the past where statistical tools, for example, Chi-square test of independence, rank correlation or Pearson correlation Coefficient have been used to estimate relationships about participation or adoption of improved practices by farmers in rural communities (Morris *et al.*,1999; Wien and Sobrado, 1998). While completed results from such analysis allowed identifying factors with significant correlation and as well the relationship sign (positive or negative). However, such analysis does not really proceed further after such factors of influence have been identified and consequently provided no knowledge concerning the degree of influence or how much the participation or adoption varies when the factors increase, or decrease. Recent studies introduced econometric regressions to overcome the weaknesses enumerated above. The econometric models linked participation or adoption variable to variables influencing adoption. The model form can be linear or non-linear, and the common use of non-linear forms is linear probability, probit and logit models (Honlonkou, 1999; Roberts *et al.,* 2002). The running of the models provides regression coefficients whose analysis allows us to determine whether or not particular factors significantly influence participation or adoption and to estimate the degree of influence. Regrettably, the use of an econometric model to identify such factors is subject to two main problems. First, the supposition that the factors explain participation or adoption so that the influence is in a single way, exist only in theory. In practice, the relationship between the factors and participation or adoption can be in the two senses. Actually, participation or adoption processes belong to a complex system where direct and indirect causality effects play key roles. A single regression model fails in that it cannot take into account the overall direct or indirect causality effects. Therefore, the Structural Equation Modeling (SEM), which provides estimates of the strength of all the hypothesized relationships between variables, comes out as the appropriate method of estimation of direct and indirect causality effects involved in participation and adoption as key issues of the study.

Regarding the estimation procedures, the study based the techniques and procedures of estimating the model on the Generalized Least Squares (GLS) followed by the Maximum Likelihood (ML). Actually, it selected the option by default. The technique performs five iterations using the Generalized Least Squares estimation procedure, regardless of the current setting in the maximum number of iterations field in the global iteration parameters group in the analysis parameters dialog. At that point, it shifts to Maximum Likelihood estimation. According to Maruyama (1997), Hu and Bentler (1995), there are a number of alternative ways in which to estimate coefficients from latent variables structural equation modeling. They include Ordinary Least Squares (OLS), Unweighted Least Squares (ULS), Generally Weighted Least Squares (GWLS), Diagonally Weighted Least Squares (DWLS), and Asymptotic Distribution-Free (ADF) estimators. The first two are, in general, similar to Generalized Least Squares and Maximum Likelihood in their requirements and properties but yield fit statistics that perform less well than Maximum Likelihood statistics. The latter three differ in that they provide estimation procedures that do not require multivariate normality in the data. Nevertheless, work on fit statistics has found that the Asymptotic Distribution-Free estimators, in comparison to Maximum Likelihood estimates, have not produced estimates with desirable properties, particularly in small samples. Therefore, assuming that the data of the study do not strongly violate an assumption of multivariate normality, the study would loose little or nothing by staying with Generalized Least Squares (GLS) followed by Maximum Likelihood (ML) estimates which we adopted for this study using the STATISTICA software package.

## Methodological Approach: the Structural Equation Modeling

### *Observed Variables and Definition of Latent Variables*

In the conceptual framework and methodological approach, linkages between agricultural projects and sustainability were outlined. Here, observed variables involved in modeling farmers' decisions of participation in projects and of adoption of modern technologies are heavily drawn from factors highlighted by the linkages formerly outlined and explained in the conceptual framework.

According to Steenkamp and van Trijp (1996), inaccuracies and imprecision in defining latent variables are usually called specification error. To overcome these, he proposed a factor analysis to explore how the manifest variables go together. Consequently, the exploration of groups of factors involved in linkages between agricultural projects and sustainability completed by factor analysis, leads to identification and definition of the latent variables of the structural model. Thus, five latent with related measured variables were defined as shown in Table 1. Most of the observed variables were coded into 5-point bipolar scale (examples of poles: 1=very low, 5=very high for per capita annual revenue, or 1=very young, 5=very old for age, or 1=high hillside, 5=flat with inundation for land hillside, *et cetera*). Additionally, when the observed variable took the value 0, the score = 0.

The first latent variable, named human capital characterizes the human property that the stake-holder can use to produce. It included manifest variables such as age, formal schooling and informal education.

**Table 1: Latent and Related Observed Variables Involved in Structural Modeling of Farmers' Decisions**

| Latent variables | Observed variables | *Codes* | Definitions |
|---|---|---|---|
| Human capital (HUCA) | Informal education of the farmer | ALPHLE | ALPHLE=1 if informally educated, 0 if not |
| | Age of the farmer | AGE | 5 poles scales (very young/very old) |
| | Formal Education of the farmer | EDU | EDU=1 if formally educated, 0 if not |
| Perception on satisfaction of production and consumption (PSPC) | Revenue of the farmer | REV | 5 poles scales (very low/very high) |
| | Size of the household | SIZE | 5 poles scales (very low/very high) |
| | Farm productivity | OUTPUT | 5 poles scales (very low/very high) |
| | Food consumption | FOOD | 5 poles scales (very low/very high) |
| Availability of and access to production inputs | Land security | TEN | TEN=1 if land is secured, 0 if not |
| | Amount of credit obtained | CREDIT | 5 poles scales (very low/very high) |
| | Access to Family labor | LABOR | 5 poles scales (very low/very high) |
| | Access to Hired labor | HILABOR | 5 poles scales (very low/very high) |
| Perception on satisfaction on soil fertility (PSSF) | Soil Slope | SITOP | 5 poles scales (high hillside/inundation) |
| | Soil structure | SOSTRUC | 5 poles scales ("terre de barre"/alluvial) |
| | Vegetation cover | VEGCOV | 5 poles scales (low /high covered) |
| | Farming duration | DUREX | 5 poles scales (very short/very long) |
| | Soil degradation | SODEGR | 5 poles scales (very low/very high) |
| Decision to participation in agricultural projects (DEPA) | Contact index | IC | 5 poles scales (very low/very high) |
| | Goal achievement index | IS | 5 poles scales (very low/very high) |
| | Opinions on projects' Usefulness | UTILPRO | 5 poles scales (very useless/very useful) |
| | Relation with projects' teams | *RELPRO* | 5 poles scales (very low/very high) |
| Decision of adoption (DEAD) | Adoption of local technologies | TA | 5 poles scales (very low/very high) |
| | Adoption of modern technologies | MA | 5 poles scales (very low/very high) |

The second latent variable was regarded as the perception of the farmer on satisfaction of agricultural production and food consumption. Here, the related manifest variables were: income per capita of the household, family size, agricultural productivity and food consumption per capita of the household.

The third latent variable constituted the perception of the farmer on satisfaction of soil fertility. Factors of agro-ecological concerns and farming systems were mostly related to this latent variable: soil hillside, soil structure, vegetation cover, degree of soil degradation and farming duration.

The fourth latent variable was the availability of and access to production inputs. Family labor, hired labor, land security and credit per hectare were observed variables that were hypothesized to characterize better availability and affordability of this latent variable.

The fifth latent variable was regarded as the stakeholder's decision to participate in agricultural projects. Variables of factors related to agricultural projects were linked to this latent variable. These variables are contact index, probability that a farmer will achieve the set goal was also used as an index, relation with projects' teams and opinions about usefulness of the projects.

Finally, the sixth latent variable was regarded as the decision to adopt modern technologies. This latent variable was supposed to be related to two measurement variables which are the degree of adoption of local tech-nologies and that of modern ones.

After the conceptualization of the latent variables, hypothesizing and defining the exogenous and endogenous variables can help to operationalize the structural modeling.

### Exogenous and Endogenous Variables

The definition of exogenous and endogenous variables goes from decomposition of relationships. As stressed previously in this study, a proven relationship between variables does not explain the causal effects and their direction. Care is therefore needed to decompose the relationships by using the logic introduced by path analysis before defining exogenous and endogenous variables.

In this study, variables related to farmers' decisions (latent and observed variables) were hypothesized to be caused and generated from the system by the other variables. Thus, the latent variables "decision of participation" and "decision of adoption", as well as related observed variables are endogenous in the system. Likewise, latent variables such as human capital, perception on satisfaction of production and consumption, perception on satisfaction of land fertility, and availability of and access to production inputs, as well as their related observed variables are considered as exogenous. One can therefore draw the structural modeling of factors influencing farmers' decisions of participation and of adoption by operationalizing the possible linkages between variables. However, the main assumption, which allowed the use of the model to be more relevant to estimation of decision factors, should first be assumed.

### *Empirical Models of Factors Affecting Farmers' Decisions*

Following the rules of drawing path diagrams and the main assumption of the study, the structural modeling of factors affecting decisions of participation in projects and of adoption of modern technologies is designed in Figure 1. In order to make clearly readable the figure, the variances and covariances among variables are not schematized. As well, one can remark that indirect relationships are not explicitly repre-sented. Actually, the model aims at focusing more on highlighting the direct causalities between decisions of participation in projects and of adoption of modern technologies and factors that are supposed to affect them. According to Langyintuo (1996) and Samantha (2001), human capital, perception on satisfaction of production, consumption and soil fertility, availability and access to production inputs may strongly affect decision of participation in projects. Thus, human capital, perception on satisfaction of production, of consumption and of soil fertility, and access to production input are hypothesized to cause farmers' decision of participation in projects. Moreover, international institutions have argued that projects are motors of modern technology adoption because they diffuse them by providing needed inputs and facilities (Samantha, 2001). From this, decision of participation in projects is hypothesized to cause that of adoption of modern technology.

### *Mathematical Specification of the Empirical Models*

The definition of the different variables involved in the model and linkages among them in previous sections leads to the formulation of the following mathematical functions of the empirical models.

**Empirical Model Measurement**

Endogenous Variables Side

$$IC = \lambda_1 DEPA + \varepsilon_1 \quad (1)$$

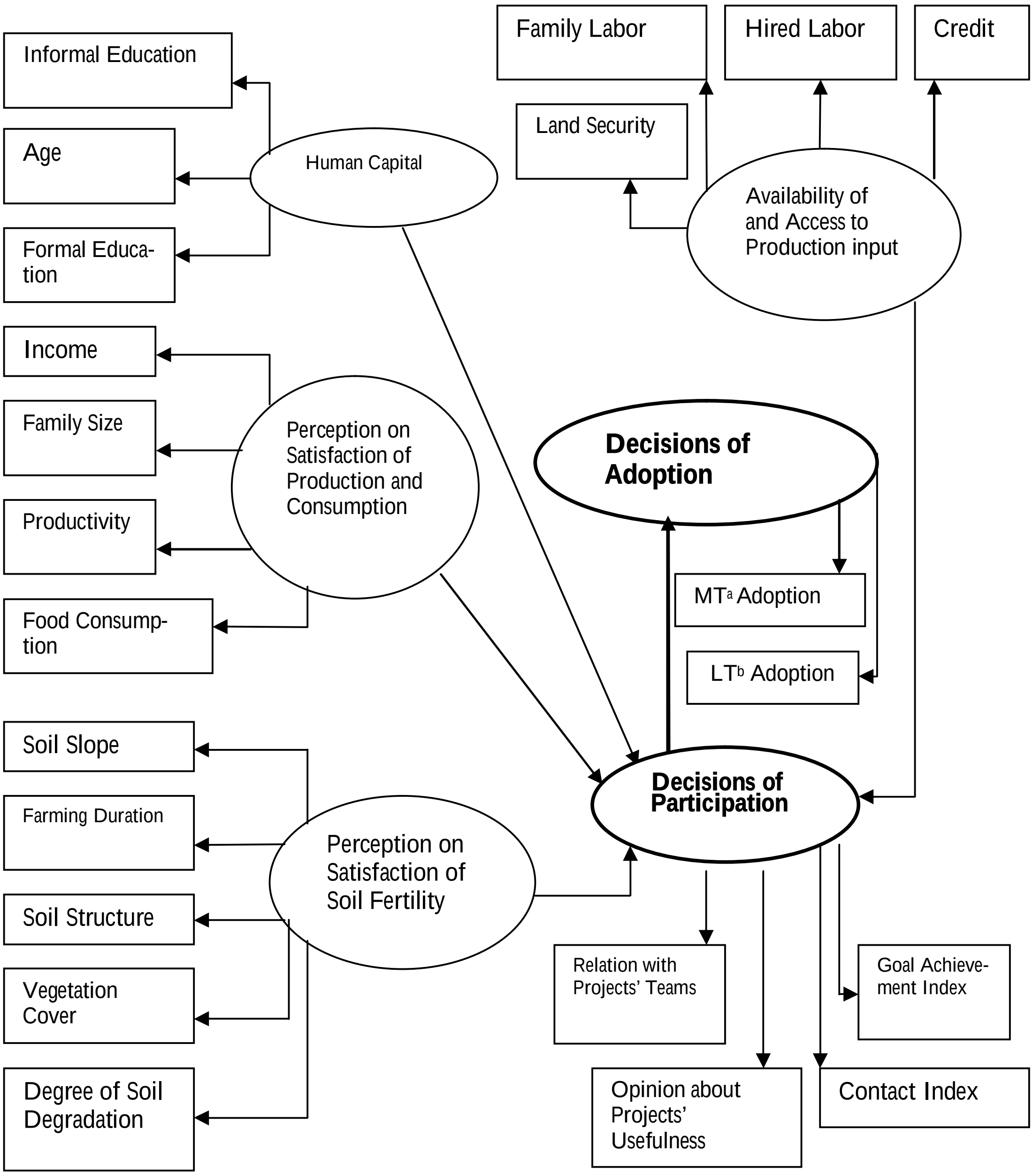
$$RELPRO = \lambda_2 DEPA + \varepsilon_2 \quad (2)$$

$$UTILPRO = \lambda_3 DEPA + \varepsilon_3 \quad (3)$$

$$IS = \lambda_4 DEPA + \varepsilon_4 \quad (4)$$

$$TA = \lambda_5 DEADO + \varepsilon_5 \quad (5)$$

$$MA = \lambda_6 DEADO + \varepsilon_6 \quad (6)$$




a: MT=Modern Technologies; b : LT=Local Technologies

**Figure 1: A Structural Equation with Latent and Observed Variables Modeling the Socio-economic Factors Affecting Farmers' Decision**

Exogenous Variables Side

$$ALPHLE = \lambda_7 HUCA + \delta_1 \quad (7)$$

$$AGE = \lambda_8 HUCA + \delta_2 \quad (8)$$

$$EDU = \lambda_9 HUCA + \delta_3 \quad (9)$$

$$REV = \lambda_{10} PSPC + \delta_4 \quad (10)$$

$$SIZE = \lambda_{11} PSPC + \delta_5 \quad (11)$$

$$OUTPUT = \lambda_{12} PSPC + \delta_6 \quad (12)$$

$$FOOD = \lambda_{13} PSPC + \delta_7 \quad (13)$$

$$SITOP = \lambda_{14} PSSF + \delta_8 \quad (14)$$

$$DUREX = \lambda_{15} PSSF + \delta_9 \quad (15)$$

$$SOSTRUC = \lambda_{16} PSSF + \delta_{10} \quad (16)$$

$$VEGCOV = \lambda_{17} PSSF + \delta_{11} \quad (17)$$

$$SODEGR = \lambda_{18} PSSF + \delta_{12} \quad (18)$$

$$LABOR = \lambda_{19} AAPI + \delta_{13} \quad (19)$$

$$HILABOR = \lambda_{20} AAPI + \delta_{14} \quad (20)$$

$$TEN = \lambda_{21} AAPI + \delta_{15} \quad (21)$$

$$CREDIT = \lambda_{22} AAPI + \delta_{16} \quad (22)$$

DEPA and DEADO represent the latent endogenous variables "decision of participation in projects" and "decision of adoption of modern techno-logies" respectively. HUCA, PSPC, PSSF and AAPI represent the exogenous variables such as human capital, perception on satisfaction of production and consumption, perception on satisfaction of soil fertility, and availability of and access to pro-duction inputs, respectively. The other variables in the equations are those defined in Table 1. These are parameters to be estimated, while the e and d the residuals.

***Empirical Structure of Structural Equation Model***

As the model contains two endogenous latent variables, the mathematical form of the structural model can be expressed as:

$$DEPA = \gamma_1 HUCA + \gamma_2 PSPC + \gamma_3 PSSF + \gamma_4 AAPI + \zeta_1 \qquad (23)$$

$$DEADO = \beta_1 DEPA + \zeta_2 \qquad (24)$$

or in matrix form,

$$\begin{pmatrix} DEPA \\ DEADO \end{pmatrix} = \begin{pmatrix} 0 & 0 \\ \beta_1 & 0 \end{pmatrix} \begin{pmatrix} DEPA \\ DEADO \end{pmatrix} + \begin{pmatrix} \gamma_1 & \gamma_2 & \gamma_3 & \gamma_4 \\ 0 & 0 & 0 & 0 \end{pmatrix} \begin{pmatrix} HUCA \\ PSPC \\ PSSF \\ AAPI \end{pmatrix} + \begin{pmatrix} \zeta_1 \\ \zeta_2 \end{pmatrix} \qquad (25)$$

where DEPA, DEADO, HUCA, PSPC, PSSF and AAPI are latent variables earlier defined in Equations (1) to (22), the b and x parameters to estimate, and the z residuals.

***Study Area and Data Base***

The data were collected in 2002, in villages of two socio-cultural areas of Benin (Adja and Nagot), where 20 selected agricultural projects were implemented. The Adja area is located in the west of Benin Republic, between longitude 1°45[1] and 2°10[1] East; and between latitude 6°15[1] and 7°30[1] North. The Nagot area is located in the centre of the country, between longitude 2°15[1] and 2°45[1] East; and between latitude 7°30[1] and 8°30[1] North. Two rainy and two dry seasons, which alternate, characterize the study areas. During the two rainy seasons, the average rainfall in Adja area is about 1,100 mm and in Nagot 1,000 mm. As regards the farming system in Adja area, the last strips of forest around the villages have been cleared between farmlands of neighboring communities. The spatial dynamics of cropping systems in the *Adja* plateau have reduced to as low as (0.2ha) disposable cultivated land per capita and has culminated into land insecurity making the landlord to engage people without land in land rent, leasehold, sharecropping, etc. On the contrary, the opposite is the case in *Nagot* area that is considered as region of food crops and cotton production. The pressure on land is lower and the disposable arable land per capita around is 1.5 and 2ha. The land is more secured than what obtains in *Adja* area since land tenancy on the basis of rent, leasehold and sharecropping is yet to be the usual practice here.

In adoption of modern technologies for natural resource management, a participation in agricultural projects, which disseminate these technologies, appears very important to take into consideration. Therefore, representative samples of agricultural households were chosen by randomization according to the number of projects in which they were involved. However, three stages of scales were distinguished. In each socio-cultural area of the study zone, three villages were selected: one without project, one with single project and one with 2 or more projects. A characterized group of households is selected in each village. Consequently, there were three groups. The first consisted of the "without project" group of households involved in no project. The second was the "with 1 project" group of households, which were concerned in a single project. The third included the "with 2 or more projects" group of households participating in 2 or more projects. In each village chosen, twenty (20) households were selected by group. In total, the sample size was 20*3*2=120. As far as possible with the randomization, the difference between the groups in each socio-cultural area remained the intensity of participation in agricultural projects. Data, which are related to agricultural production, food consumption, soil degradation, activities of the projects, socio-demographic characteristics, and techniques used to protect and to conserve natural resources were collected at the level of these selected households, with the help of structured survey.

## RESULTS AND DISCUSSION

### *Factors affecting farmers' decisions to adopt modern technologies in Adja area*

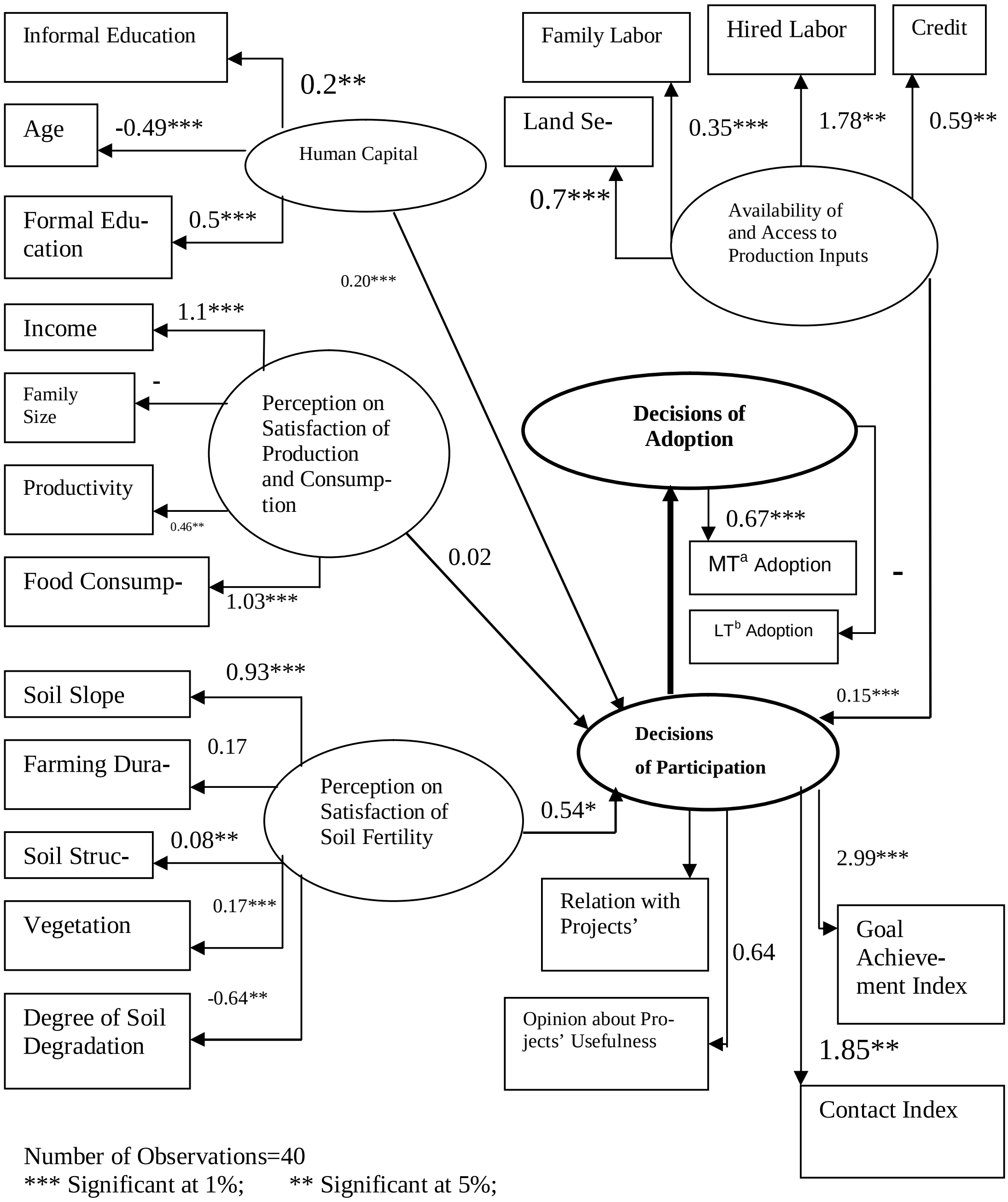
The model results in Adja area (Figure 2) revealed the perception of farmers on their satisfaction about production and consumption that had no significant impact on participation decision though its coefficient was positive. Contrarily, human capital, perception on satisfaction of soil fertility and availability of and access to production inputs affected positively and signi-ficantly decision of participation in agricultural projects, but their effects were seen to be very weak. In fact, when human capital, perception on satisfaction of soil fertility and availability of and access to production inputs increased by 1 unit, participation decision were shown to be 0.20; 0.54 and 0.15 unit respec-tively. It undoubtedly means that human capital, perception on satisfaction of soil fertility and availability of and access to production inputs represented the most important factors that guaranteed better participation of Adja farmers in agricultural projects programmes. With particular regard to soil fertility, the results confirmed that of field study, which found soil degradation and fertility decline as the most important problems of agricultural production of Adja farmers. Consequently, as far as these farmers are satisfied with regards to soil fertility, they will continue to be involved in projects.

Moreover, majority of observed exogenous variables were significant with expected signs. We can conclude, based on the results of this study showing formal and informal education to be statistically significant at 1 percent and 5 percent, respectively, as presented in figure 2 that human capital increased with formal and informal educations of the stakeholders. Additionally, perception on satisfaction of production and consumption increased with the productivity, the quantity per capita of food consumed and the revenue per capita of the stakeholders' households. Likewise, the availability of and access to inputs is seen to increase with the land security, the credit amount, the family and quantity of available hired labors all showing statistically significant relationship with availability of and access to production input at 1 percent level as shown in Figure 2. In contrast, human capital decreased with age of stakeholders as shown with the negatively significant relationship between age and human capital. Actually, the older the farmer is, the less likely his physical ability is and, hence, the less his human capital is. As regards the family size, its increase calls for more production and for more food consumption. Thus, the higher the family size, the less the perception on satisfaction of production and consumption. Finally, the more the soil degradation is, the less its fertility is and hence the less the perception on satisfaction of soil fertility is. From these explanations, the coefficients obtained for the observed exogenous variables were quite justifiable.

The second findings of the structural equation modeling showed that the impact of participation decision on adoption was positive and significant at I percent level. In fact, the increase in participation decision by 1 unit led to an increase in adoption decision by 1.28 units. More so, observed endogenous variables such as contact and goal achievement indexes are also positive and have their coefficients to be significant at 5 percent and 1 percent levels, respectively. They represent sub-sequently the key factors to take into consideration for the improvement of participation decision. Brought together, these results supported the idea that the factors determining management and goal achievement of the projects affected indirectly adoption decision through that of participation in projects. The study proved therefore that agricultural projects widely helped farmers to take the decision of adopting modern technologies. These brought out the undoubted key role that the projects could play in popularizing and diffusing modern technologies. Furthermore, by affecting positively farmers' decision of participation in projects, factors such as human capital, perception on satisfaction of soil fertility and availability of and access to production inputs all found to be significant at 1 percent, 5 percent and 1 percent respectively influenced indirectly the decision of adoption in Adja area through implementation of projects. It can, therefore, be concluded that projects with good management and high goal achievement that provide positive impacts will directly induce better participation and indirectly lead to high adoption of modern technologies as well as to improvement on agricultural productivity and the livelihood of farmers.

### *Socio-economic factors affecting farmers' decisions to adopt modern technologies in Nagot Area*

The model results for Nagot area show some differences when compared to those previously described for Adja area (Figure 3). Perception on satisfaction of production and consumption, human capital, availability of and access to production input significantly and positively affected the decision of participation in Nagot. Consequently, better human capital, perception on satisfaction of production and consumption, and availability of and access to production input all have positive impact on participation in projects. Most observed variables related to these significant latent variables are




Number of Observations=40
*** Significant at 1%; ** Significant at 5%;
* Significant at 10%
a: MT=Modern Technologies;
b: LT=Local Technologies

**Figure 2: Socio-economic factors affecting farmers' decisions to adopt modern technologies in Adja Area (2001-2002)**

also significant and positive. They represent therefore the key factors to take into account for participation and projects' sustainability improvement in this area. Particularly, education of the stakeholders was found as shown in Figure 3 to have significantly and positively influenced the human capital. While formal education was significant at 1 percent level, informal education was found to be significant at 5 percent level. It appears, therefore, important to target education of rural people to give them opportunity to understand the activities of the projects in order to increase their participation. In contrast, observed variables like family size and land tenure did not signi-ficantly affect perception on satisfaction of production and consumption and availability of and access to production inputs, respectively. At the moment, these factors do not represent serious constraints for participation in projects and hence do not affect projects sustainability in Nagot area. As regard land tenure, land was relatively much available in Nagot area, and very few farmers experienced land insecurity. Nevertheless, access to land could be a constraint for participation in projects in future if agricultural development policy does not set about strategies of stopping deforestation and soil degradation.

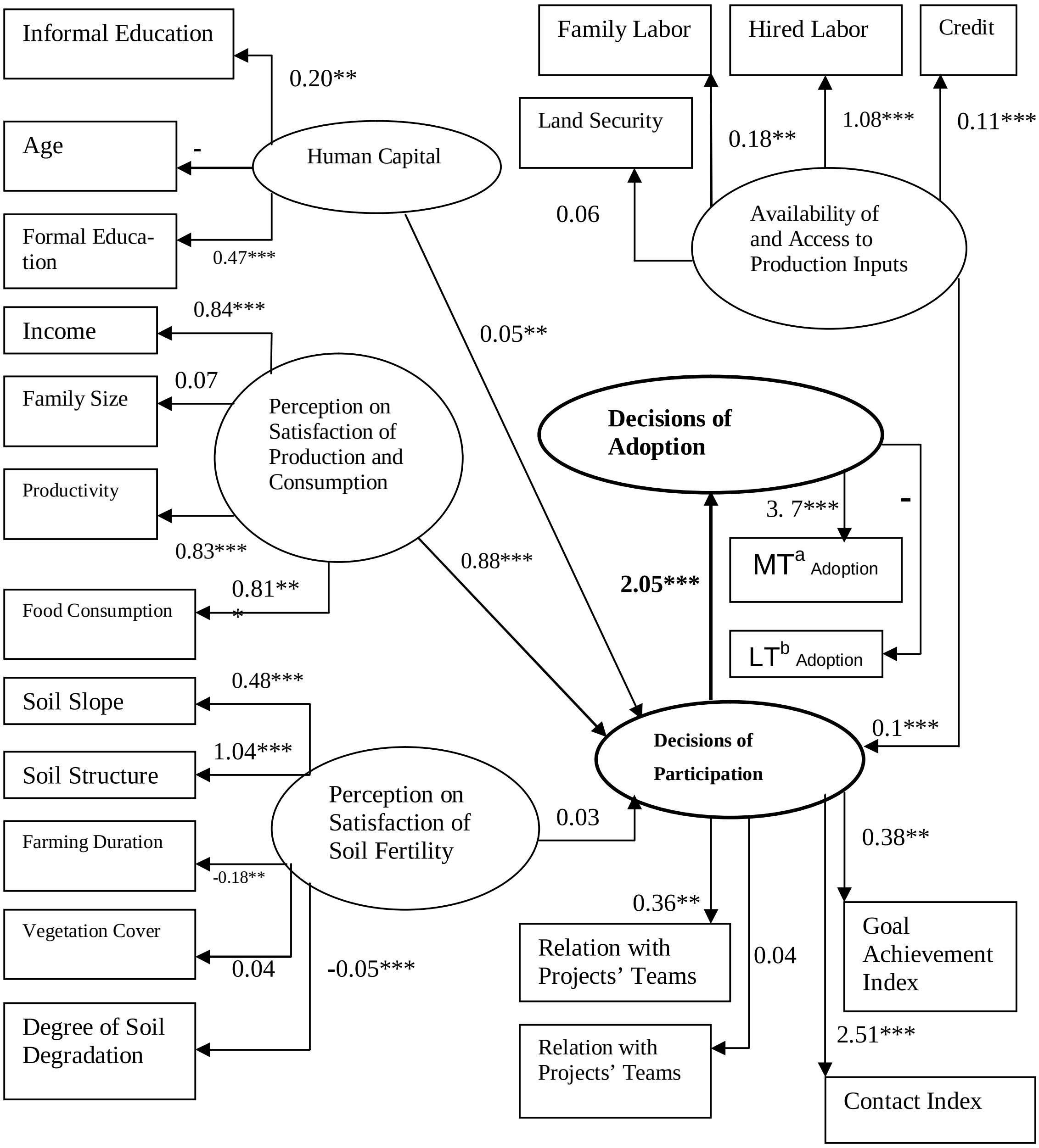
With regard to the perception on satisfaction of soil fertility, it did not significantly influence the decision of participation in projects in Nagot area. As farmers in this area thought their soil was relatively fertile and gave satisfactory productivity, soil fertility decline presently did not represent very serious concern. However, analysis done here is only relevant from a static point of view. As earlier stressed, dynamically, the perception on satisfaction of soil fertility could in long term affect the participation decision. In reality, the arrival of new agricultural migrants and demographic growth could in long term worsen availability of and access to cultivable lands. Additionally, land could become less secured in the nearest future. Actually, it becomes urgent to explore ways of improving land security and access, and that is the challenge agricultural projects should deal with in Nagot area.

As it was the case in Adja area, decision of participation affected positively that of adoption. Indeed, a unit increase in participation decision induced 2.05 units in adoption decision. Therefore, the considered exogenous factors may have indirect significant causal effect on adoption decision through decision of participation in agricultural projects. Actually, the interpretation given previously for Adja area is as well valid here. The projects are the motors of popularizing, diffusing and adopting the modern technologies. However, there is need for good project design, management and monitoring for success in goal achievement and high positive impacts.

## CONCLUSION

The results obtained from the structural modeling of farmers' decisions show importance of some factors in facilitating participation and adoption decisions of the stakeholders. In the two areas, formal and informal education, and age of the stakeholders influenced the human capital latent variable, which was shown to have enhanced the participation of the farmers in projects. Actually, the decision of partici-pation increased with increase in these factors. Likewise, partici-pation decision increased with availability and access to production inputs.

Nonetheless, there are variations in findings according to the socio-cultural area. For example, factors related to soil fertility and land




Number of Observations=40
*** Significant at 1%; ** Significant at 5%; * Significant at 10%
a: MT=Modern Technologies; b: LT=Local Technologies

**Figure 3: Socio-economic factors affecting farmers' decisions to adopt modern technologies in Nagot Area (2001-2002)**

security appeared very important to consider in Adja area, where land pressure were relatively greater and land security lesser. Thus, by putting in place strategies to address land security and availability, agricultural projects can give incentives to farmers in this area to increase their participation. In contrast to Adja area, the per capita income, per capita annual quantity of food consumed and productivity influenced positively the perception on satisfaction of production and consumption latent variable, which influenced positively the participation decision of Nagot stakeholders. Nevertheless, the factors related to soil fertility and land security did not affect significantly the stakeholders' decision of participation. According to their opinions, availability and access to cultivated land did not represent serious problems.

Another viewpoint of the results in the two areas showed that agricultural projects were the vehicle for popularization and diffusion of modern technologies for sustainable management of natural resources and improvement of agricultural productivity for better livelihood. In fact, decision of adoption increased significantly with participation in agricultural projects, which also promotes the goal achievement of the projects. It could, therefore, be concluded that more efforts should be geared towards farmers' participation in developmental project in communities in Benin Republic by both government and donor agencies to facilitate adoption of modern agricultural technologies as a way of stimulating socio- economic development and consequently poverty reduction.

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