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Model Analysis of Transitions in Land Use Strategies among Small Farmers in the Amazon

—A Case Study of Marabá Region in the State of Pará, Brazil—

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Abstract

Small farmers' migration to the Amazon and their land use practices were reviewed and analyzed. Special attention was given to transitions of land use strategies among small colonist farmers. The thesis looked into project initiatives in introducing perennial crop production through agroforestry systems — a transition of land use from former attempt of small-scale pastures following experiences of predominant large-scale ranch developers. Based on reviewing historical migration process, land tenure and land use practice among selected sample households, comparative revenue analysis was carried out on annual, perennial crops and pastoral production, in addition to revenues arising from the service sector. The prevalent practice of slash-and-burn agriculture and pasture were found to share nearly an equal importance in generating revenues, followed by perennial crop production through introduction of agroforestry. Agroforestry systems had yet to generate dominant share in revenues. Yet, its productivity was nearly equal to pastures among commercializing households.

The revenue study analysis was followed by characterization of land use options and analysis on transitions of the land use strategies, involving slash-and-burn agriculture, pastures and agroforestry systems. The analysis engaged in the classification into extensive/intensive parameters in the use of land, capital and technology. The process classified both slash-and-burn agriculture and agroforestry systems into a common denominator, defined as a 'closed-cycle' land use strategy. Such strategy was compared to an opposed land use model of 'open-end' land use strategy, represented by capital-intensive monoculture plantations. The characterization and subsequent model analysis enabled to explain the rational in the above land use transitions among small farmers in the Amazon.

1. Introduction and Method

Small tenure colonists' migration to the Amazon and their struggles to adapt themselves into the new environment developed historical incentives to introduce ecologically sound and economically viable land use options. Experiences in Marabá region of the Pará state attested increasing examples of transition in land use strategies among small farmers. The field survey on land tenure and land use practice among selected small farmers was conducted[1]. During the survey a volume of literature, data and research documents was available concerning the subject, in addition to data obtained by hearing studies on some of the target communities within the Marabá municipality. Within the municipality of Marabá, three communities were selected by choosing 15 small farmer households. The selected communities included; 1) Murumuru, 2) Deserto, and 3) Piquiá[2]. These communities were participants to project initiatives aiming at promoting sustainable family agriculture. For example, while selected farmers in Murumuru and Deserto were participants to World Bank financed PED — Decentralized Execution Project —, Piquiá farmers participated in a farming improvement project initiated by the rural workers' union (STR) in Marabá.

Interviewed households in Murumuru and Deserto were selected by the president of the community Associations — Murumuru Rural Producers Association and Association of Agro-Extractivist in Lago de Deserto in Murumuru and Deserto, respectively. In Piquiá, representative households among the project participants were selected by the STR's project manager. During the selection process, the instruction was given to choose five representative households corresponding the approximate wealth ranking of the community. During the survey, four households from Murumuru, six households from Deserto, and five households from Piquiá, totaling 15 households were selected[3].

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1 The field survey was conducted during the author's participation in the Project Formulation Study for the Restoration of Degraded Area in the Pará State, Brazil, undertaken by Japan International Cooperation Agency (JICA) during April and May in 1999.

2 These communities were selected as those in which farmers were participants to projects aiming at introducing perennial crops in their farming systems by public or private project initiatives.
According to administrative jurisdiction, Deserto and Piquiá constituted independent communities within the municipality of Marabá, while Murumuru was one of the districts constituting city of Marabá. Here in this discussion however, all three study sites were referred to as communities, in the light of physical characteristics rather than administrative jurisdictions.

3 The objective of the selection was to present overall picture of the initiative taken by Marabá farmers directed towards alternative and sustainable farming systems. Small sampling numbers may not correctly represent each community's reality at full scale. Yet the data obtained from altogether 15 households in three different communities were expected to reflect enough characteristics of small farmers in Marabá joining alternative land use initiatives, compared to other types of populations in the Amazon such as riverine farmers and rubber tappers.

2. History of Marabá Region

Marabá region, an area of 2,894,921 ha, is strategically located along the river Tocantins in the state of Pará, and is comprised of six municipalities; Itupiranga, Jacundá, Marabá, Nova Ipixuna, São Domingos and São João do Araguaia. The region offers a geographically pivotal gateway for infamous large-scale development including Carajás iron ore development project and Tucuruí hydroelectric reservoir. Before the influx of large-scale migrants, the region's economy was sustained by forest extractivism dominated by rubber and Brazil nut (Homma, 1993). Significant production of Brazil nut continued until the 1970s. Benign extractivism was replaced by more intensive resource extraction through timber harvesting and gold mining that sustained the region's economy throughout the 1970s until the early 1980s. Together with commercial harvesting came agricultural colonization and cattle ranching since the 1960s, benefiting the completion of Belém-Brasilia highway. The occupation process by insertion of family agriculture and ranch development in the region occurred basically in three phases: first during 1970–1984 principally by *fazendeiro* — large-scale property holders — facilitated by the government integration policy. Medium- and small-scale land proprietors also settled in the region through colonization projects. The second phase of colonization during 1985-1989 occurred along the completion of Turucuí dam reservoir. The third phase began after this period occupying western part of the region with limited access and infrastructure (LASAT, 1998). **Table 1** shows types of land occupation of the region in 1996. The area occupied by agriculturalists amounted to 80.81% of the total area, of which 40.90% were occupied by family agriculturalists. This category includes lands destined to pasture as well as legal forest reserves. Further, the category includes degraded and abandoned agricultural and pasture lands.

Table 1. Types of Land Occupation in Marabá Region

Land Occupation Types	ha	%
Land Occupied by Family Agriculturalists	956,331	33.03%
Land Occupied for Non-Family Agriculturalists	1,381,751	47.73%
Unoccupied Public Lands	88,359	3.05%
Biological Reserve and Other Protected Areas	259,752	8.97%
Indigenous Areas	177,146	6.12%
Industrial Centers, Army Property	9,168	0.32%
City Areas	8,956	0.31%
Inundated Zones	13,458	0.46%
	2,894,921	100.00%

Source: Laboratório Sócio-Agronômico do Tocantins — LASAT, 1998.

Due to its pioneer history under 'modern' development initiatives in the Amazon, Marabá region today presents a typical example of consequences characterized by unscrupulous development replacing forest coverage with unsustainable cropping and cattle raising, that led to great extension of degraded landscape predominantly with abandoned pastures. During the 1970s and the

1980s conversion of natural forest into agricultural land by colonist farmers progressed. Significant influx of migrants occurred during this period to the interior of the Pará state that sought for land to cultivate. Many came from the neighboring state of Maranhão.

Cattle ranch development and rudimentary slash-and-burn agriculture with unfamiliar farming techniques left with large expansion of cleared and degraded lands. Although in 1973 97% of the region was covered with primary forest, the coverage was reduced to 67% in 1993 (*ibid*). In terms of land use strategies, many small-scale colonists in the region sought for becoming ranchers by introducing cattle in their small tenure property of the size up to 100 ha. Developing cattle pasture in the Amazon met with fierce criticism from scientists as intolerable and unsustainable land use (Fearnside, 1980, 1988a, 1999; Browder, 1988; Hecht *et al.*, 1988). In recent years however, some researchers have cautiously endorsed and recognized lucrative aspects of extensive pasture development in the eastern Amazon (Mattos, M. and Uhl, C., 1994; Arima, E. and Uhl, C., 1996). Yet, cattle pasture within small property tended to become less extensive, hence not economically viable according to experiences among the small farmers. Initial investment capital and high maintenance costs were often beyond subsistence farmers' financial capability, with minimal returns obtained from small ranch establishments.

Based on such past experiences, new ventures started to emerge among small farmers in their land use. They embarked on introducing various types of agroforestry systems as an alternative land use strategy. The strategy included crop mixing of annual and perennial crops (EMBRAPA-CPATU, 1991; REBRAF, 1996). In the state of Pará, preceding examples existed in the municipality of Tomé-Açu since the 1970s by Japanese migrant farmers (Subler, S. and Uhl, C., 1990; Yamada, 1999), as well as in Santarém where agroforestry was introduced on experimental basis as a promising self-sustaining method (Marques, L. C. T. *et al.*, 1993). Introducing perennial tree crops included planting a variety of fruit-bearing trees, palm species and commercial timber species. In addition to tree cover with diverse species, minimal inputs of nutrients and energy were noted as a key element (Fearnside, 1988b). The following will review and analyze such new land use trend initiated by small farmers in Marabá region.

Communities Profile

Community Murumuru is one of the districts in the municipality of Marabá, located 38 km to the north of the center city. The district was formed in 1974 and had a population of 1,900. Local farmers were organized into the Association of Rural Producers in Murumuru created in 1987 and the membership totaled 120 families[4]. Community Deserto is situated 17 km further inward from Murumuru community along one of the feeder roads extending from the Pará state highway. The community was officially created in 1985 following a process of spontaneous settlement of small

4 The population and the Association members were as of April 1999 when the field study was conducted.

farmers invading the *fazenda* of 3,000 hectares. The settlers became *posseiros* — recognized land occupants without official land title. Small farmer comprised of 30 households successfully organized themselves into the Association of Agro-extractivist in Lago de Deserto in 1993, establishing the first tree nursery in the community. Starting in 1994, the Association initiated planting fruit and forest trees within members' plots based on agroforestry systems. Six households in Deserto became the PED — Decentralized Execution Project (PED) — participants, as discussed later. Further, a small fund of R $ 44,000 during two years was available for the community targeting 30 households under the execution of Demonstration Project (PDA) in the Amazon Pilot Program financed by G7 countries (PPG7). The fund assisted with the establishment of tree nurseries and vegetable gardens, in addition to payroll of management personnel. Community Piquiá is located 40 km southward from Marabá city center along the Pará state highway, and 5 km further inward along the feeder road. The community was formally established in 1988 and had 250 families with the population of 1,600[5]. The area occupied by the community area was a former state-owned property invaded by *posseiros*.

Main Agents Involved with Sustainable Family Agriculture

Rural Workers' Unions

Small farmers and rural workers in Brazil normally organize themselves into innumerous Rural Workers' Unions (STR), which become principal rural agents involved with initiatives for upliftment of living conditions. In the Marabá municipality the Rural Workers' Union was formed in 1980 and had 7,500 members at the time of the field survey. The Union's objective was to promote 1) agrarian reform in the region, 2) environmentally conscious farming systems, and 3) commercialization of products. Regarding 2), the Union took various initiatives. In 1994 the Union initiated actions towards recuperation of degraded areas through planting perennial crops.

Agro-Environmental Center of Tocantins (CAT)

Cattle pasture progressively transformed traditional landscape in Marabá since the 1970s, intensifying land concentration among large-scale proprietors. This brought about land conflicts accompanied by violence. In the late 1980s social movements by landless groups expanded, successfully organizing Rural Workers' Unions (STR) in the region. The organization of the STR further materialized a land reform extending 300,000 ha in 1988, and created a group of small-scale landowners. The need arose for productive farming systems within their properties. The Unions searched for technical assistance from the Pará state Secretary of Agriculture (SAGRI) with no avail. Scholars from the Federal University of Pará (UFPA) and research institutions organized a series of seminars and workshops on sustainable farming systems.

Consequently the Agro-Environmental Center of Tocantins (CAT) was established initially as one of the programs administered by the Environment Study Center (NEA) of the Federal University of Pará (UFPA). CAT activities included research and training for support and pro-

5 The data on membership of all organizations were as of April 1999 when the field study was conducted.

motion of sustainable family agriculture, as well as undertaking concrete demonstration projects on introducing agroforestry systems. Training and visits (T&A) approaches to agroforestry farms and tree nurseries gradually convinced farmers in transforming rudimentary slash-and-burn agriculture.

CAT's collaborative partners included the Federal University of Pará (UFPA) and the Pará state government agencies such as Secretary for Science Technology and Environment (SECTAM) and Secretary of Agriculture (SEAGRI). Further, it developed overseas partnerships with research institutions and donors, including those from France, Belgium and U. K. For example, the U. K.'s international development agency (DFID) collaborated with a small-farmer support project in the amount of £1.2 million during three years since 1996. The project supported 76 locally organized small-farmer groups involved with environmental and development activities of their needs and interests, such as establishment of tree nursery, introduction of apiculture, fire prevention and nutrition improvement. Small farmers in the region further established in 1988 the Foundation for Agriculture in Tocantins-Araguaia (FATA), which became an administration body of CAT. The FATA's general assembly members consisted of representatives from six rural workers' unions established in each municipality of Marabá region.

Tocantins-Araguaia Farmers Cooperative (COCAT)

Tocantins Araguaia Farmers Cooperative (COCAT) was established in 1992 to promote commercialization of agricultural products harvested by small farmers without intermediaries, thereby attaining better agricultural revenues. In April 1999 small farming households from 74 communities representing 6 municipalities were participants to COCAT, totaling 913 members. The members were obliged first to associate themselves with the region's rural workers' unions. The COCAT aimed at dealing in all harvested produce to be collected and commercialized. Principal commercialized products included upland rice and fruit kinds such as cupuaçu (*Theobroma grandiflorum*) and açaí palm (*Euterpe oleracea* Mart.). Feijão beans and black peppers were also among the products COCAT attempted to distribute by themselves.

COCAT established a fruit processing plant capable of processing 800–1,000 kilos per day of various kinds, such as cupuaçu, açaí palm, acerola (*Malpighia glabra*), guava (*Psidium guayava*), passion fruit (*Passiflora edulis*), cajá (*Spondias mombin* L.), and muritί palm (*Mauritia flexuosa*). These fruits were processed into frozen pulp and directly shipped to domestic markets in southeastern and northeastern regions of the country. Like CAT, COCAT was assisted by foreign aid agencies. The DFID of the U. K. provided technical as well as managerial assistance by sending technical experts on agricultural technology and organizational management. Germany also provided technical assistance through Brazilian NGO — FASE — on data management and organizational administration.

Laboratory of Socio-Agronomy of Tocantins (LASAT)

With the objective of conducting research for promoting family agriculture in Marabá region, the Laboratory of Socio-Agronomy of Tocantins (LASAT) was established in 1988 initially as a research institute subordinate to CAT. LASAT later belonged to Department of Agriculture of the Federal University of Pará (UFPA), which provided professors and researchers for LASAT. The institution was equipped with ten researchers of which four were concurrent professors at the UFPA, while the rest was contracted under collaborative agreement with various foreign institutions.

LASAT research agenda included the following:

1. Production: Includes research on agricultural production such as productivity of rice and perennial crops as well as pastoral and forestry systems.
2. Organization: Includes research on organization of agricultural households for promotion of agroforestry systems and sustainable agriculture.
3. Management of Natural Resources: Includes research on community management of forest and other natural resources. For example, the research involved actual formation of community forest management project to be implemented by small farmers.
4. Agricultural Policies: Conducts research on regional agricultural policies based on organization of varied statistical data and information including satellite imagery data to be used for appropriate land use planning.
5. Processing and Commercialization: Conducts studies necessary for processing and commercialization of agricultural and forest products, such as rice, cupuaçu and Brazil nut.

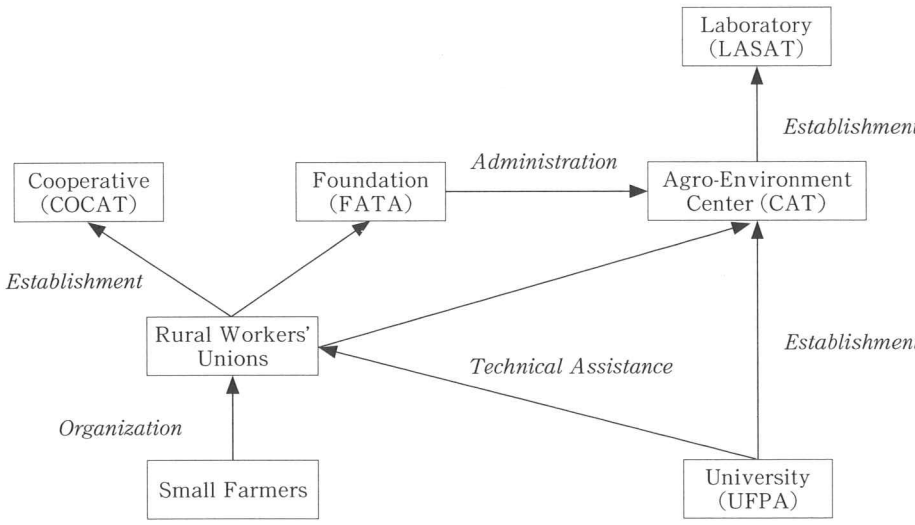


Figure 1. Development of Agents Promoting Sustainable Family Agriculture

As shown in the **Figure 1**, major established agents — the research center (CAT), the foundation (FATA) and the cooperative (COCAT) — were all created to promote sustainable family agriculture by the initiative of regional rural workers' unions in collaboration with the Federal University of Pará (UFPA).

Project Initiatives towards Sustainable Family Agriculture

National Family Agriculture Project (PRONAF)

The National Family Agriculture Program (PRONAF) started in 1997 aiming at upliftment of livelihood for small farmers by promoting family agriculture. It was a renowned national program in Brazil specifically created based on recognition of necessity for attending small farmers needs, and was a reflection of policy initiatives in giving more emphasis on small-scale agriculture. Major function of the PRONAF was to finance small farmers with accessible conditions[6]. Within the Marabá municipality 72 households became initial participants to the program in 1997, and another 72 households were projected to participate in 1999[7]. The program promoted planting perennial crops among small farmers, instead of developing pastures. The PRONAF did not directly involve with environmental conservation. It was directed towards income raising for family agriculture through promotion, for example, of introducing varied perennial crops of commercial value, thereby mitigating deforestation pressures. Piquiá was one of the participant communities and the program started in 1998 on an experimental basis. Material assistance included distribution of seedlings of various fruit and forest species, as well as provision of basic agricultural equipment and machinery.

Decentralized Execution Project (PED)

Decentralized Execution Project (PED) administered by the Ministry of Environment, Hydro Resources and the Legal Amazon (referred to as the Ministry of Environment or MMA) with the World Bank financing. The PED was carried out under the National Environment Program, and in the Amazon it aimed at restoring degraded areas. The PED introduced experimental model projects to be executed in a decentralized and participatory model through partnerships among federal, state and municipal government agencies. In Pará, the Secretary of Science Technology and Environment (SECTAM) assumed a coordination role, creating the PED Coordination Unit (UCE/PED) in July 1995. SECTAM and involved municipalities, research institutions and NGOs discussed ways for implementation and participation to the project, which prioritized restoration of degraded areas as a principal concern. These discussions screened 15 project proposals from 32 municipalities. All of the 15 proposed projects included activity components for restoring degraded areas and introducing agroforestry systems, aiming at combating the deforestation, the exodus of rural population to urban areas and income raising. In addition, they stressed the

6 For example, the participants to the PRONAF in the studied community of Deserto received funds with a grace period of 4 years with interest rate of 4 % per annum.

7 As of April 1999 when the field study was conducted.

importance of community organization, education for environmental conservation and health care. Through the screening process, 6 were selected involving municipalities of Santa Barbara do Pará, Abaetetuba, Irituia, Marabá, Ponta de Pedras and Uruará (SECTAM, 1996).

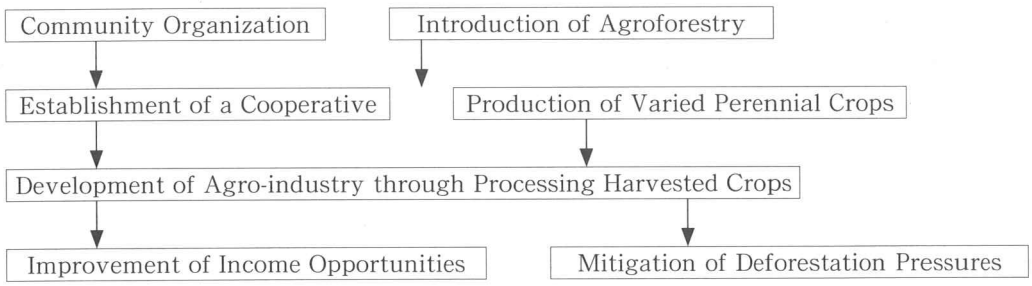
PED Project in Southeastern Pará State

The southeastern Pará involving Marabá region was included as one of the PED projects sites. The designing of the PED project started in 1997. The project budget for the region was R$ 1.14 million, of which 70% (R$ 798,000) was provided by the World Bank financing through the Ministry of Environment (MMA). Of the remaining 30%, the 10% and 20% were burdened by the Pará state and six municipalities, respectively. The project sites were located in eight municipalities covering five micro-regions, as shown in the **Table 2** (PED, 1996).

Table 2. PED Project Sites in Southeastern Pará

Micro-Region	Municipality
Marabá,	Marabá, Brejo Grande do Araguaia, São João do Araguaia
Parauapebas	Água Azul do Norte
Conceição do Araguaia	Conceição do Araguaia
Redenção	Pau Dárco, Xinguara
Paragominas	Ulianópolis

The objective of the PED project in southeastern Pará was to mitigate ongoing deforestation pressures by introducing new land use techniques. Simultaneously, it aimed at improving income generation opportunities through introduction of agroforestry techniques and collective sales of obtained produce. These aims were conceived to achieve through the following objective components, sequence and structure.



Further, five specific targets were established for each of the above component, as the following.

a. Mitigation of Deforestation Pressures:
   1. Mitigation of deforestation pressure on 10,000-ha virgin forest.
   2. Reduction of forest fires from current 2.0% to 0.5% of the project area.

3. Restoration of a total degraded area of 400 ha through participation of eight communities each recuperating a 25-ha plot by introducing agroforestry systems.

b. Introduction of Agroforestry:

1. Provision of training on agroforestry towards 400 households from eight villages each represented by 25 households.
2. Provision of training and establishment of eight collectively managed vegetable and medicinal plant gardens for each of the eight communities.
3. Production of 60 varied crops for domestic consumption and commercialization.

c. Development of Agro-industry:

1. Construction of three processing plants for agroforestry products.
2. Production of interim and final reports evaluating the project activities.

d. Improvement of Income Opportunity:

1. Creation of 480 direct and 1,920 indirect employment opportunities within the project area.
2. Guaranteeing twice as much a monthly legal salary, totaling 48 legal minimum salaries per year.

e. Community Organization:

1. Provision of environmental education program for awareness raising among eight communities involved with the project.
2. Promotion for exchange of information and experiences among producer organizations.

Initially eight communities representing the above eight municipalities were invited. Yet altogether 11 communities participated during the course of implementing the project. Total restored area reached 460 ha until 1999, surpassing originally planned 400 ha. The model agroforestry plots were planted with various tropical fruit trees including cupuaçu (*Theobroma grandiflorum*), acerola and graviola (*Annona hypoglauca*), mixed with palm species and forest species, such as pupunha palm (*Guilielma speciosa*), açaí palm (*Euterpe oleracea*), andiroba (*Carapa guianensis*) and mahogany (*Swietenia macrophylla*). These perennial crops were interplanted with annual food crops, such as feijão beans (*P. vulgaris* L.), corn (*Zea mays* L.) and banana (*Musa spp.*).

Murumuru was selected as one of the target communities of the Decentralized Execution Project (PED), in which 37 households participated. During the PED implementation in Murumuru, a farmers cooperative was created in July 1998 as a commercialization arm for the existing community association. Under the cooperative's initiative, seedlings of a variety of fruit tree species were introduced to their farm plots, such as cupuaçu, acerola, pupunha, graviola, banana, coconut as well as forest tree species such as mahogany and Ipê (*Tabebuia spp.*), totaling 16,000 seedlings distributed among 22 families. The cooperative had yet to commercialize harvests at the time of the field research. Fruit species were planted in a mixed manner usually by 5 × 5 meters spacing, as illustrated in the following.

coconut × cupuaçu × banana × coconut × cupuaçu × banana
cupuaçu × graviola × cupuaçu × graviola × cupuaçu × graviola
banana × cupuaçu × banana × cupuaçu × banana × cupuaçu

3. Results of Field Study on Selected Communities

Characteristics of the region concerning small farmers' land use and management initiatives by introducing sustainable farming systems were further analyzed based on field study results from 15 households of three selected communities in Murumuru, Deserto and Piquiá. Studied aspects included; 1) family profile, 2) land tenure and land use, 3) harvesting non-timber forest products, 4) agroforestry systems, 5) revenues types, values and analysis.

Family Profile and History of Migration

The average age of the studied household heads was 51.20 years, with an average of 5.07 children. Each household consisted of 5.00 persons. The average residence period in the community was 12.21 years. Official establishment of the three communities was rather recent. While Murumuru was established in 1974, Deserto and Piquiá were established in 1985 and 1988, respectively. On average the studied households in Murumuru were residents of the community during 15.00 years — 60% of the period of the community's 25 years of history. Likewise, average studied household in Deserto and Piquiá were community residents during 12.60 and 9.60 years — equivalent to 90.00% and 87.27% of the period since the official foundation of those communities. Altogether, average residence period of 12.21 years was equivalent to 76.00% of average history of 16.07 years of the three communities. Only one household of the total samples was origin from the state of Pará. All the other households were migrants from other states, of which 64.29% came from Maranhão. The remaining originated from northeastern and central part of Brazil, such as Espirito Santo, Bahía, Pernanbuco, Ceará and Goiás, each represented by one household. For 53.33% of the households, the motivation of migration was directly linked to obtaining land, followed by the motivation for searching improved livelihood in general (33.33%) and family reasons (13.33%).

Land Tenure and Land Use

Average size of land tenure was 57.67 hectares. All but one household had no property title to his land under tenure. They occupied their land as *posseiros*. The largest and the smallest tenure holders had 130 hectares and 15 hectares, respectively. **Table 3** shows the average land use pattern of the above 57.67 hectares. Representing a dominant land use in the region in recent years, a little over half of the land holding, 52.62%, was under pasture, followed by regenerating/secondary forest occupied by 24.93% and primary forest of 15.90%. 3.78 hectares, representing 6.55% of the land holding, were allocated for cultivation and planting.

Table 3. Land Use of the Studied Population in Three Communities in Marabá (in hectare)

Cultivated/ Planted area	%	Pasture	%	Regenerating Stands	%	Primary Forest	%	Total	%
3.78	6.55%	30.34	52.62%	14.38	24.93%	9.17	15.90%	57.67	100.00%

Source: Field Survey conducted in April, 1999.

Harvesting Non-Timber Forest Products

Harvesting non-timber forest products was not common among the studied households, presumably on account of; 1) diminished extension of natural forest, and 2) reduced tradition of forest extractivism among colonist farmers. Where natural forest still remained, wild fruits of cacao (*Theobroma cacao*), cupuaçu, açaí, bacaba (*Oenocarpus bacaba* Mart.), uxi (*Endopleura uchi*), bacuri (*Platonia insignis*), piquiá (*Caryocar villosum*) were harvested. Extraction of medicinal quality was observed for copaíba (*Copaifera langsdorffii* Desf.) and andiroba (*Carapa guianensis*) oils, bark of cedro (*Cedrela odorata*). Wild honey was also extracted for medicinal use. Hunting game included armadillo, agouti and wild deer. Fishing game was usually practiced during the dry season starting in May until November.

Cattle Ranching for Small Farmers

Many subsistence farmers in Marabá sought for cattle pasture as livelihood means. Yet they were increasingly discouraged with unfavorable results due to unfeasible economics. With limited capital access, many interviewed informants discovered the cattle pasture of up to 100 ha not a viable land use option. **Table 4** summarizes the situation of cattle raising among the studied households. All of the 15 households were raising cattle. Average pasture size was 30.34 hectares, accounting for the biggest land use among four categories of land use; cultivated area, pasture, regenerating and primary forest, as seen in **Table 3**. On average, 20.73 heads of cattle were being raised. Raising milk cattle was much more dominant than beef cattle.

Table 4. Cattle Ranching of the Studied Households

# of cattle ranching H.H. (%)	Average Pasture (ha)	Average head	Aver. head per hectare
100.00%	30.34	20.73	0.68

The smallest rancher possessed merely one cow within 2.5 hectares of pasture, while the biggest owner was raising the total 70 heads including leased cattle for creation. On average 0.68 head was raised in a per-hectare pasture. This meant on average 1.47 ha was necessary for raising one cow. The raising ratio varied from 0.18 up to 3.18 heads per hectare. Cattle were often infected with disease, incurring high vaccine and other medical treatment costs. Without scale economics, raising beef as well as milk cows often did not compensate for capital investment in ranch establishment. For example, a kilo of milk was traded at R$ 0.10–0.15 at farmers' gate market, and a

beef cattle at R $ 0.65 per kilo[8], making barely feasible such venture without a large ranch investment to pay for low unit values. Further, in the extensive cattle management system, the established pasture usually had a life span of 10–15 years before abandoned due to decreased carrying capacity. This meant that capital investment and management costs needed to pay off during this period. Cattle ventures by small colonists were made possible through available financing. Yet, they tended to be insolvent, abandoning their ranch to be eventually acquired by large-scale cattle developers. Such experiences led to realize for small farmers the need for introducing alternative land use strategies.

Agroforestry as an Alternative Land Use Strategy

The farming system incorporating varied annual and permanent crops was increasingly recognized as an alternative land use strategy among small farmers. Annual crop kinds also increased. For example, annual crops of feijão beans, cassava (*M. esculenta*) and cotton (*Gossypium*) were introduced where only upland rice used to be planted — a dominant practice among farmers from the Maranhão state. In Deserto, forest tree and palm species including mahogany, ipê (*Tabebuia spp.*) and teak (*Tectona grandis*) were introduced mixed with annual fruit crops such as banana, passion fruit and pineapple (*Ananas comosus*). A challenge for nurturing tree crops was a severe and prolonged dry season of Marabá region during seven months of the year starting in May until November. Although citrus species were relatively resilient to the dry weather, popular forest and fruit species such as mahogany, Brazil nut and cupuaçu were all vulnerable to such conditions.

Table 5 shows a list of forest and fruit-bearing species planted in cultivation plots of the studied households. Altogether 35 kinds of forest and fruit-bearing species were identified. Principal forest species were mahogany, ipê and teak. Major fruit-bearing species included graviola, cupuaçu, coconut, acerola, mango, pupunha palm, orange, banana and coffee. Forest species such as mahogany and ipê and fruit-bearing species such as graviola, cupuaçu, coconut and acerola were planted with the same magnitude of interest. One of the increasingly introduced exotic species was Teak. The seeds cost US $ 20 per kilo. The bad conditions for storage often resulted in poor germination, and a period up to 80 years was projected for a matured timber. The species planted by 2.5 × 3 meters was to be thinned after 12 years of planting.

Table 6 shows spacing methods adopted by small farmers in planting forest and fruit-bearing trees. Altogether 47 cases were gathered for 14 fruit-bearing and four forest tree species. Dominant spacing method for fruit trees was 4 × 4, 5 × 5 and 6 × 5 meters. Forest tree species were usually planted by 10 × 10 meters. These spacing methods were rather extensive among usually adopted agroforestry methods, and might reflect availability of the seedlings.

8 As of April 1999 when the field study was conducted.

Table 5. List of Forest and Fruit-bearing Species Planted by the Studied Households

Popular Name	Scientific Name	# of H.H.	%
1 Graviola	*Annona hypoglauca*	13	35.14%
2 Cupuaçu	*Theobroma grandiflorum*	12	32.43%
3 Coconut	*Cocos nucifera* L.	11	29.73%
4 Mahogany	*Swietenia macrophylla*	11	29.73%
5 Ipê	*Tabebuia spp.*	11	29.73%
6 Acerola	*Malpighia glabra*	10	27.03%
7 Mango	*Mangifera indica* L.	7	18.92%
8 Pupunha palm	*Guilielma speciosa*	7	18.92%
9 Orange	*Citrus sinensio*	7	18.92%
10 Banana	*Musa cocoina*	6	16.22%
11 Coffee	*Coffea rubusta*	6	16.22%
12 Murití palm	*Mauritia flexuosa*	6	16.22%
13 Passion fruit	*Passiflora edulis*	5	13.51%
14 Cajú	*Anacardium occidentale* L.	4	10.81%
15 Teak	*Tectona grandis*	4	10.81%
16 Bilribá	*Rollinia deliciosa*	4	10.81%
17 Pineapple	*Ananas comosus*	3	8.11%
18 Brazil nut	*Bertholletia excelsa*	2	5.41%
19 Jack fruit	*Artocarpus integrifolia* L.	2	5.41%
20 Avocado	*Persea Americana*	2	5.41%
21 Rubber	*Havea brasiliensis*	2	5.41%
22 Açaí palm	*Euterpe oleracea* Mart.	2	5.41%
23 Urucum	*Bixa orelana* L.	2	5.41%
24 Cacao	*Theobroma cacao*	1	2.70%
25 Oil palm	*Elaeis guineensis*	1	2.70%
26 Carambola	*Averrhoa carambola*	1	2.70%
27 Ingá	*Inga belemensis*	1	2.70%
28 Tamarind	*Tamarindus indica*	1	2.70%
29 Olive	*Rhamnidium elaeocarpus*	1	2.70%
30 Guava	*Psidium guayava*	1	2.70%
31 Tangerine	*Citrus reticulata*	1	2.70%
32 Jambu	*Spilanthes acmella*	1	2.70%
33 Siniguela	*Spondias purpuria*	1	2.70%
34 Sugar cane	*Saccharum spp.*	1	2.70%
35 Jacarandá	*Dalbergia spruceana*	1	2.70%
	Total	151	

Source: Field Survey conducted in April, 1999.

Table 6. The Spacing Adopted for Planting Fruit-bearing Trees by the Studied Households (by meters)

Name	5×5	6×6	4×4	8×8	10×10	3×3	5×10	20×20	1×0.5	5×6	7×7	10×15	random	Total
Mango	3	1	1									1	1	7
Graviola	2	2	1				1							6
Acerola		1	3			1								5
Ipê		1		1	2			1						5
Coconut palm	1			2							1			4
Mahogany				1	2			1						4
Banana	1	1		1										3
Orange		1	1							1				3
Pupunha palm	1	1												2
Cashew nut		1												1
Passion fruit							1							1
Pineapple									1					1
Murití palm	1													1
Coffee						1								1
Cupuaçu			1											1
Açaí palm			1											1
Teak					1									1
Total	9	9	8	5	5	2	2	2	1	1	1	1	1	47

Source: Field Survey conducted in April, 1999.

Revenues from Perennial Fruit Crops

Table 7 shows the results of revenues attained from perennial fruit-bearing crops produced by the studied households. A number of observations can be made from the data summarized in the table. Firstly, only several fruit kinds contributed economically to the studied households. Among 35 fruit species commercially planted as illustrated in **Table 5**, seven species or 20.00% generated cash revenues. Two principal species — cupuaçu and banana — comprised 91.66% of all fruits driven revenues of R$ 7,331.50. Secondly, very limited numbers of households were involved with fruit sales. For example, although cupuaçu was planted by all interviewed small farmers, less than a half (42.86%) achieved commercializing the produce. Four out of the remaining six fruit kinds were commercialized by merely two households. While banana was commercialized by only one household, passion fruit, murití palm and Brazil nut were commercialized by additional another household. Further, revenues attained from such fruit sales were rather small. Except for cupuaçu and banana, the revenues from the remaining fruit kinds were rather negligible. On average, the revenue derived from fruit sales was R$ 507.42. The above findings indicated that planting fruit-bearing species as an alternative land use strategy among small farmers was still at rudimentary stage, without bringing about concrete economic benefits as a livelihood means.

Table 7. Revenues from Perennial Fruit Crops of the Studied Households

Fruit Name	Total Revenue of Selling H.H.	No. of Producing H.H. (%)	No. of Samples	No. of Selling H.H. (%)	No. of Samples	Selling H.H. among Producing H.H.	Aver. Revenue of Selling H.H.	Aver. Revenue for Total H.H.
Cupuaçu	3,720.00	100.00%	15	42.86%	14	42.86%	620.00	265.71
Banana	3,000.00	60.00%	15	6.67%	15	11.11%	3,000.00	200.00
Urucum	367.50	13.33%	15	13.33%	15	100.00%	183.75	24.50
Acerola	149.00	80.00%	15	21.43%	14	26.79%	49.67	10.64
Passion fruit	50.00	33.33%	15	7.14%	14	21.43%	50.00	3.57
Muritĺ palm	25.00	33.33%	15	6.67%	15	20.00%	25	1.67
Brazil nut	20.00	13.33%	15	6.67%	15	50.00%	20	1.33
Total	7,331.50	—		—			3,948.42	507.42

Source: Field Survey conducted in April, 1999.

Revenues from Annual Diet Crops

Table 8 is a summary of revenues derived from annual diet crops, including rice, cassava, cassava flour, feijão beans and corn. Rice and cassava constituted a major revenue source, accounting for 91.67% of the total diet crops revenues of R$ 9,174.00. Meanwhile, feijão beans and corn accounted for a minor importance. The average revenue from these crops sales was R$ 834.00. Yet the value was 64.36% larger than that from fruits revenues analyzed in the above.

Table 8. Revenues from Annual Diet Crop Production of the Studied Households

Crop Name	Total Revenue	No. of Selling H.H. (%)	No. of Samples	Aver. Revenue of Selling H.H.	Aver. Revenue for Total H.H.
Rice	4,100.00	90.91%	11	410.00	372.73
Cassava flour	2,950.00	36.36%	11	737.50	268.18
Cassava	1,360.00	36.36%	11	340.00	123.64
Feijão beans	660.00	27.27%	11	220.00	60.00
Corn	104.00	27.27%	11	34.67	9.45
Total	9,174.00	—		1,742.17	834.00

Source: Field Survey conducted in April, 1999.

Revenues from Annual Crops

Table 9 shows study results on revenues derived from annual crops other than diet crops, such as vegetables and annually planted fruit kinds. Altogether six commercialized annual crops were identified, involving at maximum three households equivalent to 16.67% of the households. The breakdown of each produce was not available. Yet the revenues derived from these products amounted to R$ 500, R$ 300 and R$ 200, totaling R$ 1,000 for these households. On average the revenues of R$ 333.33 and R$ 66.67 were gained for the commercializing and the total households.

Table 9. Revenues from Annual Crop Production of the Studied Households

Annual Crop Name	No. of Selling H.H.	%	Total Revenue for Selling H.H.	Aver. Revenue for Selling H.H.	Aver. Revenue for Total H.H.
Watermelon	3	20.00%	—	—	—
Cucumber	3	20.00%	—	—	—
Slipper gourd (maxixi)	3	20.00%	—	—	—
Pumpkin	3	20.00%	—	—	—
Okra	2	13.33%	—	—	—
Tomato	1	6.67%	—	—	—
Total		16.67%	1,000.00	333.33	66.67

Source: Field Survey conducted in April, 1999.

Cattle Ranching and its Revenues

Table 10 shows results of cattle ranching revenues. The revenues were derived from two sources; 1) cattle sales, and 2) milk sales. Only three and one households were selling cattle and milk, respectively. Yet attained revenues were rather significant compared to fruit, diet and annual crops sales. Total revenues from cattle sales were R $ 8,850.00 derived from three commercializing households. Average revenue for cattle sales household amounted to R $ 2,950.00. Meanwhile, the revenue obtained from milk sales by one confirmed household was R $ 1,080.00. These results led to the average revenue for the total households of R $ 590.00 and R $ 72.00 for commercializing cattle and milk, respectively.

Table 10. Revenues from Cattle Ranching of the Studied Households

Total Revenue of Cattle Sales	No. of Selling H.H. (%)	Ave. Revenue for Selling H.H.	Ave. Revenues for Total H.H.	Total Revenue of Milk Sales	No. of Selling H.H. (%)	Ave. Revenues for Total H.H.
8,850.00	20.00%	2,950.00	590.00	1,080.00	6.67%	72.00

Source: Field Survey conducted in April, 1999.

Other Revenue Sources

Table 11 shows results of other revenue sources. They included the revenues from employment both from public and private sectors, the revenues from credit facility, and pension funds. Altogether these revenues amounted to R $ 49,414.00, a half of which was obtained from employment, while revenues from credit facility and pension comprised 31.92% and 18.21%, respectively. Over a half obtained revenues from credit facility. Those households gaining revenues from employment and pension funds occupied 40.00% and 30.77%, respectively.

Table 11. Other Revenue Sources of the Studied Households

	Employment				Credit Facility				Pension		Total	
	Public Service	Private Employm't	Sub-Total	%	FNO[9]	PRONAF	Sub-Total	%	Sub-Total	%		%
R$	19,200	5,440	24,640	49.86%	11,930	3,844	15,774	31.92%	9,000	18.21%	49,414	100.00%
No. of H.H. (%)	26.67%	13.33%	40.00%	—	33.33%	20.00%	53.33%	—	30.77%	—	31.03%	—

Source: Field Survey conducted in April, 1999.

Comparative Revenue Analysis

Table 12 presents the results of comparative revenue analysis. The revenues were derived from two principal sectors; the Production Sector and the Service Sector. The Production Sector further consisted of crops production (annual and perennial crops) and pastoral production (cattle and milk). The Service Sector included employment opportunities. The results are presented in three manners. The Column 1 presents the results of obtained overall revenues of each category. The Column 2 and 3 present the results of average revenue for the households. The Column 2 presents the average value obtained by the total revenues divided by the total number of samples obtained for each category[10]. The Column 3 presents average value obtained by the total revenues divided by the total number of households successful in commercialization and/or employment. According to the column 1, the best earning means among the production sectors was the production of annual crops with the revenue of R$ 10,174 (37.08%), marginally followed by the pastoral production of R$ 9,930 (36.19%). The significant revenue attained from pastoral production endorsed the historical land use strategy among small farmers. Meanwhile, the result also outlined a typical subsistence farmer's profile that the leading revenue source was derived from surplus commercialization of principal diet crops produced predominantly for domestic consumption by household members.

The survey results also highlighted the recent trend of growing revenues from perennial crop production. The sales amounted to R$ 7,331.50, occupying 26.72%. Together with annual crop production sales, the crop production sector revenue reached 63.80%. The finding indicated that

9 FNO is part of a financial assistance system created and administered by the federal government by Law 7827 of 27 September 1989, to be especially applied for the north region of the country. The Law was created under requirement of the Brazilian constitution which established that 3 % of the total Union revenue from industrialized products tax and income tax be used in investments in the productive sectors of the north, northeast and central west regions of the country.
At the time of the survey the credit limit to each household was established for R$ 12,000. Part of the assistance was available through installation of basic agricultural infrastructure and provision of various materials, such as water facility, fertilizer and necessary equipments.

10 Divergent sample numbers for each category led to the percentage results of the Column 2 differed from those appeared in the Column 1.

Table 12. Revenue Analysis on Agriculture, Pasture and Service Sector

	Column 1			Column 2			Column 3		
	Total Revenues	%	%	Aver. Revenue for Total H.H.	Aver. Revenue for Total H.H.	%	Aver. Revenue for Selling/ Employed H.H.	%	%
Annual Crops	10,174.00	37.08%	19.54%	900.67	43.51%	26.88%	2,075.50	20.64%	13.97%
(Diet Crops)	(9,174.00)			(834.00)			(1,742.17)		
(Vegetables/Fruits)	(1,000.00)			(66.67)			(333.33)		
Perennial Crops	7,331.50	26.72%	14.08%	507.43	24.51%	15.15%	3,948.42	39.27%	26.58%
Pasture	9,930.00	36.19%	19.07%	662.00	31.98%	19.76%	4,030.00	40.08%	27.13%
(Cattle)	(8,850.00)			(590.00)			(2,950.00)		
(Milk)	(1,080.00)			(72.00)			(1,080.00)		
Sub Total	27,435.50	100.00%	52.68%	2,070.10	100.00%	61.79%	10,053.92	100.00%	67.69%
Service Sector	24,640.00			1,280.00			4,800.00		
Sub Total	24,640.00	—	47.32%	1,280.00	—	38.21%	4,800.00	—	32.31%
Total	52,075.50	—	100.00%	3,350.10	—	100.00%	14,853.92	—	100.00%

small farmers were gaining the bulk of revenues from their crop production compared to that of pastoral production. Further, to the extent this was the case the tendency towards increased perennial crop production might be coherent to their current land use strategy. Further, the revenue from perennial crops was quite significant in comparison to annual crops and pastoral revenues for those involved in commercialization. As shown in the Column 3, the households successful in commercializing perennial crops gained the average revenue of R $ 3,948. The value surpassed that obtained from the sales of annual crops, reaching almost the same level of the pasture revenue R $ 4,030. The finding indicated that provided perennial crops were harvested for commercialization the planting of such crops could become a powerful income generating means and an economically viable land use option, in addition to bringing about effective soil conservation and other environmental benefits. As far as the Service Sector was concerned, the revenues occupied nearly a half (47.32%) of the total. This signified the importance of employment opportunity as a cash earning strategy among small farmers for whom revenues from surplus production sectors were comparatively limited. Yet, the importance of the Service Sector became significantly reduced from 47.32% to 32.31% among those households involved with commercialization of crops as well as pastoral products.

Model Analysis of Transition in Land Use Strategies

The above revenues analysis reviewed economic effects of adopted land use strategies. It turned out that slash-and-burn agriculture and pasture had nearly an equal importance in generating revenues, followed by the perennial crop production through increasing introduction of agroforestry systems. Although the agroforestry systems accounting for the perennial crop production had yet to generate dominant share in revenues, its productivity was nearly equal to the

pastures among those involved with commercialization, as shown in Column 3 of **Table 12**. Based on such findings, transitions in principal land use strategies were illustrated in **Figure 2**.

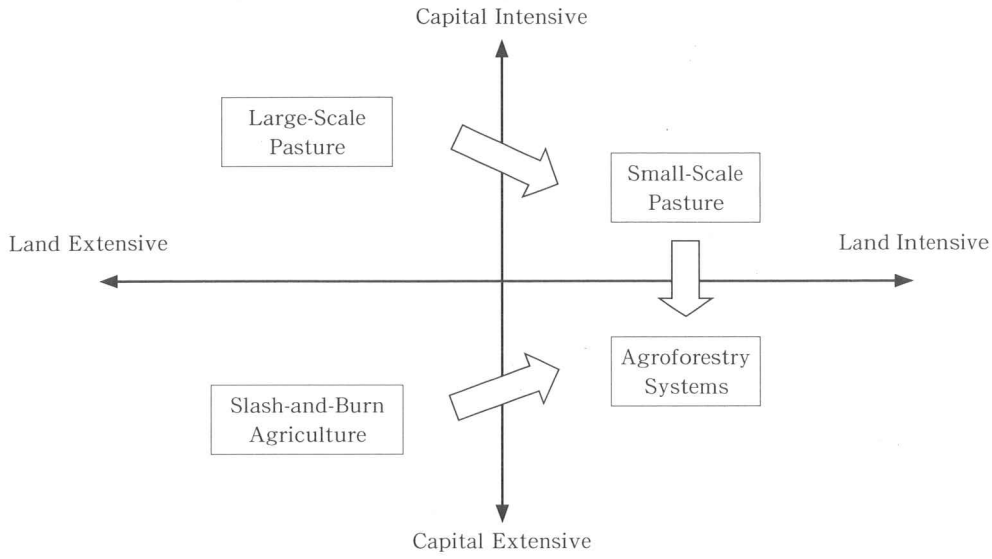


Figure 2. Transitions of Land Use Systems among Small Farmers in Marabá Region

The strategies involved; 1) slash-and-burn for annual crop production, 2) pastures, and 3) agroforestry for mixed production of annual and perennial crops. Small tenure colonists historically attempted to establish pastures as a powerful livelihood means. Extensive pasture establishment may compensate for a required capital investment by benefiting a scale economy. A venture of small-scale pasture did not enjoy such benefits. Instead, a conventional slash-and-burn agriculture was improved by combination of introducing permanent crops and crop mixing. Such strategy involved not much initial capital and yet made the land use more intensive to the extent the per-unit land productivity improved.

The Figure illustrates the transition of land use systems from two typical examples of extensive land use model — a large-scale pasture and a slash-and-burn agriculture — towards new land use initiatives — a small-scale pasture and agroforestry systems. While the former two land use strategies were based on extensive land use, the latter two were introduced within relatively limited tenure properties, obliging to undertake a relatively intensive land use. A small-scale pasture did not require as much capital as a large-scale pasture, yet it turned out beyond the financial capacity for small farmers. Meanwhile, although introducing agroforestry systems required new capital investment, it became less capital intensive than developing a small-scale pasture. It became especially so under various project initiatives, which covered much of the capital investment needs by providing support for tree nursery establishment and seedling production.

Closed-Cycle vs. Open-End Land Use Strategies

Transitions of land use strategies were further examined characterizing common denominators of slash-and-burn agriculture and agroforestry, as opposed to conventional agriculture represented by capital-intensive monoculture plantation. **Table 13-15** and **Figure 3** presented such common denominators and the opposing characteristics of three major agricultural practices: 1) Slash-and-burn agriculture or swidden agriculture; 2) Agroforestry; and 3) Conventional monoculture plantation. **Table 6** presented both swidden agriculture and agroforestry as a closed-cycle land use

Table 13. Agroforestry and Swidden Agriculture as a Closed-Cycle Land Use System

Agroforestry and Swidden Agriculture as a Closed-Cycle Land Use System, to be defined as:
Autonomous, self-sustaining land use system producing a variety of forest as well as agricultural products through a combination of specific space and/or time sequential arrangements, which enables to obtain sustainable return on investment by making maximum use of natural nutrients cycle without degrading the resource base of a land under tenure.

Swidden Agricultre as a Closed-Cycle, Extensive Land Use System

1. **Closed-Cycle Land Use**
   - —Self-sustaining land use system in which nutrients, soil conservation and disease control needs are entirely satisfied by ecological functions of the land under tenure
   - —Making use of organic matters and the nutrient cycle available from human interventions on natural forest and subsequent regeneration process
   - —No inputs of outside capital and consuming goods
     - No inputs of nutrients from chemical fertilizer
     - No inputs of correctives — pesticide/herbicide
     - No inputs of purchased organic fertilizer obtained from agicultural residues and animal dung
2. **Extensive Land Use**
   - —Involving extensive use of land area covering a present cultivated lot as well as fallow lands under rotation cycle
   - —Involving extensive labor input in terms of volume of labor in relation to the size of land under tenure

Agroforestry as a Closed-Cycle, Intensive Land Use System

1. **Closed-Cycle Land Use**
   - —Self-sustaining land use system in which nutrients, soil conservation and disease control needs are effectively satisfied by ecological functions of the land under tenure
   - —Making use of organic matters and the nutrient cycle from the creation of manmade multi-storied forest environment and its management
   - —Low inputs of outside capital and consuming goods compared to conventional monoculture plantation
     - Low inputs of nutrients from chemical fertilizer
     - Low inputs of correctives — pesticide/herbicide
     - Low inputs of purchased organic fertilizer obtained from agicultural residues and animal dung
2. **Intensive Land Use**
   - —Involving intensive use of land of limited size under title or tenure
   - —Involving intensive labor input in terms of volume of labor in relation to the size of land under tenure

Table 14. Swidden Agriculture vs. Agroforestry Systems as Labor/Capital Intensive Production Systems

Swidden Agriculture as a Labor Intensive, Low input/Low output Production System

1. **Inputs**
   - —Labor only
   - —Trained human capital inherited and capacitated with traditional swidden agriculture techniques
   - —Labor input volume is low on relative terms (required labor volume per size of the total area under tenure including the fallow land is low), but may be high on absolute terms due to hard labor necessary for forest clearing, land preparation, planting and harvesting
   - —No financial capital inputs — natural and regenerated forest system as an initial and working capital for nutrient requirements, soil conservation and disease control
     - Nutrients — making use of nutrients stored in the biomass through slash-and-burn followed by natural regeneration
     - Soil conservation — limited period of land use of a cleared land, involving intercropping between residual stands and top soil conservation techniques
     - Disease control — limited period of cropping, benefitting from crop mixing and biodiversity of adjacent natural forest

2. **Outputs**
   - —Low harvest volume per cultivated plot
   - —Low harvest volume per size of the land under rotation cycle
   - —Sustained harvesting yield under appropriate rotation system

Agroforestry as a Capital Intensive, High Input/High Output Production System

1. **Inputs**
   - —Labor and initial financial capital
   - —Trained human capital trained and capacitated with agroforestry techniques
   - —Labor input is high on relative terms (labor input per size of the total area under tenure is high), but may be low on absolute terms due to relatively easy manual labor volume necessary for establishing and managing agroforestry plantations
   - —Financial capital inputs — established manmade multi-storied plantation system as an initial and working capital for nutrient requirements, soil conservation and disease control
     - Initial investment — requires initial investment for creating and managing manmade forest system (seedlings, tree nursery, transportation costs)
     - Nutrients — making use of nutrients stored in the soil and biomass through planting leguminous trees and symbiotic crops
     - Soil conservation — crop mixing, intercropping, coutour cultivation, hedgerow planting to conserve top soil
     - Disease control — creating understory, shades and maximum biodiversity of flora and fauna in the manmade forest eco-system

2. **Outputs**
   - —High harvest volume per cultivated plot
   - —High harvest volume per size of the land under tenure
   - —Sustainable harvesting yield under appropriate management

system to be defined as 'autonomous, self-sustaining land use system producing a variety of forest as well as agricultural products through a combination of specific space and/or time sequential

arrangements, which enables to obtain sustainable return on investment by making maximum use of natural nutrients cycle without degrading the resource base of a land under tenure.'

Table 15. Swidden Agriculture and Agroforestry Systems vs. Conventional Monoculture Farming System

Conventional Monoculture Plantation as an Open-End, Capital Intensive, High Input/High Output Land Use System

1. **Open-End Land Use**
   - —Dependent land use system in which nutrients, soil conservation and disease control needs are principally satisfied by outside inputs of materials
   - —No ecological functions of planted crops are expected by making use of nutrients cycle available from the land under tenure
   - —Inputs of outside capital and consuming goods
     - Inputs of nutrients from chemical fertilizer
     - Inputs of correctives — pesticide/herbicide
     - Inputs of purchased organic fertilizer obtained from agicultural residues and animal dung

2. **Capital Intensive, High Input/High Output Land Use System**

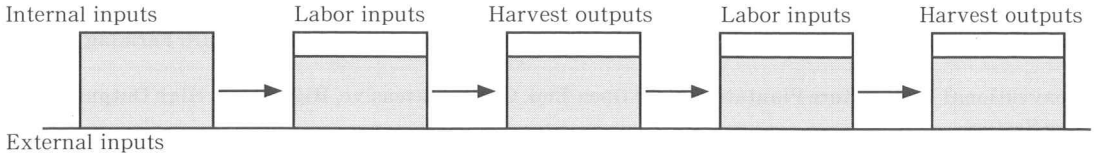
   Inputs
   - —Financial capital and labor
   - —Not required trained and capacitated human capital
   - —Labor input per size of the total area under tenure may be high or low, depending on required labor volume not replaced by machine labor volume necessary for establishing and managing agroforestry plantations
   - —Financial capital inputs — fertilizers, pesticide/herbicide to establish and maintain monoculture plantations for nutrient requirements and disease control
     - Initial investment — requires initial investment for creating and managing monoculture plantation system
     - Nutrients — making use of nutrients available from inputs of chemical and/or organic fertilizers
     - Disease control — application of pesticide/herbicide

   Outputs
   - —High harvest volume per cultivated plot
   - —High harvest volume per size of the land under tenure
   - —Harvesting yield sustained by inputs of outside fertilizers and corrective goods

The difference between the two systems is characterized by intensiveness of land use, labor and capital. Swidden agriculture does not require financial capital investment. Necessary capital for production is provided through natural regeneration and nutrients cycle process, relying on vast forest coverage and a time period sufficient to restore original vegetative cover. Agroforestry, on the other hand, is a compressed replica of such process confined to a limited space and time period. It is an intensive land use model involving initial capital investments for artificially planting and nurturing a variety of economically valuable tree and crop species. Involving initial capital investments, numerous tree and crop species are obtained for a unit of plantation, making agroforestry a high input/output production system compared to swidden agriculture. Therefore, while swidden agriculture is characterized by land extensive, labor intensive land use and low

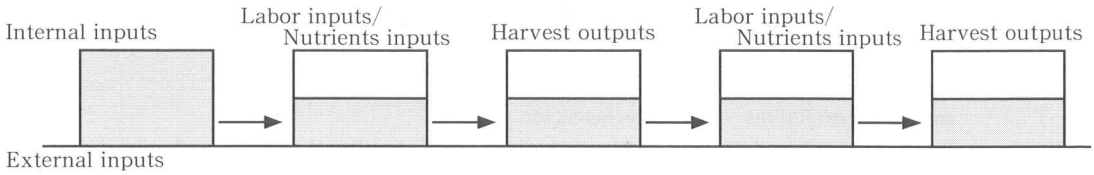
Land Use Model 1 — Swidden Agriculture

= Closed-Cycle, Land Extensive, Labor Intensive, Low Input/Low Output Production Model



Land Use Model 2 — Agroforestry

= Closed-Cycle, Land Intensive, Capital Intensive, High Input/High Output Production Model



Land Use Model 3 — Conventional Monoculture Plantation

= Open-End, Land Intensive, Capital Intensive, High Input/High Output Production Model

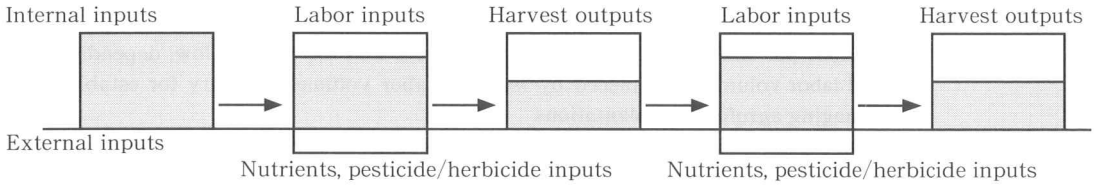


Figure 3. Comparison of Land Use Models — Swidden Agriculture, Agroforestry, and Conventional Monoculture Plantation

input/low output production system, agroforestry in comparison is characterized by land intensive, capital intensive and high input/high output production system. These two systems, however, share distinct common characteristics as being a closed-cycle land use system, as opposed to conventional monoculture plantation, the characteristics of which are outlined in **Table 8**. It is defined as an open-end land use system, which depends on periodical external inputs of nutrients, pesticide/herbicide for disease control. **Figure 3** illustrated and summarized the comparative features of the above three agricultural options.

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