Appropriate agroforestry technologies and extension and their potential to increase the ecological sustainability of swidden-fallow agricultural systems in the sub-humid tropical lowland, dry forest zones of Panama

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Abstract

Swidden-fallow agricultural (SFA) systems (types of slash-and-burn agricultural systems) have been widely studied by researchers from a variety of disciplines over the past 75 years. SFA is a traditional agricultural system that is the primary method of food production for millions of subsistence farmers in the humid tropics. SFA takes many forms and is a complex agricultural system with several interdependent components whose relationships need to be understood using a multi-scalar approach. At a local village-level, these components include SFA technologies and practices, natural resource endowments (including land availability and soil fertility), labor availability, as well as several other socio-economic, ecological, and cultural considerations. This master's thesis explores appropriate agroforestry technologies and appropriate agricultural extension approaches for increasing the ecological sustainability of swidden-fallow agricultural systems in the sub-humid tropical lowland, dry forest zones of Panama. The village of San Jose, a village located in the Province of Veraguas, Panama is described. This includes an in-depth description of the farming systems used by its 123 inhabitants who primarily use SFA as a livelihood strategy. Ways to improve the performance of SFA systems such as the one used by San Jose farmers and to increase their sustainability are also discussed. An assessment, based on several criteria, is conducted of the appropriateness of an agricultural extension programme (PROCESO) implemented in San Jose, administered by the Japan International Cooperation Agency (JICA) and the Ministry of Agricultural Development of Panama (MIDA). Recommendations are made regarding potential improvements and alternatives to the extension approach used by these agencies. These include taking a context-specific, community-based approach to agricultural extension efforts when attempting to maximize the adoption of introduced technologies. In addition, appropriate agricultural technologies must be sensitive to social, cultural, economic, and environmental factors when being developed and introduced. This includes taking a phased approach to the introduction of new technologies rather than attempting to introduce sweeping and revolutionary change.

Résumé

Les systèmes d'agriculture itinérante (des formes de systèmes d’agriculture sur brûlis) ont été étudiés intensément par des chercheurs et chercheuses provenant de nombreuses disciplines dans les dernières 75 années. L’agriculture itinérante est un système d’agriculture traditionnel utilisé en tant que méthode de production majeure par de millions d’agriculteurs de subsistance à travers les tropiques humides. L’agriculture itinérante se pratique sous de nombreuses formes et est un système agricole extrêmement complexe ayant des composants interdépendants nécessitants une analyse à échelles multiples. A l’échelle locale de village, ces composants incluent les technologies et pratiques de l’agriculture itinérante, la dotation des ressources naturelles (incluant la disponibilité de terrains agricoles et la fertilité des sols), la disponibilité de main d’œuvre ou de travailleurs, ainsi que de nombreuses autres considérations socio-économiques, environnementales, et culturelles. Ce mémoire de maîtrise traite sur les technologies agroforestières appropriées ainsi que sur l’extension agricole appropriée, et leurs potentielles pour accroître la durabilité écologique des systèmes d’agriculture itinérante dans les zones forestières sèches des plaines basses des tropiques humides du Panama. San Jose, un village situé dans la province Panaméenne du Veraguas et comptant 123 habitants ayant comme stratégie de subsistance majeure l’agriculture itinérante, est décrit en détail, ainsi que le sont les systèmes agricoles pratiqués par ces habitants. Des approches visant l’amélioration de la performance des systèmes d’agriculture itinérante tel que le système utilisé par les habitants de San Jose ainsi que l’accroissement de la durabilité de ces systèmes-ci, sont aussi abordées dans ce travail. Une évaluation basée sur de nombreux critères est aussi menée sur un programme d’extension agricole (PROCESO) implémenté à San Jose et administré par JICA et MIDA. Aussi, ce mémoire offre-t-il des recommandations vis-à-vis les possibilités d’améliorations et les alternatifs à l’approche d’extension agricole utilisée par ces agences. Ceux-ci inclues de prendre une approche communautaire et contextuelle lors d’entreprendre des activités d’extension agricole afin de maximiser l’adoption de technologies introduites. De plus, les technologies agricoles appropriées doivent être sensible aux facteurs sociaux, culturels, économiques, and écologiques lors de leur développement et introduction. Ceci inclus une approche échelonnée a l’introduction de nouvelles technologies plutôt que d’essayer d’introduire des changements radicaux ou révolutionnaires.

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‘Como siempre, aquí estamos luchando...que siguen luchando mis hermanos y hermanas. Estamos aquí también, luchando a su lado.’

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List of abbreviations and acronyms

AF: Agroforestry

ANR: Accelerated Natural Regeneration

CATAPAN: Catastro de Tierras y Aguas de Panamá

D&D: Diagnosis and Design

ICRAF: International Council for Research in Agroforestry

IDEAS: Institución para el Desarrollo Económico Auto-Sostenible (Sustainable Economic Development Institution)

IDIAP: Instituto de Investigación Agropecuaria de Panamá (Agricultural Research Institute of Panama)

INA: Instituto Nacional de Agricultura (National Agricultural Institute)

JICA: Japan International Cooperation Agency

JOCV: Japan Overseas Cooperation Volunteers

MIDA: Ministerio de Desarollo Agropecuario (Ministry of Agricultural Development, Panamá)

MPTs: Multi-Purpose Trees

NGO: Non-Governmental Organization

NTFPs: Non-Timber Forest Products

ODA: Official Development Assistance

PCVs: Peace Corps Volunteers

PPs: PROCESO Participants

PRA: Participatory Rural Appraisal

PTD: Participatory Technology Development

PROCESO: Proyecto de Capacitación y Extensión Agropecuaria Sostenible (Sustainable Agricultural Training and Extension in Rural Areas of the Republic of Panama Project)

PRONAT: Programa Nacional de Titulación de Tierra (National Land Titling Programme)

NPs: PROCESO Non-Participants

SABA: Slash-and-burn agriculture

SFA: Swidden-fallow agriculture

STRI: Smithsonian Tropical Research Institute

ToT: Transfer of Technology

Glossary of Terms[1]

Agroforestry system: A land-use system in which woody perennials are deliberately used on the same land management unit as agricultural crops, animals or both, either in some form of spatial arrangement or temporal sequence.

Agropastoral system: A land-use system in which crops and livestock (but not trees) are the only components.

Agrosilvicultural system: Agroforestry system for the concurrent production of agricultural crops (including woody perennial crops) and forest crops. Forest crops serve in either a productive or service role. Woody perennial and agricultural crops are chosen first for their productive capacity.

Agrosilvipastoral system: Any agroforestry system that includes trees or shrubs and herbaceous food crops and pastures and animals.

Alley cropping: An agroforestry intercropping system in which species of shrubs or trees are planted at spacings relatively close within row and wide between row, to leave room for herbaceous cropping between, that is, in the 'alleys' (syn: hedgerow intercropping).

Bokashi[2]: (Japanese for "fermented organic matter") is a method of intensive composting. It can use an aerobic or anaerobic inoculation to produce the compost. Once a starter culture is made, it can be re-used. Since the popular introduction of effective microorganisms (EM), Bokashi is commonly made with only molasses, water, EM, and wheat bran. However, Bokashi can be made by inoculating any organic matter with a variety of hosts of beneficial bacteria/microbes. This includes manures, spent mushroom compost, mushroom spores, worm-casting tea, forest soil tea, yeast, pickles, sake, miso, natto, wine and beer. Molasses, the sugary aspects of beer and/or wine, feed the microbial cultures as they inoculate the organic matter.

Bush fallow: The natural vegetation that arises when land is left uncultivated for some time. Composed of small trees, shrubs, grasses and herbaceous plants. Bush fallow may be grazed or browsed and firewood collected from it before it is returned to cultivation.

Cash cropping: Growing crops for sale to a market or to agents, or at the 'farm gate'.

Compost:

1. In plant nursery work, a mixture of inorganic and organic materials, perhaps with some soil of a particular suitable kind, in which seeds can be readily germinated or seedlings or young plants grown. Particular composts are made for particular purposes, and fertilizers are often added.

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[1] Source: (Huxley and van Houten 1997) unless otherwise specified.
[2] Source: http://en.wikipedia.org/wiki/Bokashi

2. A pile of decomposing organic matter of plant or animal origin. Soil and other amendments such as lime, nitrogen and phosphorus may be mixed with organic matter.
3. Organic residues, or a mixture of organic residues and soil that have been made into a pile and allowed to undergo biological decomposition.

Compost Tea[3]: Brewed water extract of compost that contains all of the soluble nutrients that were in the compost.

Contour: Linear demarcation of the land surface that indicates places of equal elevation.

Contour cropping: Sowing a crop in rows or strips so that these follow along a contour.

Crop rotation: The growing of different crops on the same land in recurring succession.

Enriched fallow: A form of agroforestry in which useful, mainly woody species are sown or planted before or when cultivation ceases so that during the fallow period, or when the land is next cleared for cultivation, products are available for household use or market that would not otherwise have been there (e.g. fruits, bamboos, medicinals, etc.).

Erosion: The detachment and movement of the solid material of the land surface by wind, moving water or ice, and by such processes as landslides and soil creep.

Fallow:
1. Allowing crop land to lie idle, tilled or untilled, during the whole or greater portion of a growing season. Tillage is usually practiced to control weeds and encourage storage of soil moisture.
2. Land rested from deliberate cropping, not necessarily without cultivation or grazing but without sowing.
3. State of land left without a crop or weed growth for extended period, often to accumulate moisture.

Green manure:
1. A crop that is grown for soil protection, biological nitrogen reduction, or organic matter and ploughed, disked or hoed into the soil.
2. Any crop grown for the purpose of being turned under while green, or soon after maturity, for soil improvement.

Hedgerow: A barrier of bushes, shrubs or small trees growing close together in a line.

Homegarden: Land-use form on private lands surrounding individual houses with a definite fence, in which several tree species are cultivated together with annual and perennial crops; often with inclusion of small livestock. Many forms exist varying in how intensively they are cultivated and their location with regard to the home.

[3] Source: http://www.soilfoodweb.com.au/index.php?pageid=341

Indigenous: Native to a specified area, not introduced. An indigenous tree grows naturally within a specific environment or within certain predetermined boundaries.

Live fence: A way of establishing a boundary by planting a line of trees and/or shrubs, at relatively close spacing and by fixing wires to them. If animals are to be kept in or out, more uprights (dead sticks) can be tied to the wires. Also called a 'living fence'.

Multipurpose tree: Woody perennial that is purposefully grown to provide more than one significant contribution to the production or service functions (e.g. shelter, shade, land sustainability) of the land-use system that it occupies. Also called 'agroforestry tree'.

Multistorey cropping: Multispecies crop combinations involving both annuals and perennials with an existing stand of perennials. An association of tall perennials with shorter statured crop species.

Multistorey system: An agroforestry system, such as a homegarden, that has a number of plant components of differing stature so that several layers of canopy are formed.

Nitrogen-fixing plant: A plant that can assimilate and fix the free nitrogen of the atmosphere with the aid of bacteria living in root nodules.

Nodule: Nitrogen-fixing root swelling of characteristic shape and size for particular leguminous species that contain rhizobia. If the rhizobial strain is effective, atmospheric nitrogen can be fixed and is readily utilizable by the plant.

Organic farming: The production of crops from land that does not receive and has not received (for a stated period of time) any inorganic inputs (fertilizers, pesticides, etc.).

Permaculture: 'Permanent agriculture'. Design and maintenance of sustainable, ecologically favourable, energy efficient agricultural and horticultural systems. The concept includes not only agroforestry but the integration of organic farming principles and intermediate technology, the use of renewable resources and recycling, the exploitation of biodiversity, conservation and habitat protection, as well as social and institutional well-being. It can be applied to urban as well as rural environments.

Shifting cultivation: Found mainly in the tropics, especially in humid and sub humid regions. There are different kinds; for example, where a settlement is permanent, but certain fields are fallowed and cropped alternately ('rotational agriculture'). In others, whole settlements move and clear new land once the old is no longer productive. Also called 'swidden' (Old English for a 'burnt clearing'), used more to designate the social group, or 'slash-and-burn', so-called because of the operations undergone.

Silviculture: Branch of forestry concerned with methods of raising and growing trees.

Silvopastoral system: Agroforestry system with trees or shrubs, pastures and animals.

Slash-and-burn system:
1. A kind of shifting cultivation in high rainfall areas where the cropping period is followed by a fallow period during which grass, herb, bush or tree growth occurs.
2. Pattern of agriculture in which existing vegetation is cut, stacked and burned to provide space and nutrients for cropping; also called 'swidden' and shifting cultivation.

Smallholder: Usually a farmer who is relatively resource poor, cultivates or keeps animals, or both, on only a small piece of land, sometimes only a small plot. These farmers may or may not have access to other common land.

Soil organic matter: Material found in soil derived from living matter; includes labile and stable forms.

Subsistence farming: Growing crops and, where appropriate, keeping animals so as to provide food, shelter materials, and possibly other products for family use.

Sylvopastoral system: Agroforestry land-use system for concurrent production of trees and animals that graze or browse or both.

Taungya system: Method of raising forest trees in combination with (seasonal) agricultural crops. Used in the early stages of establishing a forest plantation. It not only provides some food but also can lessen the establishment costs.

Windbreak: Group of trees or shrubs in any arrangement that will afford protection from high winds to animals or crops or both.

Introduction, objectives, and organization

1.1 Thesis rationale

Swidden-fallow agriculture (SFA), a form of slash-and-burn agriculture (SABA), is used worldwide by millions of smallholder farmers in the humid tropics[4]. Many studies have described SFA negatively. Lawrence et al. (1998: 1) for example state that several authors (e.g. Myers 1993; Riswan and Hartanti 1996) identify shifting cultivation as the primary cause of deforestation in the tropics. Mertz (2002: 149-152) points to several authors (e.g. Gilruth et al. 1995; Greenland 1975; Juo and Manu 1996; Kleinman et al.1995; Szott et al. 1999) who describe shifting cultivation as necessarily breaking down or becoming unsustainable under population pressure due to the increased frequency and intensity of land use, particularly when associated with shortened fallow periods (Greenland and Okigbo 1983; Ruthenberg 1980; Sanchez 1976).

As a result of SFA being labeled as destructive and unsustainable, agricultural extension and development workers often recommend SFA farmers to abandon SFA and to transition to a more permanent form of agriculture by substituting SFA technologies with alternative ones. The promotion of such alternative technologies is often accompanied by the recommendation to abandon burning as a land clearing technique, a recommendation reinforced by the commonly held view that fire is a necessarily destructive and intrinsically unsustainable component of agricultural systems[5].

The categorical view of burning as unable to be a component of sustainable agricultural systems ignores the historical and contemporary proof that many forms of SFA were sustainable for thousands of years[6], and that “local technical knowledge found in integral swidden societies can contribute to better natural resource management and the development of sustainable agroecological systems” (Warner 1991). This misperception is often due to a lack of discrimination between SFA systems and other types of

[4] See Map 1: Distribution of the humid tropics.

[5] This negative perception of the use of fire in agricultural systems also tends to ignore the integral role fire plays as a natural component of succession in forest and grassland systems.

[6] Slash and burn agriculture has been practiced in Panama since 5000 B.C. (Fischer 1998; Fischer and Vasseur 2000).

agricultural systems which use burning as a land clearing technique[7] (e.g. pioneer farming, cash cropping, plantations, ranching, etc.), or to a lack of acknowledgement of the variety of forms SFA systems can take (Warner, 1991: 14). This misperception is further complicated by many researchers' and agricultural development workers' lack of understanding of fire's potential roles in SFA systems. Development workers and extension agents tend to view burning performed by SFA farmers as serving only to clear forested land for agricultural use. Although this is certainly one of the primary reasons for SFA farmers to burn their fields, there are many others[8]. As noted by Mertz (2002: 149), "the strong resentment by governments [and others] towards shifting cultivation practices has made it difficult to focus on the development of sustainable shifting cultivation systems which may be more environmentally acceptable than permanent farming systems in terms of deforestation, soil erosion, and carbon storage."

Agroforestry (AF) is often promoted as a viable alternative towards a more sustainable form of agriculture in the humid tropics (Nair and Fernandes 1984). Several studies have focused on how to best promote the successful adoption of AF technologies[9] in communities using SFA (Cochran 2003; Fischer 1998; Fischer and Vasseur 2000; Fischer and Vasseur 2002). However, identifying SFA as inherently unsustainable and promoting AF as an alternative meant to replace SFA poses several problems.

1.2 Thesis scope and objectives

In general terms, the primary objectives of this research project are:

- To research ways to assist SFA farmers in improving their agricultural practices, both in terms of improving food security and environmental sustainability.
- For the conditions where sustainable SFA is not viable, to research ways to improve the adoption rates of AF practices by SFA farmers through the

[7] See Fujisaka et al. 1996b and Sunderlin 1997.

[8] The multiple roles of fire as a part of SFA systems will be presented in the section entitled 'Fire as a component of SFA systems'.

[9] For the purposes of this paper, technology will be used to mean "any object, process, idea, or practice that enhances human fulfillment through satisfaction of human needs" (Conteh 2003: 2).

An appropriate technology will refer to one that is "compatible with local [ecological], cultural and economic conditions, and utilizes locally available materials and energy resources, with tools and processes maintained and operationally controlled by the local population". It must be "small scale, energy efficient […] and controlled by the local community, […as well as] simple enough to be maintained by the people using it" (Hazeltine 2003: 1).

improvement of agricultural extension approaches used by agricultural extension agents working in SFA communities.

This study will address how to:

(a) *define* and *classify* SFA systems;

(b) *implement* improvements to SFA systems via specific agricultural extension approaches[10];

(c) *assess* and *improve* the sustainability of SFA systems using an AF approach[11].

These themes will first be presented using relevant scientific literature (including conceptual frameworks and approaches) within the general context of SFA as practiced in the lowland sub-humid tropics of Panama.

These themes will then be addressed within the local, case-specific context of San Jose[12], a rural farming community located in the sub-humid tropical lowland, dry forest zones of the Azuero region in the Veraguas Province of Panama.

More precisely, this paper describes the case of a community in which the sustainability[13] of its agriculture and the likelihood of adoption of AF technologies by SFA farmers may be improved to a greater extent by recommending that SFA farmers make operational and technical adjustments to SFA management practices, rather than that they abandon and replace the SFA system altogether. Such adjustments entail adapting the SFA system to address, among other issues, context-specific ecological constraints to agricultural production potential (i.e. soil fertility and nutrient availability, water availability, weed competition, etc.). Thus, this paper will focus primarily on the ecological production constraints affecting the sustainability of SFA systems. Certain context specific socio-cultural, political, and economic constraints affecting the sustainability of the San Jose

[10] For practical reasons, an in depth assessment of all steps of the agricultural extension project life-cycle (i.e. project design, planning, implementation, monitoring, evaluation, and overall management) will not be performed. Specific aspects of these steps will be discussed within the context of how they can contribute to promoting the ecological sustainability of SFA systems through the transfer of appropriate technologies.

[11] Diagnosis & Design approach developed by the International Centre for Research in Agroforestry (ICRAF).

[12] San Jose is not the actual name of the community in which research was conducted, but is used in this paper as an alias used to protect the identity of study participants.

[13] For the purposes of this paper, sustainable agriculture will be defined (à la NRC 1993: 672-673) as "an agricultural production system in which the farmer increases or maintains productivity at levels that are economically viable, ecologically sound, and culturally acceptable, through the efficient management of resources with minimum damage to the environment or human health."

SFA system will be addressed to help clarify specific ecological production constraints presented herein.

Although a number of agricultural extension projects have been implemented in San Jose by various agricultural extension and rural development agencies, emphasis will be placed on describing and assessing the Sustainable Agricultural Training and Extension in Rural Areas of the Republic of Panama (PROCESO) programme carried out by the Japan International Cooperation Agency (JICA). Specifically, participatory extension approaches and agricultural technologies promoted by JICA in San Jose will be described. Recommendations (based upon farmer survey results) will be made regarding how these extension approaches and technologies could be improved to better target the specific needs of SFA farmers of San Jose.

1.3 Thesis organization

This thesis is organized as follows. Chapter two will be a review and presentation of current approaches proposed in relevant scientific literature on: (1) SFA systems *definitions* and *classifications*, (2) SFA *sustainability assessments*, (3) approaches to *improving* SFA system *sustainability*, and (4) *implementing* specific *AF improvements* to SFA systems.

Chapter three will present the methodologies used to collect and analyze document data, as well as data obtained during interviews with San Jose SFA farmers and JICA extension agents working in San Jose. Chapter four will describe JICA's activities as an organization and those specifically carried out in San Jose. Chapter five will present the study site of San Jose, as well as present and discuss the results and analyses of collected data. This will include a discussion of how the San Jose SFA system can be described and classified using approaches presented in the literature review, as well as of the appropriateness of PROCESO technologies for San Jose farming systems. Chapter six will offer a review of the thesis objectives, while providing final conclusions and recommendations for future research and agricultural extension work in San Jose.

2. Literature Review

2.1 *Introduction to the literature review*

This chapter will present a review of scientific literature on current approaches on: (1) how to *define* and *classify* SFA systems, (2) how to *assess the ecological sustainability* of SFA systems, (3) how to *improve the ecological sustainability* of SFA systems, and (4) how to *implement agroforestry improvements* to SFA systems through the use of *participatory agricultural extension* approaches. This is not an exhaustive review of the literature on these themes, but rather a selection of scientific literature considered relevant for conceptualizing extension approaches to be used by extension agencies targeting beneficiaries in communities similar to San Jose that are engaged in SFA as a primary livelihood strategy.

2.2 Describing slash-and-burn (SABA) and swidden-fallow agricultural (SFA) systems

This section will present proposed definitions and conceptual frameworks of SABA and SFA systems, followed by a presentation of SABA, SFA, and AF classificatory schemes[14].

2.2.1 *Proposed definitions and conceptual frameworks of SABA system*

Slash-and-burn agriculture (SABA) may exhibit a great variety of forms depending on, among other variables, soil conditions, topography, extent of available land, labor, capital, kind of principal crops, and degree of social and political integration (Metzger 2000, Conklin 1961). Weinstock and Sunito (1989: 5) observed that '[e]ven after wading through the plethora of terminology one is confronted with a vast array of definitions of this form of agricultural production, each definition having a different view as to what types of activities should or should not be included'. Because of this, when referring to 'slash-and-burn', one should specify to what exactly one is referring. There is a range of

[14] The San Jose SFA system will be defined and classified using these approaches in chapter 5 entitled "Results and Discussion".

definitions of SABA in the literature. Associated terminology is often unclear and ill-defined. There is, however, increasing recognition of the wide diversity of farming systems that were previously subsumed under the term 'shifting cultivation[15]' (Sunderlin 1997: 6).

SABA is a widespread agricultural system practiced by more than 250 million people in tropical regions (Metzger 2003: 1). Figures such as these, often cited in the literature, include a range of land-uses which incorporate slash-and-burn as a form of clearing vegetative and woody land cover. Such figures do not provide an accurate count of the number of farmers using slash-and-burn as a component of SFA or shifting cultivation. Sunderlin (1997: 4) describes a complete lack of "data that clearly demonstrate the relative proportions of households in each of the three broad categories of farming systems illustrated in the forest farming continuum[16]". Among others, Weinstock and Sunito (1989) have called for a survey of the many farming systems operating under the term 'shifting cultivation'. "Unfortunately", states Sunderlin (1997: 4), "no such survey has been carried out". Sunderlin (1997) goes on to note that "there are still no convincing data on the extent and rate of deforestation, and of the relative importance of different actors[17] in the process of forest cover loss." The definition of deforestation itself lacks specificity and lends to selective interpretation when considering for example whether the term refers to permanent deforestation or also includes the temporary removal of forest cover (Sunderlin and Resosudarmo 1996: 3-5).

A consensus should be reached among academics of various disciplines to clarify and simplify the terminology used in the study of SABA systems. This would provide researchers, policy makers, and natural resources managers among others, with the ability to more accurately describe the systems with which they work, thereby helping to avoid situations such as those described by Sunderlin (1997: 2) in which various proponents in the debate on the extent to which shifting cultivation contributes to deforestation refer to entirely different types of farming systems. For the purposes of this paper, slash-and-burn

[15] The term 'shifting cultivation' is often used synonymously in academic and scientific literature with the term swidden-fallow agriculture, and to a lesser degree with the term slash-and-burn agriculture. A variety of definitions can be found for each of these terms throughout associated literature.

[16] These categories are (1) forest pioneer farming, (2) short fallow shifting cultivation, and (3) long fallow shifting cultivation.

[17] These actors include smallholder farmers ranging from "forest pioneers" to "shifting cultivators" (see Weinstock and Sunito 1989).

will be used to describe the higher-level system which incorporates, as its subsystems, the range of land-uses (e.g., logging, ranching, SFA, etc.) that employ slash-and-burn as an initial form of land clearance and an intermediate step to land-cover conversion (e.g. from forest to annual crop cover, from forest to pasture cover, etc.). Within this framework, SFA will be considered a subsystem of the higher level SABA system. Thus, slash-and-burn will be used in this paper to refer to the mechanical technique of 'slashing' and 'burning' used for land clearance, and not to the intended land use of the cleared plot.

2.2.2 *Proposed definitions and conceptual frameworks of SFA systems*

The term 'shifting cultivation' is often used synonymously with 'swidden-fallow agriculture' in the literature, and is frequently identified as the primary cause of deforestation in the tropics (Lawrence et al. 1998: 1; Riswan and Hartanti 1996; Myers 1993). It would be more appropriate, however, to identify 'slash-and-burn agriculture' rather than 'shifting cultivation' as a major cause of deforestation in the tropics. Relevant institutional bodies'[18] failure to recognize swidden-fallow farmers as different from other 'slash-and-burn' forest users has resulted in low availability of data on the swidden-fallow sub-group. Shifting cultivation has been defined as an agricultural system in which the fields are cleared, usually by fire, and cultivated for shorter periods than they are fallowed (Conklin, 1957). There is a tendency in the literature to associate shifting cultivation with long-fallow, traditional or indigenous swidden-fallow systems (Sunderlin, 1997). Some writers have argued for a restriction of the term to systems involving relatively long fallow periods (Ruthenberg, 1971; Lanly, 1983). However, according to Raintree and Warner (1986), general usage of the term 'shifting cultivation' is often applied to any fallow-based agricultural practice involving the movement of cultivation sites. NRC (1993: 672) defines shifting cultivation as any farming system where land is periodically cleared, cropped, and returned to fallow. More precisely, it considers swidden cultivation (673) to be a *traditional* food-crop production system that

[18] This includes actors (particularly government institutions, international development bodies, academic and scientific research programmes, and NGOs) involved in the study of, the management of, and policymaking influencing swidden-fallow farmers and their practices.

involves partial clearing of vegetation (forest or bush fallow) followed by flash burning and *short-term mixed intercropping*. Emphasis is placed on the fallow period being sufficiently long to allow for soil regeneration and weed suppression, based solely on the restorative properties of *woody* species.

In this paper, SFA will be used to refer to farming systems where vegetative land-cover is periodically cleared by being cut back and burnt off to allow for a swidden[19] plot to be cropped, and then returned to fallow[20]. Emphasis will be placed on swidden-fallow as an agricultural system characterized by cyclical rotations of fallow grounds within a clearly delimited area, as opposed to one that is unbounded in space, nomadic, and invasive (Sunderlin 1997: 6).

SFA systems can therefore be considered sub-systems of SABA. Once an agricultural system has been classified as SFA however, it is important to further describe the system in order to differentiate it among the range of SFA systems that exist. This variability can be described using specific characteristics of the system (such as fallow length, spatial arrangement and composition of crops, degree to which swidden and fallow is managed and the nature of these swidden and fallow management regimes, degree to which traditional (local and/or indigenous) and modern (or conventional) technologies are used, etc.). Hence, more descriptive terminology should be used to describe the specific SFA system under study (e.g. 'extended-fallow, traditional swidden agricultural system', etc.), so as to differentiate it from other SFA systems.

Classificatory schemes[21] are a useful tool to assist in describing SABA and SFA systems. The following section presents Sunderlin's (1997) 'forest farming continuum' and the classification scheme proposed by Fujisaka et al. (1996b). These classification schemes are useful for describing SABA systems. Agroforestry classification schemes (à la Nair 1990) will also be presented, and are appropriate for describing SFA systems.

[19] In this paper, 'swidden' is defined as "a temporary agricultural plot produced by cutting back and burning off vegetative cover" (NRC 1993: 673).

[20] In this paper, 'fallow' is defined as "the period during which land is left to recover its productivity (reduced by cropping) mainly through the accumulation of water, nutrients, attrition of pathogens, or a combination of all three" (NRC 1993: 664).

[21] See Table 1: SABA and SFA classificatory schemes for a list of the main classificatory schemes covered in this paper.

Table 1: Useful SABA and SFA classificatory schemes

Classificatory Scheme	Use	Author(s)
Forest Farming Continuum	SABA	Sunderlin 1997
Four distinguishing variables	SABA	Fujisaka et al. 1996
Agroforestry classification scheme	SFA	Nair 1990

2.2.3 *SABA classificatory schemes*

Several classificatory schemes exist which enable generalized categorizations useful for the purposes of facilitating comparative case study analyses of SFA and more generally in clarifying our understanding of SABA systems. This section will briefly discuss classificatory schemes that have been proposed to group and describe SABA systems. Particular emphasis will be given to the 'forest farming continuum' (Sunderlin 1997) and Fujisaka et al.'s (1996b) classification scheme using four distinguishing variables. Subsequently, the SFA system used by traditional farmers of San Jose will be classified and described using these approaches[22].

As noted by Fujisaka et al. (1996b: 152), most classificatory schemes and lists of descriptive variables of slash-and-burn systems that have been developed have "resulted in either manageable but limited, purpose-specific classifications based on one or two factors or hypothesized systems which consider a range of albeit important variables, but which soon become too unwieldy to apply in the sense of distinguishing among and then grouping cases".

Fujisaka et al. (1996b, 1997) identify and group several classificatory schemes[23] that have been proposed to describe and assess SABA systems, as follows:

- simple contrasts between culturally 'traditional' or 'integral', versus 'non-integral', 'new', or 'partial' systems.
- similarly simple typologies based on one or more usually biophysical factors,

[22] See Chapter 5 entitled "Results and Discussion".
[23] See Table 2 for a list of classificatory systems and their authors.

e.g. durations of cultivation and fallow; fallow length; migratory versus sedentary shifting cultivation patterns; and impacts on vegetation;

- several-stage evolutionary analyses and typologies; and
- descriptions of the diversity of systems within particular localities or regions.

Table 2: Classificatory typologies and their associated literature

Classificatory Typologies	Traditional/integral vs. non-integral/partial systems	Biophysical factors	Several-stage evolutionary analyses and typologies	Descriptions of the diversity of systems within particular localities or regions
Associated literature references	(Conklin, 1954; Spencer, 1966; Watters, 1971)	*length of swidden and fallow periods* (Kundstadter and Chapman, 1978); *fallow length* (Ruthenberg, 1980); *migratory versus sedentary shifting cultivation patterns* (Majid, 1983); and *impacts on vegetation* (Boerboom and Wiersum, 1983)	(Grandstaff, 1978; Greenland, 1974; Margolis, 1977; Norgaard, 1981)	(ASB, 1994; Kartawinata *et al*, 1984; Miracle, 1967; Stocks, 1983).

Source: adapted from Fujisaka and Escobar 1997

Lists of variables are also used to describe SABA systems (Fujisaka et al. 1996b, 1997). Conklin (1954), for example, proposes using principal crops, crop associations and successions, crop-fallow time ratios, livestock, tools and techniques, vegetative cover of cleared land, and climatic and edaphic conditions. Hecht et al. (1995) recommends using crop-fallow time ratios, cropping systems, clearance systems, level of technology, and the allocation and organization of labor.

Fujisaka et al. (1996b: 154) propose a classificatory scheme developed to provide a simple and easily applicable way to compare SABA cases and to provide a relatively small number of useful groupings of SABA systems. Four variables are used to classify SABA systems under this scheme[24]: initial vegetative cover, type of user, final vegetative cover, and fallow length. This classificatory scheme is thereby used to group various land uses, which together make-up what is referred to here as the higher level SABA system.

[24] See Table 3: Fujisaka et al's Four distinguishing variables of SABA systems.

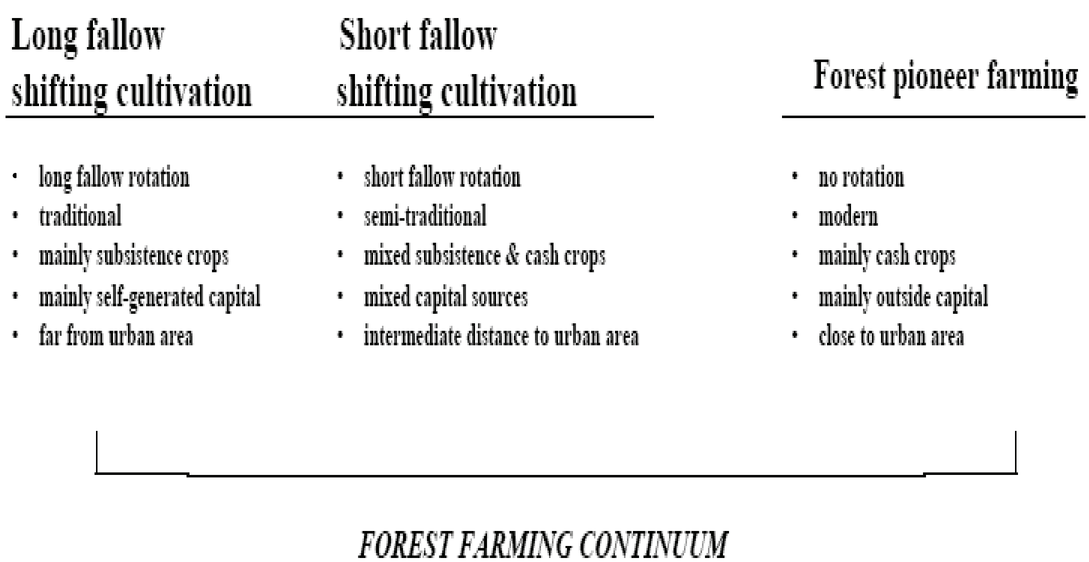
The authors state that 'the desired method should be neither unidimensional or purpose-specific nor a broad list of attributes'. Similarly, Sunderlin (1996, 1997) proposes that slash-and-burn agricultural systems be considered as falling along a 'forest farming continuum'[25] running from traditional shifting cultivation (involving long fallows and long-term forest conservation) at one extreme, and "forest pioneer" cultivation (often involving long-term degradation and deforestation) at the opposite extreme.

Table 3: Fujisaka et al's four distinguishing variables of SABA systems

Distinguishing Variables (by community groups)			
Initial vegetative Cover	**Resource users**	**Final vegetative cover**	**Length of fallow**
• Primary forest • Secondary regrowth, bush fallow, degraded forest, agroforests • Grasslands, pastures, savannas	• Indigenous communities • Government organized colonists (including *taungya* system) • Self-sponsored settlers or ranchers	• Fallows and secondary regrowth • Pastures • Perennial crops and agroforests • Plantation crops and *taungya*	• No fallow or non-cyclical • Short (1-2yrs.) • Medium (3-8yrs.) • Long (>8yrs.)

Adapted from Fujisaka and Escobar 1997

Figure 1: Idealized typology of farming systems on the forest farming continuum



Source: Sunderlin 1997

[25] See Figure 1: Idealized typology of farming systems on the forest farming continuum.

2.2.4 *Swidden-fallow agroforestry systems and classification*

Agroforestry has been defined as an "overall production that combines agricultural crops, tree crops and forest plants and/or animals simultaneously or sequentially, and applies management practices that are compatible with the cultural patterns of the local population" (Bene et al. 1977). As noted by Raintree and Warner (1986), agroforestry[26] has become a major focus in the search for solutions to problems associated with the sustainability of SFA systems. Nair and Fernandes (1984) note that swidden-fallow cultivation is a type of agroforestry system. Here, the authors are referring to the lower-order sub-system of SFA system and not to the higher-order SABA system. Nair (1990: 32-34) offers a clarification of what is meant by the terms "system", "subsystem", and "practice" in AF literature[27]. He states that an *agroforestry system*, as used in the AF literature, corresponds to specific or generalized AF land utilization types, which can be defined and distinguished based on biological, technical, economic, and social characteristics. A *sub-system* in AF literature is said to refer to "a part of a system with a more restricted role, content, and complexity than the system itself". A system can thus be considered to be composed of several subsystems, each producing a defined 'basic need' as its major output, as in a food subsystem. An *agroforestry practice* "usually denotes a specific land management operation of an agroforestry nature on a farm or other management unit". Nair also notes that "several such practices will be involved in the constitution and maintenance of an AF system" and that "these practices commonly include the arrangements of components in space and time vis-a-vis the major functions of the tree component".

"Since shifting cultivation is a type of agroforestry, scientific agroforestry is not so much an 'alternative' to shifting cultivation", as suggested by Nair and Fernandes (1984), but "a systematic approach to the reintegration of its basic elements into more productive,

[26] The term 'agroforestry' will be used to refer to "an approach of integrated land-use that involves deliberate retention or admixture of trees and other woody perennials in crop/animal production fields to benefit from the resultant ecological and economic interactions" (Nair 1985: 98; Raintree 1984; Lundgren 1982).

[27] Hierarchically, the system, the sub-system and the practice form different levels of organization of the components, i.e., a system to consist of several sub-systems and each sub-system to consist of several practices.

sustainable and politically viable forms of land use, under pressure of population and competing uses for land and labor" (Raintree and Warner 1986: 40).

> "The combination of strategic variability and response to the biological, physical and socio-cultural environment creates a wide array of potential swidden agroecosystems. Swiddeners can plant root crops or seed crops or both; fields may be used for 1 - 4 years and have planted fallow or be left with a few root crops remaining; fields may be left to rest for 5, 10, 25 years or virtually forever; fields may range in size from barely a tenth of a hectare to many hectares and be dispersed or contiguous; swidden fields may be used to supplement hunting and fishing, or for supplementary crop production by farmers whose main concern is their permanent fields. This variety and flexibility is the strength of the swidden agroecosystem (Ruddle and Manshard 1981: 74)."

Based on these considerations, a useful approach for describing SFA systems is to frame them within agroforestry classification schemes.

Several agroforestry classificatory schemes have been proposed. Nair's however, is a "logical, simple, pragmatic and purpose oriented approach to the classification of AF systems" (Nair 1985: 97). Nair (1985: 99) states that 'from the point of view of distinguishing and classifying AF Systems, an AF system can be considered as a type of AF land use that is specific to a locality and described according to its biological composition and arrangement, level of technical management, or socio-economic features.

"The classification of agroforestry (AF) systems is necessary in order to provide a framework for evaluating systems and developing action plans for their improvement" (Nair 1985: 97). Nair (1990: 34-35) points out that a classification scheme should: "include a logical way of grouping the major factors on which production of the system will depend; indicate how the system is managed (pointing out possibilities of management interventions to improve the system's efficiency); offer flexibility in re-grouping the information; and be easily understood and readily handled (practical)." As such, "several criteria can be used to classify and group agroforestry systems and practices", the most commonly used being[28]: (1) the system's structure (composition and arrangement of components); (2) its function; (3) the socio-economic scale and level of management; and (4) its ecological spread [or extent]." He suggests that structurally, the

[28] See Table 4: Major approaches in classification of agroforestry systems (and practices).

system can be grouped as agrisilviculture (crops, including tree-shrub crops, and trees), silvopastoral (pasture and/or animals plus trees), or agrosilvipastoral (crops plus pasture and/or animals plus trees)[29]. He goes on to describe that the arrangement of components of agroforestry systems should be considered in both space (spatially) and time (temporally). He describes the functional basis as the main output and role of components, particularly the woody ones. These, he notes, can be productive functions (meeting basic consumption needs) and protective roles (protecting natural resources that promote ecosystem function and services, particularly with regards to the productive potential of land). Identifying the socio-economic scale of production and level of management of the system provides a basis for designating whether the system serves a commercial, 'intermediate', or subsistence purpose. Finally, he notes, that the 'ecological spread' (or ecological physical extent) can be defined by the agro-ecological zone(s) within which the system functions. Of significance is Nair's statement that, with regards to agroforestry systems, "no single classification scheme can be accepted as a universally applicable one." "Therefore, [the] classification of agroforestry systems needs to be purpose-oriented[30]" (Nair 1990: 45).

Table 4: Major approaches in classification of agroforestry systems (and practices)

Categorization of systems (Based on their structure and function)			Grouping of systems (According to their spread and management)	
Structure (Nature and arrangement of components, especially woody ones)		Function (Role and/or output of components, especially woody ones)	Agro-ecological/ environmental adaptability	Socio-economic and management level
Nature of components	Arrangement of components			
Agrisilviculture (crops and trees incl. shrubs/trees and trees) Silvopastoral (pasture/animals and trees) Agrosilvopastoral (crops, pasture/animals and trees) Others (multipurpose tree lots, apiculture with trees, aquaculture with trees, etc.)	*In space* (Spatial) Mixed dense (e.g.: Home garden) Mixed sparce (e.g.: most systems of trees in pastures) Strip (width of strip to be more than one tree) Boundary (trees on edges of plots/fields) *In time* (Temporal) Coincident Concomitant Overlapping Sequential (separate) Interpolated	*Productive function* Food Fodder Fuelwood Other woods Other products *Protective function* Windbreak Shelterbelt Soil conservation Moisture conservation Soil improvement Shade (for crop, animal, and man)	*Systems in/for* Lowland humid tropics Highland humid tropics (above 1,200 m a.s.l; e.g.: Andes, India, Malaysia) Lowland subhumid tropics (e.g.: savanna zone of Africa, Cerrado of South America) Highland subhumid tropics (Tropical highlands) (e.g.: in Kenya, Ethiopia)	*Based on level of technology input* Low input (Marginal) Medium input High input *Based on cost/benefit relations* Commercial Intermediate Subsistence

Source: Nair 1985: 103

[29] Also included are agroforestry systems with additional components such as apiculture, aquaculture, etc.

[30] This does not contradict Fujisaka et al.'s (1996) statement that "the desired method should be neither unidimensional or purpose-specific nor a broad list of attributes, as here Nair is referring to the lower-level system of SFA, whereas Fujisaka et al. (1996) are referring to the higher-level SABA system.

2.3 Managing SFA systems

Once a SFA system has been defined and classified, a "diagnosis and design" (D&D) approach (à la ICRAF; Raintree 1990) can be taken to assess the sustainability of the SFA system within its local context by identifying its constraints, problems, and possible intervention opportunities ('diagnosis'), and then developing and implementing potential appropriate intervention technologies and extension strategies ('design') to address them.

2.3.1 *Assessing the sustainability and constraints of SFA systems and their components*

One of the primary aims of this paper is to identify key components of SFA systems (similar to the one used in San Jose) that may be used to assess and increase[31] their ecological sustainability. A brief discussion on assessing the sustainability of *agricultural systems* will be followed by a more focused discussion on assessing the ecological sustainability of *SFA systems* specifically. The D&D approach will be presented and a discussion on how D&D can be applied to SFA systems will ensue.

2.3.1.1 The sustainability of agricultural systems

"The sustainability [of an agricultural system] at any level of complexity can be based on the sustainability of its components, possible adaptations, or the adaptive response of the key actors at each level in finding and fitting in new components" (Hairiah et al. 2005). In a broad sense, a sustainable agricultural production system can be defined as one in which "the farmer increases or maintains productivity at levels that are economically viable, ecologically sound, and culturally acceptable, through the efficient management of resources with minimum damage to the environment or human health" (NRC 1993: 672). Statements such as this characterize the dynamic and complex nature of farming systems. In simpler terms, for an agricultural system (including AF systems) to be sustainable, all of the components that make up this system (i.e. its practices) must also be sustainable. Practices identified as unsustainable must be adjusted or eliminated from the system, at times being replaced by the introduction of a new practice or by

[31] i.e. in terms of increasing the resilience, resistance, and adaptiveness of the system to exogenous and endogenous factors

intensification in the use of an existing one. Undertaking an assessment of the sustainability of an agricultural system can therefore be a very challenging task. Hairiah et al. (2005: 145) note that it is easier to define what is non-sustainable than it is to say what is sustainable. With the aim of simplifying this objective, some of the main considerations important to performing an assessment of the ecological sustainability of SFA systems[32] will be introduced.

2.3.1.2 The Diagnosis and Design (D&D) approach

Diagnosis and Design (D&D) is "a systematic and objective methodology used to initiate, monitor, and evaluate agroforestry research for development" (Avila and Minae 1992). The basic objectives of D&D are: (1) describing and analyzing existing land use systems; (2) diagnosing their constraints and causal factors; (3) designing appropriate agroforestry technologies; (4) designing appropriate research work; and (5) identifying needs and opportunities for inter-institutional collaboration. This paper is primarily concerned with objectives 1-3, as well as with the use of appropriate[33] extension approaches to transfer appropriate agroforestry technologies to communities using SFA as their primary subsistence-based agricultural production system.

According to Raintree (1990), the D&D approach should be iterative, in that it should allow for the construction of a framework that provides systematic and dependable solutions to AF system constraints by continuously incorporating new and context specific knowledge into decision making frameworks. In this sense, the D&D approach must also be heuristic in nature, providing for an adaptive, multi-scalar, and context specific approach. This multi-scalar approach should consider social, economic, and ecological aspects. Three scales of land use have been considered in D&D: (1) the 'micro-scale'[34], (2) the 'meso-scale' (community/watershed level)[35], and (3) the 'macro-

[32] Particularly of SFA systems similar to the one used in San Jose.
[33] See section entitled: 'Designing appropriate AF technologies and conducting appropriate agricultural extension for SFA systems' for a detailed discussion of what is meant by 'appropriate' agricultural extension.

[34] This includes farm & plot level considerations (in ecological terms) and household level considerations (in social and economic terms).
[35] This includes landscape & ecosystem level approaches (in ecological terms) and small group processes (in social/community terms).

scale' (region/country/ecozone level). Table 5 (Raintree 1987: 225) shows the different ecological and social scales to which the D&D method has been applied. This paper will focus on some of the key ecological aspects of SFA systems at the micro-scale, at both farm and farm plot levels. Certain important meso-scale, landscape-level ecological aspects will also be discussed, as will certain micro-[36] and meso[37]-scale social aspects.

Table 5: Variable scale D&D methods and applications

Scale	Focal system or unit
Micro	Household management unit (e.g. the family farm, household herd, or other elementary land management unit)
Meso	Local community or ecosystem (e.g. a neighbourhood, village or small watershed)
Macro	Region, country, ecozone

Source: Raintree 1987: 225

2.3.1.2.1 Diagnosing constraints, problems, and intervention possibilities for SFA systems

"[The] ability to solve a problem begins with the ability to define it. Often, a clear statement of the problem is all that is needed to suggest [an appropriate] solution" (Raintree 1990: 61). The D&D approach for agroforestry considers whole land use systems, as opposed to simply considering cropping or farming systems. "For D&D purposes, a land use system may be defined as a distinctive combination of three interrelated elements: (1) the land resources exploited by means of (2) a particular technology to satisfy (3) the production objectives of a particular type of land user" (Raintree 1990: 62).

Intrinsic to D&D, is a concern with both sustainability and productivity in its diagnostic scope. D&D is also "explicit and detailed in its concern with technology design in the engineering sense and focuses on connecting with the objectives of the existing land user as a starting point for the assessment of agroforestry related problems and potentials" (Raintree 1990: 61-62). The collection and analysis of all essential information[38] relevant to the process of arriving at an appropriate agroforestry design for a given land use

[36] Household-level
[37] Local community/village-level
[38] See Raintree 1990: 64-65 for information needs and sources for D&D.

system is yet another key component of the D&D methodology (Raintree 1990: 62). According to the D&D methodology (Raintree 1990: 67), agroforestry project planning and implementation occur in five successive (and at times overlapping) stages[39]: (1) a prediagnostic stage, (2) a diagnostic stage, (3) a technology design and evaluation stage, (4) a project planning stage, and (5) a project implementation stage. This paper will touch upon important aspects of all of these stages[40], particularly those aspects this author considers to be key ecological considerations associated with the selection of appropriate AF technologies that are to be transferred via participatory extension projects to communities with ecological, socio-economic, institutional, political, and cultural characteristics similar to those of San Jose. Table 6 shows the basic procedures for community level project planning and implementation at these different methodological stages.

Table 6: Basic Procedures for Community Level Project Planning and Implementation

Stage	Basic Procedures
Prediagnostic	Define and describe land use system under study and select study site
Diagnostic	ID problems, constraints, and leverage points for technological intervention
Technology Design & Evaluation	ID what is needed to improve system performance using iterative design and evaluate alternatives
Project Planning	Develop mode by which to develop/adapt and disseminate system technological improvements within a system's local context
Project Implementation	Implement technology dissemination program using appropriate participatory extension approaches

Adapted from Raintree 1990: 67

2.3.1.2.2 Designing appropriate AF technologies and conducting appropriate agricultural extension for SFA systems

Raintree (1990: 58) notes that agroforestry should be an approach to the development of land management systems that are productive, sustainable, and culturally appropriate. Farmer adoption potential and subsequent diffusion potential for a given technology are

[39] See 'Table 3.2: Basic D&D Procedures for Project Planning and Implementation: Level 1 ' (*in* Raintree 1990:67) for a description of these stages.

[40] However, it is not within the scope of this paper to perform a complete diagnosis and design of the San Jose SFA system.

heavily dependent upon the appropriateness of a technology to its local context. "What is needed is a systematic way, [based on a careful diagnosis], to match agroforestry technologies to the actual needs and potential of existing land use systems [and of local land users]" (Raintree 1990: 61).

Traditional farmers tend to prioritize the production of outputs over the conservation of resources. Therefore, technologies promoted via agricultural extension projects should be presented using the sustainability of production as a lens through which to operationalize conservation objectives in terms of production objectives (Raintree 1990: 58). In addition, as traditional farmers (particularly those with insecure tenure) tend to take a short-term approach to planning natural resources conservation measures, it is recommended that incentives for farmer adoption be built "directly into the production technology itself, as by-products of the conservation practice" (Raintree 1990: 60). Hence, a continuous effort should be made to incorporate attributes of adoptability into the design of new technologies (Raintree 1990: 60). An effective way of achieving this goal is "to involve the intended users directly in the technology development process from the beginning, as active participants in the design, trial, evaluation, and redesign of agroforestry innovations" (Raintree 1990: 61)[41].

In general, land use practices perceived as economically attractive to farmers are those that yield maximum output per unit of land and labor inputs. Several authors (e.g. Boserup 1965; 1981) have noted traditional farmers' sensitivity to increased labor intensity and preference for low labor intensive production systems. As a result, highly labor intensive technologies will tend to have significantly lower farmer adoption rates by farmers operating in low intensity land use systems than by those operating in land use systems of higher intensity. For farmers operating in low intensity land use systems, a phased transfer of technology is recommended when transitioning between land use systems of increasing intensity (Raintree 1990: 77). Thus, the best overall development strategy for an SFA system is incremental improvement rather than complete transformation.

[41] In general, a participatory approach should be taken in all stages of agricultural extension projects and farmer to farmer training should be encouraged. See Cochran's (2003) and Fischer and Vasseur's (2000; 2002) studies for good reviews of the use of these approaches in Panama.

With regards to the aforementioned design considerations, it is also important to consider multipurpose AF production systems and technologies during the D&D technology design stage, when AF technologies to be used in interventions intended to enhance SFA system performance are developed. With regards to fallow management for example, using improved fallow practices to incorporate dual purpose fallow species is recommended. Although adoption of this technology at an early stage of intensification may be based primarily on the perceived economic benefits to the farmer, an early adoption of biologically enriched fallows also serves an ecological purpose as intensification increases (Raintree, 1983a; Raintree and Warner 1986: 47). As is apparent, "the distinction between economically and biologically enriched fallows is not rigid, since the same trees might fulfill both functions" (Raintree and Warner 1986: 47).

2.3.1.3 Diagnosing constraints to the ecological sustainability of SFA systems

According to Raintree and Warner (1986: 39), "it is now widely acknowledged that shifting cultivation, in its more traditional and culturally integrated forms, is an ecologically viable and economically rational form of tropical agriculture as long as population densities are low and fallow periods are long enough to maintain soil fertility". It is important to note that a specific cropping system on an individual swidden plot may be considered unsustainable when considered independently at a specific moment in time. That is, after a period of time soil fertility of a swidden plot may reach a point at which a crop or set of crops can no longer be produced in sufficient quality and/or quantity to make it worthwhile to continue to pursue. In terms of cost-benefit, continued investment in such a strategy would lead to diminishing units produced (output) per unit of input[42] invested (Hairiah et al. 2005). Hairiah et al. (2005) note, however, that when the system considered is swidden-fallow rather than a specific swidden system "the basic resources are maintained from one cycle to the next and allow continued exploitation". Harwood (1996) states however, that "evolving demographics and changing economic, political, and social environments make the traditional, formerly

[42] Agricultural inputs include chemical and organic fertilizers, pesticides, and herbicides; water; physical labor inputs (measurable in man hours or machinery use); as well as any other agricultural input that is in finite supply.

stable systems less and less productive." "Many [SFA] systems, previously existing in ecological balance with their environment, are now breaking down under pressure[43] and something must be done to help them regain a sustained yield path" (Raintree and Warner 1986: 40).

Although it is not within the scope of this study to address all of the numerous factors exogenous to SFA systems that influence ecological constraints, it is clear that socio-economic and demographic constraints[44] cannot be disregarded when assessing the ecological sustainability of SFA systems.

2.3.1.3.1 Household-level economic and demographic considerations

It is not within the scope of this paper to provide an in depth discussion of household considerations regarding the sustainability of swidden-fallow systems. However, what follows is a brief discussion of how certain household level considerations can reduce agricultural production demands on farm land.

Non-farm employment and off-farm income

It is important to determine the percentage of a farming household's basic livelihood needs[45] that are to be derived from on-farm sources (this provides a food production target), and the percentage to be derived from off-farm sources. If off-farm sources of income (both in terms of cash and goods) are substituted for on-farm income sources, resource draw (à la Coomes et al. 2004) and land-productivity requirements can be reduced. The degree of economic reliance on on-farm goods can be quantified by identifying how much of each crop a household needs to harvest to meet its basic subsistence needs. After having calculated the cost[46] of producing these goods and compared it against the cost of purchasing them with income derived from off-farm income sources (including alternative income sources such as remittances), household

[43] In this context, Raintree and Warner are referring to multiple sources of pressure negatively affecting the sustainability of SFA systems. These include: population pressure, economic market pressures, pressure from competing land uses, etc. Several of these sources of pressure shall be addressed in this paper.
[44] …as well as political, institutional, and cultural constraints.
[45] See 'Table 3.6 Potential Functions of Trees and Shrubs in Meeting Basic Needs' (*in* Raintree 1990:87) for a list of basic (food, water, energy/fuel, shelter, raw materials for local industry, cash, savings/investment, and social production) needs that can be met by using appropriate AF technologies in food production systems.
[46] In terms of labor intensity and financial/capital investments

decision makers must decide which livelihood activities are the best investments of labor and capital (cash savings and land) in both the short- and long-term. Reducing the degree of household economic reliance on on-farm income-generating, food-producing activities can be an effective way to lessen the need for reducing fallow length by reducing productivity demands on agricultural land. A drawback to an increased reliance on off-farm sources of income is that those households living at a subsistence level will have to assume the risks associated with a dependence on labor markets[47], may suffer from decreased nutritional benefits of market purchased versus self-grown crops[48], and may become less connected with their surrounding natural resources, thereby potentially losing traditional agricultural and natural resource stewardship knowledge, attitudes, and values. The primary trade-off however, will be a reduction in the risks associated with farming, such as risks of crop or land losses resulting from unfavorable weather conditions (e.g. drought, flood, etc.) or insecure land tenure. Assisting subsistence farmers in developing appropriate strategies to balance these risks by determining an appropriate balance of on-farm & off-farm livelihood activities and market-oriented & subsistence-oriented production strategies and technologies is crucial to reducing poverty in rural areas of developing countries, and should be an objective of appropriate agricultural extension programs working in these regions.

Population Pressure and Intensification

The relationship between population density and agricultural intensification, in particular, has been a major topic of academic study by many social and natural scientists studying agricultural intensification and shifting cultivation. One of the most prominent of these has been Ester Boserup. Boserup (1965; 1981) describes the evolution of tropical land use systems as a function of population pressure on resources (Raintree 1990: 75). According to Boserup (1965; 1981), an increase in population pressure that is not reduced by migration or an increase in the availability of farm land, most often leads to

[47] As well as markets associated with any other off-farm income generating activity they are involved in as a livelihood strategy (e.g. markets for NTFPs, etc.).
[48] This may be a result of decreased diversity and freshness, and higher chemical content of available off-farm food sources as compared to on-farm food sources.

technological changes associated with either: (1) more frequent cropping (or swidden)[49] in the case of SFA systems or (2) more productive[50] permanent plots in the case of permanent agricultural systems. These in turn, however, are most often characterized by lower yields per unit of labor. Raintree (1990: 76) notes that one of the implications of Boserup's theory is that subsistence-oriented farmers[51] will give preference to extensive, low labor-intensive land use options for meeting their production needs over intensive, high labor-intensive strategies, unless population pressure forces them to do otherwise. This theory, according to Raintree (1990: 75), is based on the assumption that "traditional farmers are rational decision makers who will change their land use technology if and when economic circumstances make it rational to do so". Raintree (1990: 75) points out however, that Boserup's theory assumes perfect economic rationality based on an adequate knowledge of technological alternatives. He points to an imperfect knowledge of appropriate technological alternatives and cultural & psychological barriers as potential sources of resistance to change by farmers or of a breakdown in communication between agricultural extensionists and farmers. In these instances the predictive power of Boserup's theory regarding the evolution of tropical land use systems may be compromised (Raintree 1990: 75). Boserup identifies the main stages of agricultural intensification, particularly with regards to subsistence-oriented farmers using non-fossil fuel based agricultural technologies[52]. Table 7 shows the factors that could be used to distinguish between fossil fuel and non-fossil fuel based farming systems. This table shows approximate degrees of technology usages which could be quantified[53] to be more precise.

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[49] (and thereby shorter fallows)
[50] (in terms of increased agricultural output per unit of land)
[51] (as opposed to primarily market-oriented farmers)
[52] Although synthetic/chemical based inputs such as chemical fertilizers, herbicides, and pesticides require the consumption of fossil fuel for their production and therefore have high levels of embodied energy, such inputs used by subsistence farmers in moderate to low levels is not considered as a distinguishing factor between fossil fuel based and non-fossil fuel based agricultural technologies. In this analysis, the distinguishing variables are the degree to which chemical inputs are used (ranging from heavy usage, to moderate usage, to low usage, to no usage) and the degree to which fossil fuel driven machinery is used (ranging from heavy use, to the use of animal driven machinery, to man powered machinery and tools, and finally to no machinery usage).
[53] These could be quantified in relative terms to allow a comparison of levels of specific technology usage within a local context to average usage levels within desired geographical or demographic scales. Alternatively, they could be quantified in absolute terms, allowing for categorization and generalizable definitions of usage levels.

Table 7: Use of fossil fuel based vs. non-fossil fuel based agricultural technologies

Technology	Degree of technology usage	Non-fossil fuel based	Fossil fuel based
Use of chemical/synthetic inputs	Heavy		X
	Moderate	X	
	Low	X	
	None	X	
Use of fossil fuel driven machinery	Heavy		X
	Animal driven	X	
	Man powered	X	
	None	X	

An FAO (1985) paper describes a hypothetical intensification pathway from "planted fallow to intensive multistorey intercropping suitable for maintaining or improving per capita yields on a fixed land base under conditions of population pressure and land shortage." Long-fallow farmers are first forced to become short-fallow farmers to meet basic subsistence needs due to increasing population pressure and/or land shortage. At this stage of intensification, appropriate tree legumes species can be incorporated to improve fallows, thereby increasing and sustaining soil fertility and overall land productivity with a relatively low increase in labor intensity. Once fallow trees (preferably indigenous multi-purpose trees (MPTs)) are incorporated into an SFA system and planted in row crops or other intentionally organized spatial arrangements, decreasing fallow lengths eventually lead to the permanent cultivation of alley crops between hedgerows. As intensification progresses accompanied by increasing labor intensity, increasing amounts of green manures are added to the system as multiple tree stories are allowed to develop and intercropping practices are refined. This stage is referred to as multi-storey intercropping and is considered the final stage of intensification for subsistence, non-fossil fuel based farming in the humid and sub-humid tropics (FAO 1985; Boserup 1981; Raintree 1980; Boserup 1965). Figure 2 shows the agroforestry pathways for swidden intensification. Table 8 shows the generalized nature of the relationships between some of the key determinants of SFA intensification[54].

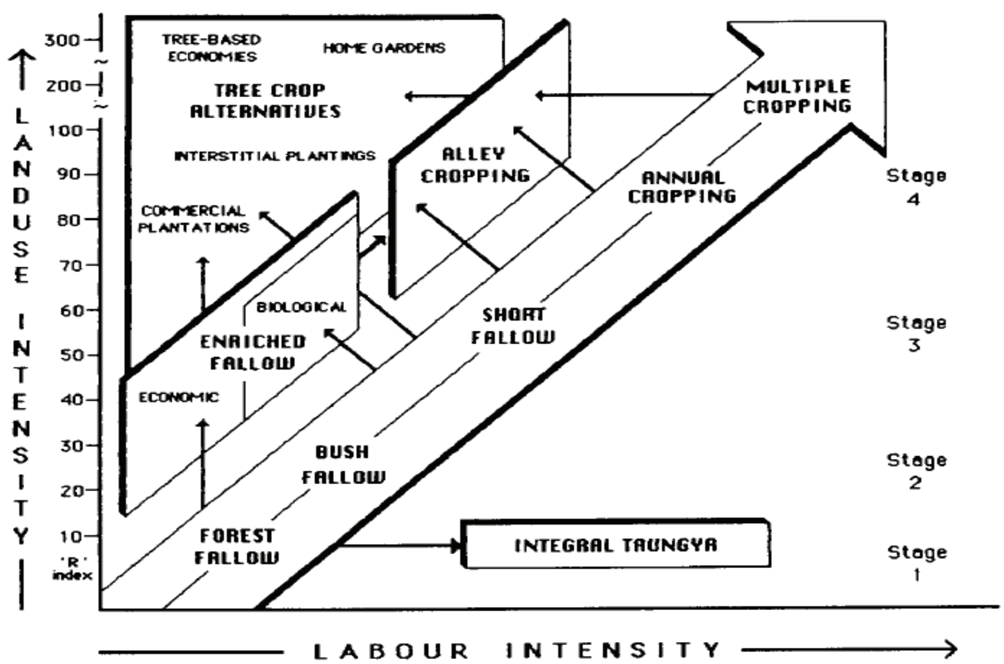
[54]It is not within the scope of this paper to explore these relationships in detail. It is important to note however, that these are in fact generalized relationships and that some contention still remains regarding certain associations that lack empirical evidence (e.g. questioning of the relationship between fallow length

Table 8: Generalized relationships between population pressure and important economic and ecological variables in subsistence based SFA systems

Variables	Increasing Population Pressure	Decreasing Population Pressure
Cropping frequency	+	-
Fallow length	-	+
Soil fertility	-	+
Land use intensity	+	-
Labor intensity	+	-

+ denotes an increase in variable
- denotes a decrease in variable

Figure 2: Agroforestry pathways for swidden intensification



Different agroforestry options open up for different stages in the main historical sequence of agricultural development. The R index (Joosten 1962) shown on the left gives an approximate indication of the land use intensities corresponding to the stages shown on the right. R = (C/C + F) × 100. Where: C = cropping period and F = fallow period. The R index is also equivalent to the percentage of land in cultivation, as read from aerial photos. Boserup's (1981) treatment of R as a 'frequency of cropping' index allows the interpretation to be extended to multiple cropping. For R > 100, R corresponds to the number of crops taken per year × 100. Source: Raintree and Warner 1985: 44.

2.3.1.3.2 Plot- and landscape-level ecological considerations

and crop yields in shifting cultivation; more specifically, questioning that labor productivity will decline with a shortening of fallow length (Mertz 2002: 151)).

Performing a diagnosis of a SFA system can lead to the identification of numerous constraints and problems with the system and several opportunities for intervention by design. A diagnosis of SFA systems should include details as to how ecological constraints manifest themselves physically and spatially, particularly at the plot[55] level but also at the landscape level.

The following sections will focus primarily on identifying[56] important plot-level[57] ecological constraints to the enhanced performance of SFA systems, and on how to address these constraints by suggesting[58] the adoption of specific AF technologies. These sections will focus on some of the major factors endogenous to SFA systems that are associated with these constraints. Three major components of SFA systems will be the focus of the remainder of this chapter: (1) fallow length, (2) soil fertility, and (3) fire ecology. The use of improved fallows as an appropriate intervention technology in SFA systems will also be discussed.

2.3.1.4 Identifying intervention opportunities to address soil fertility loss and shortening fallow lengths

Plot-level considerations

In general terms, Hairiah et al. (2005) identify four ways by which continued farming degrades its own resource base to a level that impairs future productive use of the land: (a) Not maintaining soil of sufficient structure; (b) not balancing the budget of nutrient exports and imports; (c) letting pest, weed, and disease problems reach unmanageable proportions; (d) not maintaining essential soil biota, such as mycorrhizal fungi and *Rhizobium.* The authors go on to point out that threats to water quality and quantity, air quality, and biodiversity are additional considerations that may dominate discussions on agricultural sustainability (Hairiah et al. 2005). Demographic and economic pressures leading to shortened fallow cycles which make nutrient and soil regeneration insufficient to maintain the productivity of traditional swidden-fallow systems is often cited as a major impediment to swidden-fallow sustainability (Harwood 1996, NRC 1993).

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[55] In this paper, plot-level represents the scale of a single contiguous farm plot farmed by an individual farmer or farming household.

[56] Or ‘diagnosing’.

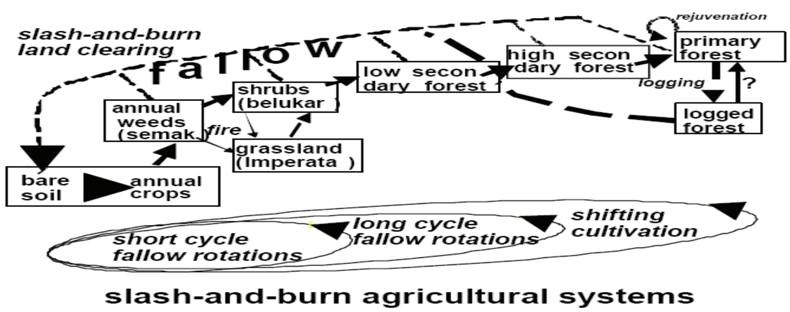
[57] Certain community- and landscape-level considerations will also be addressed.

[58] Or ‘designing’.

When assessing the ecological sustainability of SFA systems similar to the one used in San Jose, fallow length and soil fertility are often identified as the primary ecological and production constraints and components to be adjusted. This is particularly the case for communities such as San Jose that have reached a stage of intensification characterized by relatively[59] short and steadily decreasing fallow lengths, where soil fertility and organic matter content are low. More specifically, one of the first questions to arise is: "What is the minimum ratio of fallow period to cropping period required to maintain soil fertility?" (Metzger 2002). Otherwise said, the sustainability of swidden-fallow depends upon fallow periods allowing for the restoration of organic matter and nutrient losses that occur during the cropping phase (Metzger 2003).

Diaw et al. (2001) discuss how soil fertility changes over time[60] throughout the sequence of land covers[61] that characterize the SFA system. The generalized relationship between soil fertility and fallow succession describes a case in which sufficient fallow length is able to restore soil fertility and production potential over a complete cycle. It does not however account for the variation in soil fertility restoration as a response to natural[62] or human-induced[63] variation in fallow succession rate, composition, or spatial distribution.

Figure 3: Sequence of land covers during fallow and forest succession



Source: Diaw et al. 2001: 4

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[59] The term "relatively" is used here to qualify median fallow length used by San Jose SFA farmers as compared to that used by SFA farmers in surrounding communities. San Jose farmers employ a median fallow length of 3.9 years (see Table 20). Based on this author's personal observation from having visited several other communities throughout Panama and having obtained an approximate estimate of these communities' fallow lengths, San Jose farmers use a relatively short fallow length. In terms of the literature on SFA farmer fallow lengths worldwide, San Jose's median fallow length is also relatively short.

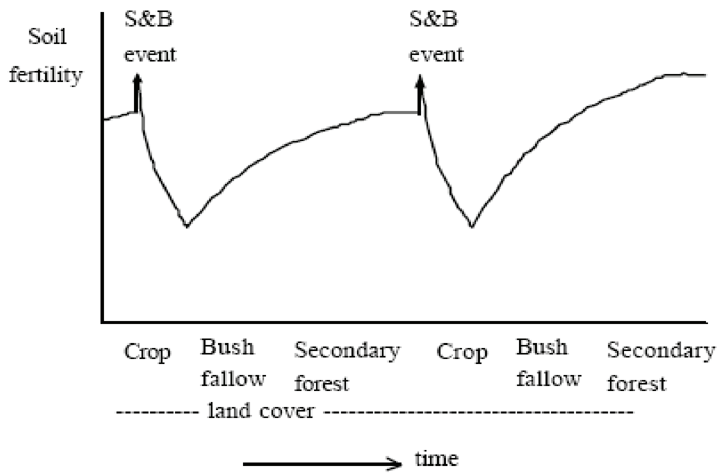
[60] See Figure 4: Soil fertility, land cover, and slash-and-burn agriculture.

[61] See Figure 3: Sequence of land covers during fallow and forest succession.

[62] Plot- and landscape-level natural resource endowments (soil physical, chemical, and biological properties, topography, etc.).

[63] Degree and nature of fallow management.

Figure 4: Soil fertility, land cover, and slash-and-burn agriculture



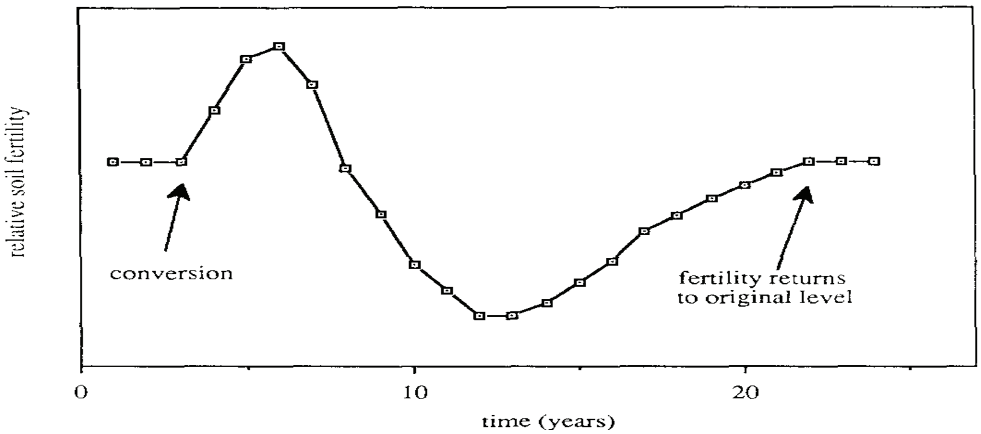
Soil fertility change in sequence of land covers that together form a land use system of 'shifting cultivation'. Here, fallow length is sufficient to restore soil fertility and production potential over a complete cycle. Source: Diaw et al. 2001: 2

Kleinman et al. (1995)[64], show that soil fertility can be restored at varying rates and that soil fertility levels can vary over time on different plots. Upon comparing indigenous traditional swidden-fallow cycles of the Brazilian Amazon, Metzger (2002) states that sustainable conditions could be maintained with 11 years of fallow for each cropping year, while shorter cycles would break down the system if agricultural improvements are not implemented. Others note that, fields fallowed for less than 2 to 3 years for every year they were in production will experience declining soil fertility levels (Metzger 2002, Sanchez 1976, Norman et al. 1984). These figures can be used as general guidelines for minimum recommended length of fallow period. However, local variability should always be considered, particularly since the rate of soil fertility recovery depends largely upon soil properties at the start of the fallow period, the density and composition of vegetative cover during the fallow period, and local climactic factors. Crop types and crop densities planted in the swidden period will also affect soil fertility levels[65].

[64] See Figures 5 and 6.

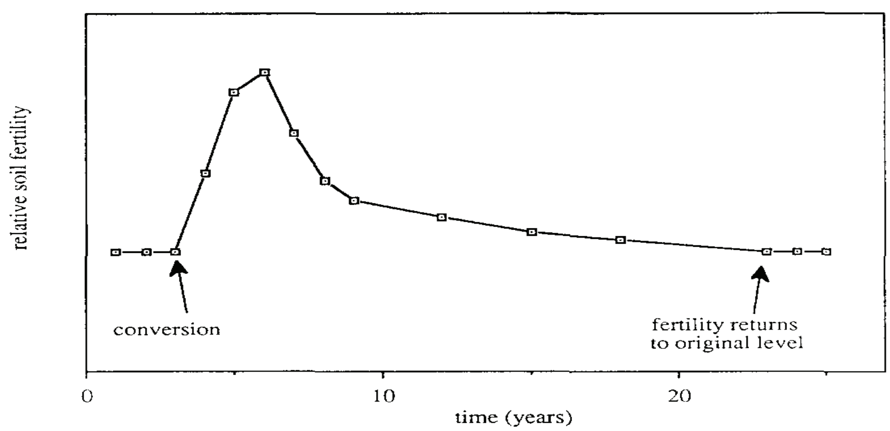
[65] For a detailed description of the decline in fertility under cropping, see (Nye and Greenland 1960: 73).

Figure 5: Projected soil fertility curve for a sustainable system



Source: Kleinman et al. 1995 : 241

Figure 6: Alternative soil fertility curve for a sustainable system



Source: Kleinman et al. 1995: 242

For a given location, the point at which soil fertility levels can no longer support desired crop productivity levels can be informed by results of chemical soil analyses. Such analyses can inform farmers as to approximately when a swidden should be transitioned to fallow, and when a fallow has restored soil fertility to levels which allow for the sustainable production of food crops. Opportunities to perform such analyses however are often extremely limited due to time, financial, and soil analysis service access constraints, both on the part of the farmer as well as the development worker. A way to identify these thresholds more easily and at a lower cost would be by using a series of indicators of soil fertility, such as the presence of certain plant species or the stage of forest succession having been reached. Soil maps can also be of use when available. Plot-level soil assessments can also be conducted by identifying soil properties such as texture and composition[66]. Once this data is collected, it should be corroborated with the farmer of the plot being analyzed. Even if the farmer may not be familiar with scientific terminology used to describe soils, he (or she) will almost always be able to provide a soil technician with useful data. One can then identify an array of suitable crops to be planted based on a plot's soil physical characteristics and soil nutrient availability, thereby assisting farmers in selecting appropriate crops to meet farmer needs.

Landscape- and community-level ecological considerations

In addition to plot-level natural resource constraints to SFA system sustainability, it is important to identify and address landscape- and community-level ecological constraints.

As noted by Raintree (1987: 228), "not all the land use problems experienced by people originate within a single farm, nor can they always be solved by action at the individual household level. Such problems", he states, "may require a larger-than-farm approach both to the diagnosis of problem syndromes and to the design of appropriately scaled solutions." By also considering 'larger-than-farm scale' landscape units, "potential spatial and functional complementarities can be identified within the larger system" (228). As such, at the landscape-level, approaches such as Forest Landscape Restoration[67] (FLR) should be taken. This process "focuses on restoring forest functionality: that is, the goods, services, ecological processes and future options that forests can provide at the broader landscape level as opposed to solely promoting increased tree cover at a particular location" (Maginnis and Jackson 2003: 90). Thus, an approach of "integrated management of all landscape functions in deforested or degraded areas in order to regain ecological integrity and enhance human well-being" can be adopted (Forest Restoration Research Unit 2005: 182).

According to Metzger (2003), a reduction in fallow period leads to landscape homogenization, whereby a large contiguous area of land (or landscape) is composed of

[66] These include field tests such as testing for degree of decomposition of organic soils (using the von Post scale of decomposition) or performing soil texture field tests such as a finger assessment of soil texture (this includes the moist cast test-testing for presence of clay, the ribbon test, feel tests-graininess test-testing for sand, dry feel test-testing for silt and clay in sandy soils, stickiness test, taste test, shine test-testing for clay).

[67] Defined as "a process that aims to regain ecological integrity and enhance human well-being in deforested or degraded forest landscapes" (Maginnis and Jackson 2003).

fewer and fewer land cover types thereby becoming more uniform throughout. Saldarriaga and Uhl (1991) note that "small areas disturbed by slash-and-burn agriculture recover their original species composition, but the time required varies, depending on the intensity and frequency of disturbance in the area. On a large scale, the forest is a mosaic of different aged patches and structural characteristics, with high variability among stands, depending on soils, micro-relief, species composition, and disturbance dynamics." Inter plot dynamics, to a large part determined by landscape-level land-cover composition, are an important factor in fallow succession rates and thereby, soil fertility regeneration rates. Coomes and Burt (1997) point out that "at the community level, the result of multiple field sequencing[68] across households [can be] a rich mosaic of swidden fields, orchards and fallow forest which reflects for many researchers a viable model for more sustainable use of acidic upland soils (Denevan and Padoch, 1988; Padoch et al., 1985; Hiraoka, 1986)." This paper questions the notion that when forests become scarce, an increase in agricultural production can only be obtained by reducing the fallow period (Metzger 2002). A key strategy for improving soil fertility (and thereby agricultural production) without decreasing fallow lengths or converting additional forest to agricultural land is to reduce fallow time needed to restore soil fertility levels by increasing the rate of soil fertility regeneration in swidden-fallow cycles (i.e. through the use of improved fallow and improved swidden practices). The following section describes how fallow management and more specifically the incorporation of multi-purpose trees (MPTs) in improved fallows can be used to increase soil fertility regeneration rates and agricultural productivity at both plot- and landscape-levels.

2.3.1.5 Improved fallows and perennial MPTs as appropriate AF technologies for enhancing SFA systems

Beneficial functions of trees

Managing plots during fallow periods can be very beneficial in both economic (Hairiah et al. 2005) and ecological terms (Unruh 1988). Fallow management "may actually serve to speed soil nutrient recovery and inhibit the spread of exotic weeds and grasses, in

[68] Here, "multiple field sequencing" is meant to describe the practice of rotating the use of farm plots or fields in terms of crop type planted and fallow schedule.

addition to providing a cyclically increasing abundance of valuable fallow plants" (Unruh 1988: 180). It is important to note that if a fallow is to be managed, it must be done in a way which maintains or improves the protective functions of secondary regrowth. This includes woody species' influence in reducing the occurrence of soil compaction and associated erosion and runoff problems that compromise sustainability (Hairiah et al. 2005). Reducing the risk of soil erosion is especially important for swidden-fallow farmers in areas such as San Jose, as their farm plots are often on relatively steep slopes with soils of low organic matter content and low litter cover, as well as being located in an ecological life zone characterized by high intensity rain events with occasional flooding during the rainy season. "One common feature of these findings" notes Young (1987: 283), "is of particular significance: the major contribution of trees to the control of soil erosion is through maintenance of a surface litter cover; and this cover is at the same time a source of organic matter and nutrients for maintenance of soil fertility." "Thus in the design of agroforestry systems, special attention should be given to the maintenance of a surface cover of litter [particularly] during the period of erosive rains and early crop growth, with the combined aims of checking erosion and providing nutrients released through mineralization" (Young 1987: 283).

The restorative properties of trees with respect to soil fertility make their incorporation into SFA systems (as well as into permanent annual cropping systems) a key means by which to address declining soil fertility levels commonly found in tropical environments, resulting from soil-plant cycles of organic matter and nutrients (Young 1987: 281). Young goes on to note that "the corresponding cycles under natural forest or woodland vegetation sustain fertility, as shown by the high initial productivity of newly cleared soils." The primary function of trees in soil productivity and conservation are described as being: (1) maintaining soil organic matter through addition of leaf litter; (2) maintaining nitrogen through fixation by leguminous trees; (3) reducing leaching losses and making the plant-soil nutrient cycle more closed; (4) improving soil physical conditions through maintenance of organic matter and the role of roots; and (5) mitigating soil erosion caused by water and wind (Young 1987: 279)[69].

[69] For a list of functions of agroforestry in soil erosion control see Young 1987 (280). Also, see Table 1 (*in* Young 1987: 282) for a list of processes by which trees maintain or improve soil fertility.

One approach to optimizing the natural succession of forests for farmer benefit and forest health is known as Accelerated (or assisted) Natural Regeneration (ANR) (Forest Restoration Research Unit 2005). ANR can be defined as "management actions to enhance the natural processes of forest succession (regeneration)" (179), including "promoting the natural establishment and subsequent growth of indigenous forest trees, whilst preventing any factors that might harm them (e.g. competition from weeds, browsing by cattle, fire, etc.)" (53). The ANR approach involves no tree planting, but rather optimal stewardship of forest succession.

Improving fallows through the incorporation of trees

A more intensive form of forest regeneration optimization is the incorporation of multi-purpose perennial trees (and other perennial woody vegetation) into fallows. Here, it is important to distinguish between simple reforestation[70] and forest restoration[71]. There have been many proponents for the adoption of "perennial tree crop systems[72] for environments in which annual cropping systems, often based on temperate zone models, are inherently inappropriate and difficult to sustain" (Raintree 1990: 59)[73]. Raintree (1990: 90) notes that:

> as a form of living capital, trees may partially substitute for labor and less accessible forms of capital, making it possible for smallholders to aspire to a more balanced mix of production factors. (…) Tree crops may have the potential to help tropical smallholders achieve a more balanced mix of land, labor, and living capital. (…) The relatively lower labor requirements of tree crop systems (per unit of output) should work for, rather than against their adoption by small farmers.

Others (Young 1987: 278; Nair and Fernandes 1984) note that "apart from demonstrating the soil-improving role of trees, an obvious direct development is to replace natural fallows with planted fallows of fast-growing woody perennials, which might have the potential to restore soil fertility more rapidly and at the same time provide one or more

[70] This involves planting trees to reestablish tree cover of any kind on deforested land, including plantation forestry, agroforestry, community forestry and forest restoration (Forest Restoration Research Unit 2005:185)

[71] Defined as "any activity aimed at reestablishing the forest ecosystem originally present on a deforested site before deforestation occurred; one particular kind of reforestation" (Forest Restoration Research Unit 2005: 182).

[72] Although multi-storey intercropping systems may be a long-term goal, initial goals should be to increase fallow lengths and improve fallows by incorporating perennial MPTs.

[73] See Raintree 1990: 59 for a list of authors with this view.

useful products". The incorporation of perennial, multi-purpose trees (MPTs) through improved fallows is therefore recommended as a key appropriate AF technology to enhance the performance of SFA systems.

Selecting appropriate tree species

Deciding which tree species to select[74] for incorporating into fallows can be accomplished by using a method known as the Framework Species Method (Forest Restoration Research Unit 2005: 65; Goosem and Tucker 1995). This method recommends planting a moderate number of key tree species, which can rapidly reestablish canopy cover and attract seed-dispersing wildlife, to accelerate forest regeneration and biodiversity recovery (Forest Restoration Research Unit 2005: 182). The following are desirable *ecological* characteristics of tree species to be selected for incorporation into improved fallows: (1) being indigenous and non-domesticated[75]; (2) being suited to the local forest habitat and elevation at which they are planted; (3) having high survival and rapid growth rates when planted in deforested sites; (4) having dense broad crowns that shade out herbaceous weeds; (5) being attractive to seed-dispersing wildlife by flowering and fruiting or by offering them some other attractive resource (e.g. habitat); (6) being resilient to fire; (7) being easy to propagate[76] in nurseries using simple techniques; and (8) having large seeds. An appropriate assortment[77] of both pioneer and climax species tree species should be planted, with at least 30% of trees planted being pioneers (Goosem and Tucker 1995).

The following are desirable *economic* characteristics of tree species to be selected for incorporation into improved fallows: (1) being multi-purpose trees (MPTs) which yield non-timber forest products (NTFPs) such as traditional medicines, edible fruits or foliage, fuel-wood, fodder for domestic animals etc.; (2) being low in labor intensity with regards

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[74] See Table 5.1 (*in* Forest Restoration Research Unit 2005: 69) for a summary of information sources for initial selection of candidate framework tree species for assessment.

[75] Being non-domesticated is desirable to increase the chance that such tree species are readily found in the wild and do not require human assistance to survive.

[76] Desirable nursery characteristics of framework tree species include reliable seed availability; rapid and synchronous seed germination, and production of vigorous seedlings of a plantable size in less than 1 year (Forest Restoration Research Unit's 2005: 66).

[77] See Forest Restoration Research Unit's (2005: 103) for recommendations for plantation design and management.

to propagation, planting, maintenance, and harvest; and (3) having a balanced assortment of tree species for meeting both market and subsistence needs.

An identified lack of scientific knowledge exists regarding the publication of lists of framework tree species[78]. Framework tree species must be identified for distinct agroecological zones. To this end, "existing literature and indigenous knowledge can be used to identify candidate framework species, but their ability to perform as such must be confirmed by field trials" (Forest Restoration Research Unit 2005: 72).

Spatial considerations for the ecological enhancement of SFA systems

Unruh (1988: 171) notes that "the single most important impact of management in the fallow cycle is the alteration in the spatial location of foliage within the stand." By selectively cutting (or slashing) vegetation early in the fallow cycle so as to protect valuable[79] plants, upper canopies of managed fallows tend to be reduced and more open than those of unmanaged fallows (Unruh 1988: 171). Furthermore, fallow management practices that promote micro-site heterogeneity play an important role in fallow improvement. The 'patchy' nature of managed fallow "provides an association of successional states which over time constitute a temporally and spatially changing mosaic of microhabitats" (Unruh 1988: 175). An important consideration regarding forest regeneration during fallows is that landscape heterogeneity is desirable as it increases seed fluxes of primary forest species from adjacent secondary forest into secondary regrowth in early fallows (Thomlinson et al. 1996 *in* Metzger 2000).

Several approaches can be used to create more accommodating and productive microsites at the plot-level for these primary forest species to develop more quickly and in turn, improve conditions for further colonization by primary forest species in later fallow successional stages. As stated by Unruh (1988), this process discourages the establishment of exotic, pantropical weeds and grasses such as *imperata*, while encouraging the colonization of local, early successional species. Kellman (1980 in Unruh 1988) states that trees left standing during cutting, and the presence of species

[78] See Goosem and Tucker's (1995) study for a list of framework species for Queensland's tropical rainforests in Australia and the Forest Restoration Research Unit's (2005: 145) study for a list of framework species of the seasonally dry forests of northern Thailand.

[79] Economically or biologically valuable.

involved in the establishment of weed communities in old swiddens can come from three sources: 1) vegetative residuum left at the site; 2) the buried viable seed component[80]; and 3) interfield migration. To avoid the invasion of weed species and instead favor colonization by valuable tree species land use and land cover of plots should be arranged spatially so that they complement one another. This entails for example, ensuring that fallow successional stages of adjacent plots are staggered (i.e. if a plot is being burned to prepare it for swidden cultivation, then the land cover of adjacent plots should ideally be established secondary forest fallow; this increases the chance of colonization of valuable tree species through seed exchange from adjacent plots). Otherwise stated, it is recommended to have a rotation of complementary and heterogeneous successional stages occurring among adjacent plots.

2.3.1.6 Fire as a component of SFA systems

Some of the primary effects of using fire as a component of SFA systems will be presented in this section. Nye and Greenland (1960: 66) describe the initial and sudden changes in the soil that occur when fallow is cleared and burned[81] as being: (1) nitrogen and sulphur loss; (2) effects on microbiological populations; and (3) the development of different microflora than originally present as a result of changes in pH and nutrient availability. Several authors (Young 1987: 278; Nair and Fernandes 1984) note that "[a]dditions of biomass and nutrients to the soil from clearance of forest fallows can be substantial, although C, N and S are largely lost if the felled vegetation is burnt." Burning makes "nutrients available to crops in the form of ash and in highly concentrated amounts immediately after a burn, but drastically reduce[es] the fertility of soils and crop nutrient availability in the long-term. Calcium, potassium and magnesium are lost as fine particles in smoke, whilst nitrogen, phosphorus and sulfur are lost as gases. Soil erosion is increased from 3-32 times, a large amount of beneficial soil micro-organisms are killed,

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[80] Fire resistance of seeds varies among tree species, some being more resistant than others due to physiological differences such as hardness and thickness of shells protecting a seed. The intensity of a fire will also determine the survival rate of many seeds, as will the depth at which a seed may be buried by vegetative matter and/or soil.
[81] For a more detailed description of the effects of clearing and burning, see Nye and Greenland (1960: 66).

especially mycorrhizal fungi and microbes which break down dead organic matter and recycle nutrients" (Forest Restoration Research Unit 2005: 49).

Other potentially negative effects of the use of fire as a component of SFA systems include (Forest Restoration Research Unit 2005: 49):

- a significant reduction in the establishment of trees (usually pioneer species) due to the high mortality of tree saplings as a result of burning (these trees could have served to minimize the establishment of certain weed species through shading as weed species will generally re-grow from root stalks and seeds not destroyed during a burn);
- a reduction in forest regeneration rates due to a reduction in tree seedling density and species richness, which in turn is caused by a reduction in seed rain from seed producing trees and seed accumulation in seed banks;
- the burning off of soil organic matter reducing the soil's moisture retention capacity, resulting in soils drying out much faster during dry periods and thereby creating an inhospitable environment for seed germination; and
- the risk of burns spreading to surrounding areas if uncontrolled or poorly managed or timed.

An additional risk of using fire as a land clearing practice is that it becomes difficult to conduct burns without harming valuable MPTs and perennial trees. However, tree species have varying degrees of fire resistance and given this, useful tree and plant species that are more fire resistant and who have more fire resistant seed can be selected for incorporation into the farm plot. Therefore, in the case of SFA systems at a stage of intensification when fire is still used for clearing vegetation, minimizing damage to MPTs from the use of fire is recommended. Such harm can be minimized by identifying thresholds above or below which fire damage to desirable tree species is minimized. These thresholds[82] can then be used to design management guidelines for when and with

[82] e.g. thresholds for mean stem density, sapling height, tree species diversity (see Forest Restoration Research Unit 2005: 54).

what intensity a prescribed burn should be applied so as to maximize the survival of desirable tree species relative to weed species.

2.3.1.7 Additional appropriate AF technologies for SFA systems

There are several additional AF technologies[83] appropriate to SFA systems which either do not involve the planting of trees or involve plot-level spatial arrangements of trees. These include: the use of leguminous cover crops; the creation of barrier hedges and live and dead vegetative barriers to serve as windbreaks and water and soil retaining barriers; alley cropping and hedgerow intercropping; companion planting; contour cropping; biomass transfer (transport of tree foliage from forests to cropland) in the form of compost and/or mulch; and the production and application of green manures (Young 1987: 280-281). The primary aims of these AF technologies include: reducing soil erosion through the reduction of run-off and wind exposure; maintaining and improving soil fertility levels (both in terms of ensuring adequate nutrient availability and increasing the presence of beneficial micro-organisms) through the application of soil amendments such as compost teas and green manures; increasing water/moisture retention capacity of soils primarily by increasing soil organic matter (SOM) levels (i.e. building soils by introducing compost and mulches as soil amendments and using live and dead vegetative barriers and hedges); attracting pollinators and other beneficial insects and fauna to control pests; etc. The use of such technologies is often a primary component of permaculture and organic agricultural farming systems. Practices such as these were introduced in San Jose via the PROCESO Project and other extension efforts and will be described in greater depth in Chapter 5.

2.3.1.7.1 Alternatives to the use of fire in SFA systems

Buckles et al. (1998) note that "[a]lthough they are not so well known, no-till slash-and-mulch systems, like the velvetbean–maize, have been developed in hillside environments to enhance productivity and sustainability." A no-till slash-and-mulch system involves the "practice of slashing natural or introduced vegetation and using it as a mulch [for crops] (typically without tilling the land)". "Of special interest", note Buckles et al.

[83] See Table 4 (*in* Szott, Palm, and Buresh 1999: 184) for a list of interventions in the crop-fallow cycle intended to conserve soil organic matter and nutrients

(1998), "are systems using legumes as the mulched species, as the N captured by the legume from the air and released through decomposition significantly boosts yields of non-legume crops such as cereals (…). For cash-poor farmers these practices offer a low-cost and ecologically sound solution to key production constraints, including soil erosion, weed invasion, and loss of soil nutrients." "Alternative forms of fallow clearing where large amounts of organic residues and nutrients are added to the soil, such as slash-and-mulch, slash-and-incorporate, and herbicide-and-mulch systems, may help alleviate the negative side effects of slash-and-burn clearing" (Szott, Palm, and Buresh 1999: 186). "Drawbacks to fallow clearing interventions that do not use burning include the reduction in crop yields due to competition by regrowing vegetation with crops, the difficulty of crop operations with large amounts of mulch, and the labor or machinery costs involved with the incorporation of cut-and-mulched or herbicide-killed fallow vegetation" (Szott, Palm, and Buresh 1999: 187). Although it may be appropriate to promote the adoption of slash-and-mulch agricultural systems as medium- or long-term strategies, this approach is not recommended initially[84] for two main reasons: (1) slash-and-mulch systems are generally more labor intensive than SFA systems and (2) recommending the complete abandonment of burning as a land clearing practice to SFA farmers who consider this practice as traditional will likely be met by high levels of resistance by targeted beneficiaries and often leads to low technology adoption levels and low participation levels in extension activities by targeted farmers.

2.3.1.8 Conclusion to literature review

This chapter has presented a review of relevant scientific literature on some of the main approaches as to: (1) how to *define* and *classify* SFA systems, (2) how to *assess the ecological sustainability* of SFA systems, (3) how to *improve the ecological sustainability* of SFA systems, and (4) how to *implement agroforestry improvements* to SFA systems through the use of *participatory agricultural extension* approaches.

This review has focused on considerations relevant to the design and implementation of AF extension approaches for targeting beneficiaries in communities (similar to San Jose) in which SFA is used as a primary livelihood strategy. The importance of using a multi-

[84] Except perhaps recommending that small trial plots be tested.

scalar approach to include plot- and landscape-levels, as well as household- and community-levels is emphasized.

This section has shown that the soil-improving capacity of trees provides the potential for agroforestry systems to be productive while at the same time sustain soil fertility, thus meeting joint criteria of productivity, sustainability and practicability (Young 1987: 279). "The productive element", states Young (1987: 279), "arises first, from the capacity to sustain, or even augment, crop or pasture production in the presence of trees; and secondly, through production from the trees themselves. Practicability stems from the fact that most agroforestry land use systems require neither costly external inputs nor complex technology."

When considering appropriate intervention technologies for communities (such as San Jose) who practice SFA and consider the use of fire for land clearing as traditional, it is recommended that improved fallows[85] (as described in this paper) be introduced in conjunction with a gradual abandonment of the use of fire and the adoption of appropriate agroforestry technologies derived from organic and permaculture agricultural systems.

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[85] Including the incorporation of MPTs and perennial trees (and other AF technologies).

3. Methodology

There are numerous methodologies available to researchers who study farming systems in developing countries. Chosen methodologies should be those that are most appropriate given: (a) the nature of the research topic, (b) the local context of the research area, and (c) associated researcher constraints. What follows is a description of the methodologies used in this study, and a justification and discussion of their appropriateness.

3.1 Primary research questions

The primary research questions addressed in this study are:

(1) How should SFA systems be *defined* and *classified?*

(2) How can the *sustainability* of SFA systems (similar to those used by San Jose farmers) be *assessed* by using an AF diagnostic approach?

(3) How can the *sustainability* of SFA systems (similar to those used by San Jose farmers) be *improved* by using an AF design approach?

(4) How can participatory agricultural extension approaches be used to *implement appropriate AF technologies* so as to enhance the performance of SFA systems?

3.2 Methodologies used

The data collection techniques used in this study were:

1. a review of scientific literature on slash-and-burn and swidden-fallow agriculture, tropical agroforestry, and participatory agricultural extension;
2. the collection and analysis of data on the study area (San Jose) derived from documents obtained from governmental and non-governmental development agencies;
3. informal conversations (including oral histories and non-structured interviews with San Jose residents and agricultural extension agents working in San Jose);
4. participant observation; and

5. semi-structured interviews with PROCESO[86] Project participants (PPs) and non-participants (NPs) from San Jose, as well as non-structured (informal) interviews with agricultural extension agents familiar with San Jose .

3.3 Time frame of study

The resulting data was gathered over several different time periods[87].

The *literature review* began in January 2006, prior to commencing field work. Sources of reviewed literature include scientific journals, master's theses and doctoral dissertations, governmental and non-governmental reports, academic books, on-line publications, etc.

The literature was obtained primarily from the McGill and the Smithsonian Tropical Research Institute (STRI) library systems as well as several on-line sources. The incorporation of relevant literature was on-going throughout this study. It was deemed that saturation of the literature was reached in June 2007. However, new literature and findings on subjects relevant to the study of SFA systems are published on an on-going basis, making it difficult to truly reach saturation of associated literature in this evolving area of research.

Governmental and non-governmental documents were collected continuously while in Panama (March-September 2006). These documents were then *analyzed* over the course of the following academic year (September 2006-June 2007).

Informal conversations were held and p*articipant observation* was used throughout the course of my field work, both when in San Jose, as well as when visiting agricultural extension organizations. I held several informal conversations with Peace Corps staff[88] and volunteers familiar with San Jose during the month of March 2006, and visited several communities over the course of April 2006. During April, I conducted a preliminary field visit to San Jose and remained there for a period of three days. I would visit the community three more times and would attend approximately five farm days at the JICA Satellite Farm over the course of these four visits.

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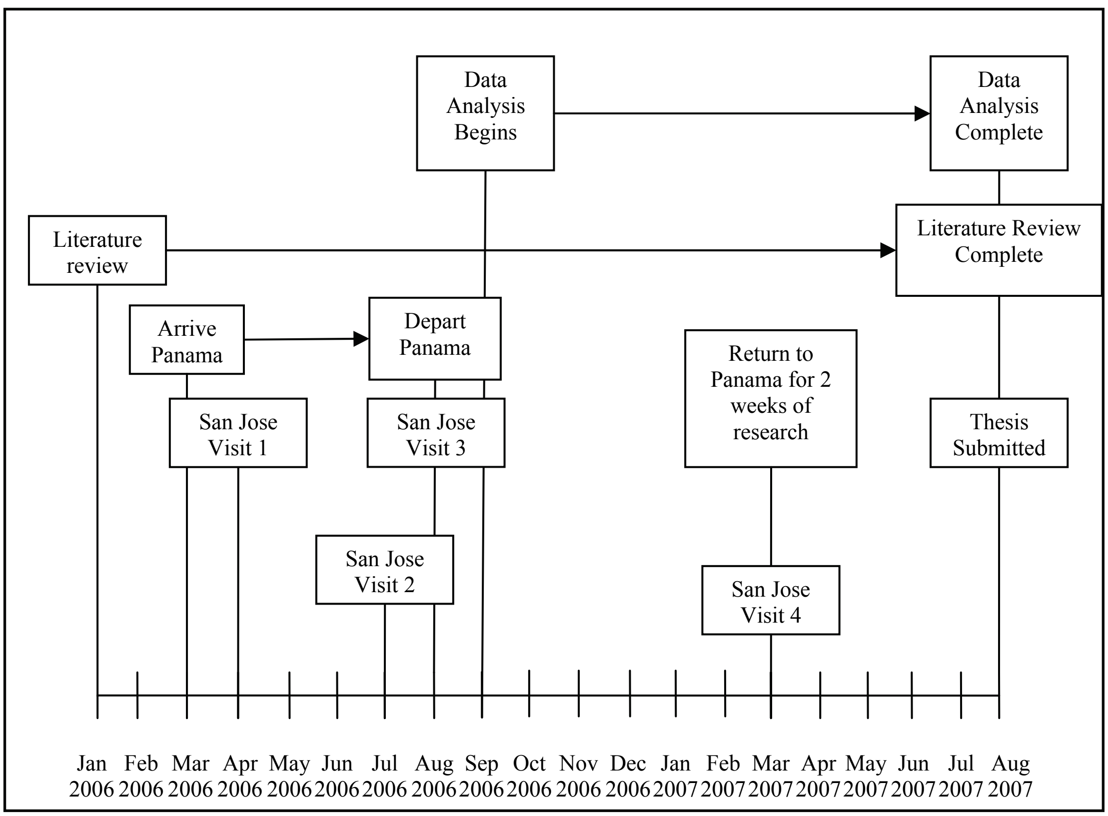
[86] Sustainable Agricultural Training and Extension in Rural Areas of the Republic of Panama Project (PROCESO) (see section 4.2)

[87] See Figure 7: Time line of study.

[88] Particularly Jason Cochran.

During two subsequent visits to San Jose[89], *semi-structured interviews* were conducted with *PPs and NPs* over the course of several days. Between April and August 2006, *non-structured interviews*[90] were also conducted with *agricultural extension staff* from the Peace Corps, JICA, MIDA, INA, and IDEAS who were familiar with San Jose. I returned for yet another field visit to San Jose in March 2007 during which I visited the San Jose satellite farm and was able to make a final assessment of the progress and status of the PROCESO Project. Data organization and analysis as well as the writing of this thesis were carried out upon my return to Montreal in September 2006 and continued until August 2007.

Figure 7: Time Line of Study



3.4 Literature review

A thorough literature review was performed of relevant scientific literature on slash-and-burn and swidden-fallow agriculture, tropical agroforestry, and participatory agricultural

[89] One in July and the other in August 2006.
[90] This type of interview was conducted using open-ended survey questions. Responses by participants were used to explore and elaborate on topics of interest to the researcher.

extension. A review of this literature is presented in Chapter 2 entitled 'Literature Review'. This literature review also assisted in defining the analytical approach used to analyze the San Jose SFA system. This analysis is presented in Chapter 5 entitled 'Results and Discussion'.

3.5 Document Collection

Several documents from government programmes and agricultural extension agencies were collected and subsequently analyzed in order to extract relevant data. These documents were obtained over the course of several visits to:

- the National Census Bureau (La Contraloría General de la Republica de Panamá)
- JICA's head office at INA
- the NGO-IDEAS' head office in Santiago de Veraguas
- the National Geography Institute (Instituto Geográfico Nacional "Tommy Guardia" de Panamá)
- the PRONAT[91] (Programa Nacional de Titulación de Tierra) office in Santiago de Veraguas
- the IDIAP office in the City of Knowledge in Panama City
- MIDA offices (head quarters, regional and local offices)
- the Peace Corps head office in the City of Knowledge in Panama City
- residences of key informants in San Jose (former promoters/JICA participants)

Documents collected included reports, brochures, maps, and instructional and training manuals. Depending on the occasion, the acquisition of these documents was accomplished in either an opportunistic[92], deterministic[93], or exploratory[94] manner.
Population and agricultural censuses from 2000 and environmental censuses from 1995-2001 and 2002-2004 were gathered from the National Census Bureau and subsequently

[91] PRONAT is an ongoing World Bank funded program, administered and executed by the Panamanian government that aims at facilitating land titling across Panama (Crête 2006).
[92] Such as coming across relevant documents unexpectedly while at the National Census Bureau or in the office of an NGO.
[93] Such as requesting a specific document to the National Census Bureau.
[94] Such as asking what type of relevant documents an NGO or a former promoter from San Jose might have.

analyzed. Soil maps were obtained from IDIAP and MIDA. Geographical and political maps of the region were obtained from "Tommy Guardia". JICA documents describing its Panamanian programmes and more specifically the PROCESO Project, were also collected and analyzed. Agricultural extension training manuals given to former promoters and participants of agricultural extension projects were obtained from key informants of San Jose. Other documents obtained from the Peace Corps office and other organizations served as useful tools for the planning and conducting of field work. A study conducted by Cochran (2003) provided much inspiration for this research as well as important background information about the study area.

3.6 Informal conversations and participant observation

Informal conversations and *non-structured interviews* were held with SFA farmers, agricultural extension professionals, and academics throughout the course of this study. These conversations included *oral histories*, sometimes including chronosequences (Cochran 2003; Buckles *et al.* 1998) of crop histories by SFA farmers or the recounting of development project histories by agricultural extension agents. This technique involves the documentation of past events experienced first-hand by interviewees. These conversations were often held in very casual settings, such as during a car ride, over coffee, or just relaxing in a farmer's home with his family. During my first visit to San Jose, I met several key informants[95] and learned a great deal about the community itself, particularly with regards to the farming systems used by its farmers and the history of rural development projects that had come to San Jose. Several informal conversations with Peace Corps staff[96] and PCVs familiar with San Jose were also held. These conversations led the author to limit this study to a single community by focusing specifically on SFA farmers of San Jose[97]. These conversations also assisted in guiding the survey design process[98].

Participant observation was also used in similar settings as for informal conversations throughout the course of conducted field work. Participant observation was at times used

[95] See section entitled "Key Informants" for more details.
[96] Particularly Jason Cochran.
[97] See section entitled "Why the community of San Jose was selected" for more details.
[98] See section entitled "Survey design" for a more detailed explanation.

while the author was present during conversations between SFA farmers. The author's participation was often limited during these conversations to allow them to flow and develop more naturally. Another situation in which participant observation was used was when attending town meetings or local meetings of a variety of boards and committees[99]. Additionally, this technique was used when assisting with agricultural extension field days on the San Jose Satellite Farm. These farm days offered a unique opportunity to observe how JICA extension agents interacted with each other and with PROCESO project participants from San Jose. The author attended approximately five farm days over the course of four visits to the community. During two of these farm days, JICA extension agents were present. The others I attended with members of the San Jose Satellite Farm only, these being regular farm work days and not extension visits.

3.7 Survey design

Several sources were used as a basis for survey design. In part, it was inspired by similar surveys used in Crête's (2006) and Cochran's (2003) studies. The literature review also served to guide this design. As mentioned above, informal conversations and participant observation influenced survey design as well. At the time of survey design, the importance of distinguishing between two groups among San Jose farmers was recognized: those participating in the PROCESO Project (PPs) and those not participating[100] (NPs). Although members of these two groups had switched over from one group to another in the past, there were no changes in group classification for any individuals during the course of my study. That is to say that no PPs decided to no longer participate in the PROCESO Project and no NPs decided to join the PROCESO Project during the course of this study. The groups were stratified accordingly and different versions of the questionnaires were developed for each of them. A separate questionnaire was also developed for the agricultural extension agents interviewed.

Survey questions[101] were developed by identifying the major themes of interest for my analysis of SFA farming systems. For NPs, these themes included: household

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[99] For example, while attending meetings of the town water board or of the Parents of School Children Board ("Padres de Familia").

[100] These groups will be referred to as "PPs" and "NPs" respectively.

[101] See Appendix A: Survey questions used in semi-structured interviews.

demographic data, data on farming practices and crop histories, economic data, historical data on individual and community, and data on individual farmer's levels of participation in and perception of rural development projects (particularly PROCESO). These same themes were used in the development of a questionnaire for PPs. However, several of the questions differed, particularly with regards to an emphasis being placed on PROCESO participants' experiences as beneficiaries of JICA and INA's agricultural extension activities. These surveys were then administered during semi-structured interviews with individual SFA farmers from both of the stratified groups. In comparison, surveys administered to non-participating SFA farmers included questions focusing on their reasons for non-participation in rural development projects, particularly in PROCESO. A questionnaire was also designed for use in non-structured interviews with *agricultural extension agents*. The major themes guiding this survey design were: institutional background, personal knowledge of San Jose, experience working in San Jose (i.e. perception of San Jose as a beneficiary), overall agricultural extension approach, and demographic data. These surveys were translated into Spanish with assistance from several native speakers. The questionnaires contained open-ended and multiple choice questions. The respondents' answers were subsequently analyzed and then coded into categorical variables. Each survey was reevaluated after being administered for the first time. Minimal changes were made, such as removing problem questions, altering wording to simplify or clarify certain questions, etc.

3.8 Participant selection for interviews

This section will describe the distinct sampling approaches used in the selection of each of the interviewee groups[102].

3.8.1 Participant selection for non-structured interviews with agricultural extension agents

A snowball sampling approach (Grisley 1994; Fischer 1998; and Fischer and Vasseur 2002) was used to identify the agricultural extension agents to be interviewed. After establishing an initial list of potential interviewees based on information obtained during

[102] Agricultural Extension Agents, PPs, and NPs.

informal conversations with key informants, each of the interviewees was asked to recommend other potential participants to be interviewed for this study. Thus, one interviewee was selected from each of the four identified agencies[103]. These included two extension agents from the NGO IDEAS, regional Peace Corps coordinators for Veraguas Province, a MIDA extension agent from the local office in La Mesa, and a JICA extension agent. The interviewees were selected based on their prior or current involvement in rural development activities in San Jose. The data collected from these interviews was both qualitative and quantitative in nature. Interviews held with IDEAS and Peace Corps staff were conducted to provide contextual and historical information regarding agricultural extension activities having taken place in San Jose[104]. Although several in-depth conversations were held with MIDA extension agents from the office in La Mesa, the extension agent who worked directly with San Jose was not available to be interviewed because of his workload and personal matters needing his attention.

The interview conducted with the JICA extension agent provided data specific to the PROCESO Project. PROCESO being the only active agricultural development project in San Jose at the time, interviews with this individual also provided the most up to date information on current constraints to agricultural extension activities in the community. It was thus decided that the PROCESO Project would be the focus of the agricultural extension component of this study[105]. The head of the PROCESO programme for JICA, who frequently participated in extension visits to San Jose, was interviewed. Although the same questionnaire was used for all extension agent interviews, during the JICA interview emphasis was placed on:

- the nature of the technologies promoted through the PROCESO Project,
- the obstacles to the successful adoption of these technologies by SFA farmers,
- and the obstacles to increased participation by SFA farmers in the PROCESO Project.

[103] JICA, MIDA, Peace Corps, and IDEAS.
[104] This data was coded and used to help identify the major themes to be addressed in this study. See section entitled 'Statistical approach' for more information on the coding approach used.
[105] Data derived from the JICA interview is presented in the "Results" section.

3.8.2 *Participant selection for semi-structured interviews*

Based on informal conversations with key informants from San Jose and document analyses of JICA and governmental documents, a list was compiled of potential interviewees for two subsets of the San Jose population: PROCESO participants (PPs) and PROCESO non-participants (NPs). The goal was to interview as many individuals of these subsets as possible[106].

For the NP group, individuals were selected to be interviewed using simple randomization. In all, 17 (n_{nph}=17) of the 24 (N_{nph}=24) SFA farmers in this subset were interviewed. Those not interviewed either refused to be interviewed, were unavailable, or were simply absent during the time research was conducted. If after various attempts it was not possible to carry out an interview with an individual, this person would be skipped and the next person on the list would be targeted.

The PP group was small enough (N_{pp}=8) that all but one of the participants (n_{pp}=7) were interviewed. The individual for whom an interview was not conducted had taken an extended absence from the community and the PROCESO Project in order to be with family living in another part of the country.

PP interview data was collected primarily to describe the characteristics of *individuals* of San Jose participating in the PROCESO Project, as well as to allow the assessment of adoption levels and the appropriateness of technologies promoted through this project. When considering interview results of the PP group independently, results reflect data for 7 PP individuals[107] (n_{pp}=7). When considering interview results of the PP group at a household level[108], results reflect data for 4 PP households[109] (n_{pph}=4).

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[106] See Table 9: Breakdown of San Jose interviewees.

[107] This approach was taken to allow for the variability among PPs to be described. Residents of San Jose were invited to participate in the PROCESO Project as households. However, interesting variability exists among members of individual PP households. Generally, all members of a PP household participated in the PROCESO project, but to varying degrees and in varying ways.

[108] This figure is used when comparing PP and NP groups, as well as counted together with the PP group when making a general statement which applies to all San Jose SFA farmers (i.e. PP household group (n=4) + NP household group (n=17) = San Jose SFA farmer household group (n=21).

[109] Three of the 7 PPs living together in one household and the remaining 4 PPs living in four separate households. Only 4 households were included in the PP household group, as the head of one of the PP households was an older woman who had recently lost her husband and was no longer using her deceased husband's plots for SFA farming. Instead these SFA plots had been taken over by one of her sons and are reflected in the results of the NP household group. She continues to practice home gardening on her home garden plot, her other subsistence needs now being met by her family.

Data collected during NP interviews, on the other hand, was primarily collected to describe the characteristics of *households* engaged in SFA farming, the agricultural technologies used by farmer households, and their reasons for not participating in PROCESO. Therefore, when considering interview results of the NP group individually, results reflect data for 17 households (n_{nph}=17). Results which apply to both PPs and NPs are presented for 21 San Jose SFA farmer households (n_{sfah}=21) of 30 total San Jose SFA farmer households (N_{sfah}=30).

Thus, PPs and NPs are at times considered as stratified household groups for comparison, at others as forming a single group of individual SFA farmers, and still at others as stratified household groups considered independently of one another. The author therefore recognizes that certain results from each of the groups cannot be readily compared, as one cannot compare household data to individual data. This approach was taken to obtain the most meaningful results possible given such small sample populations. A multi-village study with larger sample sizes would enable researchers to better compare PPs and NPs.

Eighteen years of age was set as the minimum age requirement for participation in semi-structured interviews, both for ethical and practical reasons. It should be noted however that several children and young adults participated in PROCESO activities. Their contributions to these activities were substantial. Their perspectives on the PROCESO Project were for the most part positive, and their participation in PROCESO activities was undertaken with much excitement. It was noted several times by PROCESO participants that their children would play a crucial role in ensuring a positive future for San Jose, and that educating them in sustainable agriculture was a key means to this end.

Table 9: Breakdown of San Jose interviewees

SFA Farmers Population Group	Size of Population Subset (N)	Sample Size Breakdown				% of Population Subset Interviewed
		Male	Female	As a Couple	Total Interviewed (n)	
PROCESO non-participants (NPs)	N_{nph} =24	9	4	4	n_{nph} = 17 (households)	71%
PROCESO Participants (PPs)	N_{pph} = 6	2	1	1	n_{pph} = 4 (households)	66.7%
	N_{np} = 8	4	3	0	n_{np} = 7 (individuals)	87.5%

3.9 Survey implementation

Questionnaires were used in semi-structured interviews to gather both qualitative and quantitative base-line data from agricultural extension agents, PROCESO non-participants, and PROCESO participants. Interviews were conducted orally in Spanish. Key informants and snowball sampling were used to select the sample populations to be studied. Meetings were usually set-up with prospective interviewees 1-2 days prior to an interview. Most meetings scheduled earlier than this would often be missed or forgotten by the interviewees. To avoid this problem, I would often remind prospective interviewees several times of our agreement to meet. These meetings were set-up during casual conversations when I encountered prospective interviewees in the community. If our paths did not cross to enable such a chance encounter, I would visit individuals' homes or agricultural fields to schedule interviews with them.

In accordance with McGill University's ethical guidelines[110] for research involving human subjects, individual permission to interview subjects was requested prior to beginning the interviews. Oral rather than written consent was requested so as to avoid possibly embarrassing moments with illiterate farmers. Interview participants were promised that their anonymity would be preserved and explained that they could refuse to answer any questions asked of them as well as decide to end the interview at any time. After this announcement, I would begin interviews by introducing myself to the interviewees as a means of creating a sense of trust and mutual exchange. A small gift, such as coffee, was also offered to them. We would often consume this coffee together in their houses. The interviews were recorded using a digital recording device openly visible to the interviewees.

3.9.1 Key informants

Although many individuals provided me with invaluable information during the course of my study, a San Jose resident trained as an agricultural promoter (Cochran 2003) served as an invaluable source of information. Upon arriving to San Jose for the first time, contact was established with this key informant based upon recommendations from Jason Cochran and a Peace Corps Volunteer (PCV) having worked in San Jose. The community

[110] See Appendix D: Ethics Certificate for Research Involving Human Subjects.

was reached by using public buses and walking for several miles. Upon arriving to the community for the first time, I identified and approached a key informant and explained to him the purpose of my visit and the nature of my research. He was very sympathetic to my research goals and provided me with invaluable support during the planning and implementation phases of my field research[111].

Upon this key informant's recommendation, I then attended a town meeting during which, after having received permission from the meeting chair, I introduced myself to the community and informed them of my desire to conduct this study. I explained to them that I would be conducting individual interviews and that I would be staying in their community for several days over the course of the next six months. No objections were made by any community members present at the meeting. I was asked several questions by community residents regarding clarification of certain aspects of my study, particularly with regards to my affiliation. I introduced myself as a graduate student from McGill University conducting academic research on traditional agriculture and agricultural extension in Panama. However, as the second of two PCVs having volunteered in San Jose had recently reached the end of her volunteer term and because of my association with Jason Cochran, many in San Jose assumed I had also arrived to their community as a PCV and that I would be living in their community for the next two years. It took several efforts on my part to clear up this confusion regarding my affiliation. My key informant and his family, having clearly understood the status of my affiliation, also helped to clear up this confusion during conversations with their fellow residents. After several informal conversations with this key informant and agricultural extension agents having worked in San Jose, I decided to focus my research on the SFA farmers of San Jose.

[111] This includes providing me with housing and food during my numerous visits to the community of San Jose, as well as important agricultural extension documentation from rural development projects that had come to the community. This informant offered me with his undivided attention on several occasions during the course of non-structured interviews and informal conversations. Of particular importance, was extensive data he provided me with on the participation history of SFA farmers of San Jose in rural development projects, as well as data on the crop practices of individual SFA farmers. These were subsequently verified during semi-structured interviews.

3.10 Justification and limits to the methodology

This study's aim is to explore the complex nature of SFA systems within the specific context of a rural community in Panama. It is not meant to be representative of all possible considerations of SFA systems. What it is meant to do is to contribute to the growing knowledge base of context-specific data on communities who use SFA as a component of their farming system. As noted by Cochran (2003) and others (Camara-Cabrales 1999; Fischer and Vasseur 2000; Fischer and Vasseur 2002), there is a lack of studies in the literature that investigate the environment in which farmers make decisions about technologies applied on their farms. This lack is even more apparent with regards to such studies on SFA farmers. This study aims to contribute to efforts to address this gap in information by providing much needed contextual references for researchers and extension agents developing and transferring agroforestry technologies to communities that use SFA within similar environmental and socio-economic contexts as San Jose.

3.10.1 *Survey design & interview structure*

A semi-structured interview approach was used based on recommendations from similar studies on agricultural development in developing countries (Loevinsohn *et al.* 1994; Fischer 1998; Lapar and Pandey 1999; Fischer and Vasseur 2002; and Cochran 2003). This data collection approach is appropriate within the context of this study for the following reasons:

- Formal written surveys would most likely have had poor response rates due to the remoteness of the community[112]. Conducting oral interviews increased the likelihood of obtaining a larger number of respondents and therefore a larger sample size.

- Due to the high rate of illiteracy among San Jose farmers and residents in general, it was deemed more appropriate to conduct the interviews orally. This also

[112] As is the case in many small rural communities across Panama, residents did not benefit from mail service.

allowed the interviewer to clarify any questions misunderstood by the interviewee.

- The questionnaires were primarily made up of open-ended questions so as to encourage interviewees to provide detailed responses and to elaborate when necessary. To a lesser extent, closed-ended or multiple choice questions were used to facilitate the analysis of data on certain important themes of the study.

- PPs and NPs were mainly interviewed in their homes, as it was felt this would be an environment in which they would feel comfortable and relaxed. Additionally, as interviews were often held in the presence of a farmer's family members, these individuals would sometimes assist in confirming or clarifying a farmer's response to survey questions. Upon the request of a small number of interviewees, some interviews were conducted in public spaces or in farmers' fields.

3.10.2 *Oral histories*

Being unable to conduct a long-term case study of San Jose due to time and financial constraints, oral histories were used to collect background and contextual information relating to the agricultural practices of SFA farmers and the agricultural extension activities having taken place in San Jose. Leading questions were avoided to minimize the possibility of interviewees simply telling me what they believed I wanted to hear. These oral histories were not meant to provide quantitative data, but rather to guide this study by allowing me to explore various ideas I held with respect to SFA farming systems and to assist me in focusing on a specific set of issues. They enabled me to learn much about the community of San Jose.

Recognizing that oral histories can provide results that are either inaccurate or difficult to verify unless they are based on a large sample size[113] (Buckles *et al.* 1998; Fischer 1998; Fischer and Vasseur 2002; and Cochran 2003), I decided not to include this data in my results. It should be noted however that "although scientifically imperfect, oral histories

[113] One must keep in mind that "any given individual may misremember events or distort their account for personal reasons" and that therefore "historical documentation is considered to reside in the points of agreement of many different sources, rather than the account of any one person" (Buckles *et al.* 1998).

may be the best way to understand the socioeconomic and physical environment into which a new [technology] was integrated" (Cochran 2003).

3.10.3 *Sample sizes*

As mentioned previously, my research was entirely self-funded, and funds available to cover research costs such as hiring research assistants, transportation, lodging, and equipment were extremely limited. In addition to financial constraints, I faced time constraints due to my limited stay in Panama (6 months), the length of time it took to conduct interviews (average time was 1 hour and 15 minutes), and the degree of effort and length of time it took to reach San Jose and successfully set-up an interview. Because of these constraints, sample size is relatively small. Had additional resources been available, I would have included additional communities in this study and obtained a more accurate representation of regional trends among SFA farmers. This study should nevertheless be a useful contribution to the study of SFA systems in Panama.

3.10.4 *Statistical approach*

As in similar studies (Crête 2006; Cochran 2003; Moretti 2000), small sample sizes make the data collected for this study more suited to a descriptive rather than inferential statistical approach (or analysis). A basic summary statistical approach is used to identify respondents' top responses given during semi-structured interviews. As mentioned by Cochran (2003) and Buckles *et al.* (1998) such an approach is useful for future follow-up studies. Hence, it is hoped that this study will prove useful as a basis for follow-up studies on the major considerations to be taken when conducting agroforestry extension in SFA communities similar to San Jose.

Data collected during semi-structured interviews with PPs and NPs and during the semi-structured interview with the JICA agricultural extension agent is therefore presented using a basic summary statistical approach. With the exception of the data collected during the JICA interview, data collected during semi-structured interviews with agricultural extension agents will not be presented as these were meant to serve as exploratory data for the researcher to better understand the local context of San Jose prior to interviewing SFA farmers.

A thematic coding approach was used to synthesize data collected during semi-structured interviews. These themes were then used to guide the analyses of the San Jose SFA system and the PROCESO project presented in the 'results and discussion' section of this paper. The themes used in this coding approach were: (1) *agricultural practices used by San Jose farmers* (this theme includes data primarily on SFA practices, but also on home garden practices); (2) *San Jose farmer participation in extension activities* (includes data on questions asked to PROCESO participants (PPs) and PROCESO non-participants (NPs) regarding their involvement in extension activities, or lack thereof); and (3) *basic needs and agricultural constraints of San Jose farmers*. The potential for a biased interpretation of survey data could be minimized in future studies by having larger sample sizes for interviews.

Basic descriptive data retrieved from governmental and non-governmental documents will also be presented. This includes soil data retrieved from soil maps[114], environmental and demographic data retrieved from official reports, and data retrieved from agricultural extension documents[115]. The main themes this data falls under include: *ecological characteristics* (e.g. soil, climate, and vegetation); *agricultural characteristics* (crops and agricultural practices used by San Jose farmers); *socio-economic characteristics* (e.g. poverty indices, demographics); and *PROCESO activities* (extension approach and technologies promoted).

3.10.5 *Summary*

Of the methodologies available to researchers operating in developing countries under limited budgets and within a limited time-frame, *oral histories*, *semi-structured interviews*, *snowball and simple random sampling*, and a *basic summary descriptive statistical approach* to data analysis are often cited as most appropriate. These techniques are useful for collecting data on agroforestry extension and farm management practices of SFA farmers and can also provide useful baseline data for future studies (Buckles *et al.* 1998; Fischer 1998; and Fischer and Vasseur 2002; and Cochran 2003).

[114] Soil maps were obtained from IDIAP and MIDA.
[115] These include reports, brochures, and training manuals.

4. Description of the Japan International Cooperation Agency's (JICA) work in Panama and specifically with the PROCESO Project

4.1 JICA: Background information

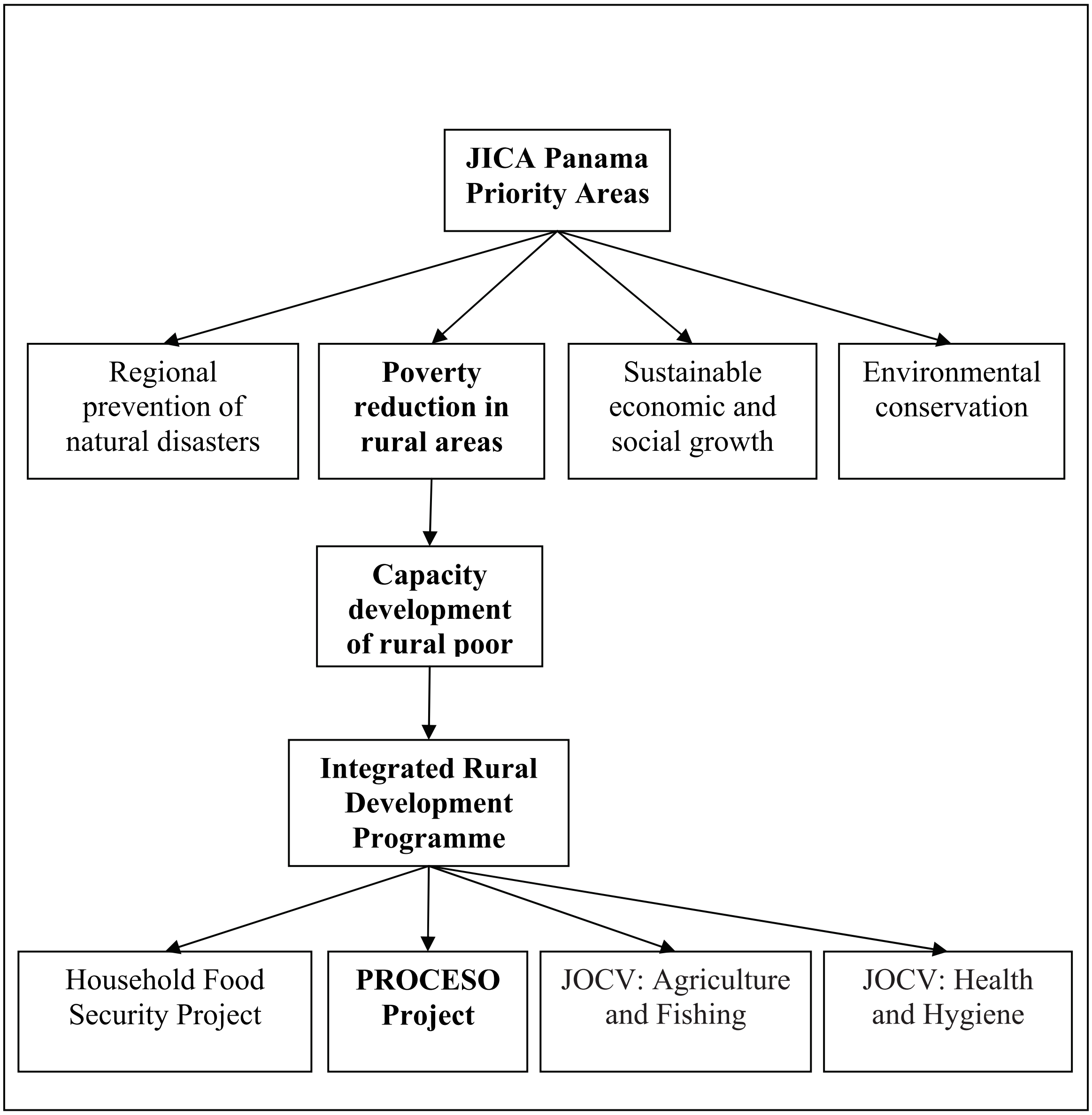
This section is meant to provide readers with an understanding of: (1) the development activities in which JICA is involved in Panama and (3) the PROCESO Project in Panama. This information is presented so that the reader may acquire a clearer understanding of the larger institutional and political contexts in which agricultural extension workers involved in extension work in San Jose during the course of this research operated.

4.1.1 JICA in Panama[116]

JICA takes a regional approach to the development needs of the Central American and Caribbean region, prioritizing poverty reduction as a major issue. JICA promotes sustainable economic growth as the key means by which to address poverty. JICA opened an office in Panama in 1988. As a result of an agreement made in 2005 between the governments of Panama and Japan, it was established that JICA would prioritize the following with regards to its cooperation in Panama: (a) poverty reduction in rural areas, (b) sustainable growth of the Panamanian economy and society, (c) environmental conservation, and (d) regional prevention of natural disasters (JICA 2006). This paper will focus on the *poverty reduction in rural areas* priority mentioned above, one of the four priority areas for cooperation identified by JICA in its Project Implementation Plan for Panama. JICA's primary objective as a part of this priority is to assist in the capacity development of the rural poor in local communities. In order to meet this objective, JICA has established the Integrated Rural Development Programme; a multi-faceted programme with activities in the areas of agriculture, human health, food security, and nutrition. Within this framework, this paper will focus on the Sustainable Agricultural Training and Extension in Rural Areas of the Republic of Panama Project (PROCESO).

[116] See Figure 8: JICA Panama technical cooperation framework.

Figure 8: JICA Panama technical cooperation framework



4.2 The PROCESO project

This section is intended to provide readers with an understanding of the following aspects of the Sustainable Agricultural Training and Extension in Rural Areas of the Republic of Panama Project (PROCESO): (1) how and why the PROCESO Project was created, (2) who JICA's national partners in the PROCESO Project are, and (3) how the PROCESO Project is being implemented in San Jose.

4.2.1 How and why the PROCESO Project was created

JICA initiated the Sustainable Agricultural Training and Extension in Rural Areas of the Republic of Panama Project (PROCESO) as a response to a request by the government of Panama to the government of Japan for assistance in implementing a technical cooperation project meant to improve the agricultural extension system for spreading appropriate technologies to poor smallholder farmers of rural areas. This request was made as a result of the Panamanian government identifying an urgent need to extend agricultural technologies suited to the needs of smallholder farmers. Because of the acknowledged weakness of INA and MIDA's extension system, appropriate technologies and pertinent information do not reach most smallholder farmers. Instead, many of them continue to live in a state of poverty. Starting in October 2000, JICA sent experts to INA to assist in the development, improvement, and research of appropriate technologies for smallholder farmers.

4.2.2 JICA's national PROCESO Project partners

On the recipient country end, JICA's national Panamanian partners in the PROCESO project include[117]: (1) the National Agricultural Institute (INA), (2) the Ministry of Agriculture (MIDA), and to a lesser extent (3) the Agricultural Research Institute of Panama (IDIAP). This section provides the reader with a brief overview of these individual partners' programs so that a better understanding of the resources dedicated to the PROCESO Project may be obtained.

4.2.2.1 The National Agricultural Institute (INA)

INA was officially founded in 1941 to serve as a vocational agricultural school, as well as being involved in agricultural research with an on-site experiment station for advancing techniques for the raising of livestock. INA quickly became one of the most important educational centers in Panama and continues to provide practical training and specialized services to farmers and ranchers nationwide (MIDA 2007a). INA operates as a national

[117] JICA's active participation in the PROCESO Project was officially terminated as of January 2007, at which time, national partners began to assume the project's operations and support activities. JICA continues to serve as an advisory partner during this transition period, including providing guidance and support for project monitoring and evaluation activities.

education and research institute under MIDA. In 2006, INA counted a student body of 187 students, with 28 teachers and 9 administrators. Students completing the educational programme receive the equivalent of a high school diploma in addition to a certificate acknowledging their agricultural expertise. INA's mission is to apply and develop educational approaches to form individuals who promote sustainable and economically competitive agricultural development that improves the quality of life of actors involved in the agricultural sector. INA is located in the town of Divisa, at the intersection of the provinces of Herrera, Veraguas, and Cocle. In addition to class-room style lectures in basic theoretical and applied agricultural sciences, INA provides students with hands-on, field-based educational projects in horticulture, livestock raising and management, apiculture, and aquaculture. INA also offers opportunities for students to participate in collaborative agricultural research projects with the Agricultural Research Institute of Panama (IDIAP). INA's vision is to be the premier specialized formal and informal educational center for the development of farmers, students of agriculture, and technical agricultural professionals. Currently, one of INA's primary objectives is to increase and improve field-based agricultural learning activities by making them more pertinent and effective in meeting the needs of farmers in terms of the quality of their agricultural production and of their competitiveness in national and international markets (MIDA 2007b). INA carries out studies on organic farming methods and the raising of small livestock on its demonstration plot for research and training purposes. Likewise, it is researching a farming system that is based on the use and conservation of renewable energy.

4.2.2.2 The Ministry of Agriculture (MIDA)

MIDA's mission is to ensure that the agricultural sector is prosperous, competitive, profitable, and sustainable, and that it contributes to overall national development by increasing employment opportunities and improving the quality of life of Panamanians, particularly those living in rural areas. MIDA's vision is to contribute to the competitiveness of agricultural producers by increasing yields and reducing costs, to improve employment opportunities in the agricultural sector, and to assist in reducing rural poverty (MIDA 2007a).

In its strategic plan for the 2004-2009 period (MIDA 2004), MIDA acknowledges that in the next thirty years 2 billion additional people will depend on agriculture for their subsistence and that concurrently, natural resources are being increasingly stressed by human activity. According to MIDA, the way to address this challenge is through technologies which: (a) increase yields and reduce costs; (b) help conserve natural resources; (c) meet the demands of consumers in terms of food quality and food safety; and (d) assist subsistence farmers, especially the rural poor, in meeting their food security needs.

4.2.2.3 The Agricultural Research Institute of Panama (IDIAP)

IDIAP is committed to meeting the needs, demands, and aspirations of small and medium sized farmers and of the agri-business sector. It is recognized as the leading agricultural research institute in Panama. Its mission is to strengthen the national agro-technological base in order to contribute to food security, agri-business competitiveness, and agricultural sustainability for the benefit of Panamanian society. IDIAP is a state-run entity and regulates all public sector agricultural research. The main objectives of this institute are to increase agricultural production and productivity, with special attention to research related to meeting the needs of smallholder farmers. IDIAP serves as the Panamanian government's main source of information for technical and scientific agricultural data. It also serves as an educational and technical training resource for those involved in the agricultural sector (IDIAP 2007).

4.2.3 The PROCESO Project in Detail[118]

The PROCESO Project was implemented by MIDA through INA and JICA. The Project officially began in January 2004 and terminated in January 2007. Its primary purpose was to address the Panamanian government's need for an improved extension system which would allow appropriate technologies to reach smallholder farmers living in areas with high levels of poverty. Thus, JICA's main goal was to establish a model of sustainable agricultural extension for smallholder farmers of rural areas so as to increase their

[118] This section is based on a document review of (JICA 2004a), (JICA 2004b), (JICA 2004c)

productivity by applying appropriate agricultural technologies in harmony with the environment.

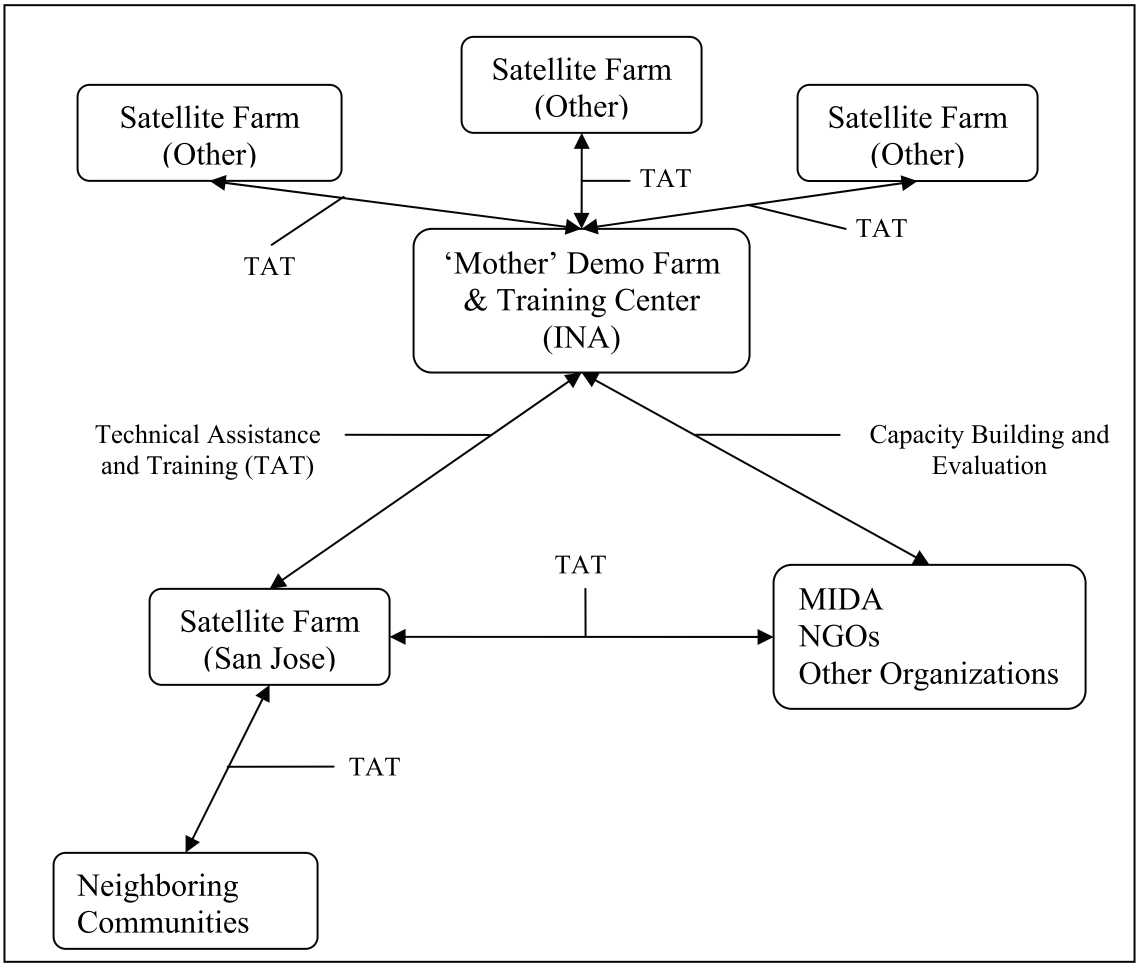
In order to achieve this goal, the project was composed of three primary activities:

1. Using seminars to train farmers, students of agriculture, and professional agricultural technicians;
2. Providing smallholder farmers with agricultural extension of appropriate technologies; and
3. Engaging and empowering communities by promoting and providing training in participatory community development and group building.

These activities were carried out by using a "Mother Farm"[119] meant to serve as a model for the demonstration, training, and the research & development of sustainable agricultural technologies to be transferred to "Satellite Farms"[120] and other interested communities or individuals. The farms were meant to: (a) provide continuous capacity building and technical assistance to participating communities; (b) provide professional agricultural technicians working on the Project with regular opportunities for capacity building on improving rural development in Panama; (c) promote on-field extension activities, including focus groups, farm visits, workshops and seminars, and on-farm technical assistance to groups and individuals.

[119] This farm is located at INA. It is 15 hectares in size.
[120] In total, four satellite farms were created in four individual communities. This includes one in San Jose.

Figure 9: PROCESO project components and activities



As previously mentioned, the scope of this paper does not include a complete assessment of the PROCESO Project life-cycle. This paper will focus specifically on the nature of the technologies transferred to San Jose smallholder farmers through the PROCESO Project. This includes technologies transferred to SFA farmers during training at the Mother Farm and training facilities located at INA, and those transferred to SFA farmers at the San Jose Satellite Farm.[121]

Candidate communities for establishing satellite farms were identified based on: 1) the community's poverty index, 2) the level of organization of farmer groups, and 3) other local conditions (including ease of access to the community and desire of community residents to participate in PROCESO[122]). Another important goal of the PROCESO

[121] See Figure 9: PROCESO project components and activities.
[122] This was assessed using participatory rural diagnoses in selected communities.

Project was the development of an extension model promoting farmer-to-farmer diffusion of appropriate technologies from the satellite farms to surrounding communities. During the final months[123] of the PROCESO Project, selected groups of project participants from each of the PROCECO satellite farms were chosen to become official promoters. They were trained to teach and promote appropriate agricultural technologies[124] taught to them over the course of the PROCESO project. These technologies were to be taught in a participatory manner, using the satellite farms as demonstration sites for the diffusion of JICA technologies to potential beneficiaries of surrounding communities. At the time of the writing of this paper, promoters had completed their training and JICA's local PROCESO partners were taking over the management of PROCESO activities.

[123] circa. October 1996.
[124] The agricultural technologies taught to PROCESO participants will be presented in the results section.

5. Results and discussion

This chapter will include a presentation of study results by theme; a discussion will then ensue for each section presented. The results will be presented under the following themes:

In section 5.1, the community of San Jose will be described. This will include a general description of San Jose's (a) geography (including vegetation and climate), (b) soils, and (c) household and population characteristics (including demographic data, livelihood and household economic data, farm plot, and land tenure data). Results presented in this section are primarily based on data collected during informal conversations and non-structured interviews with San Jose farmers and agricultural extension agents, as well as basic data about San Jose collected and analyzed from governmental and non-governmental documents[125]. As village-level (*lugar poblado*) data is not always available, county (*corregimiento*), district (*distrito*), and provincial (*provincia*) data will at times be used.

In section 5.2 the selection of San Jose as a study area will be justified.

Section 5.3 will describe in detail the agricultural systems used by San Jose farmers (i.e. the SFA, PROCESO satellite farm, and home garden systems).

Section 5.4 will present the technologies promoted by the PROCESO Project and describe their level of use in the farming systems used by San Jose PPs and NPs. The appropriateness of these technologies for San Jose agricultural systems[126] is discussed. Results[127] presented in this section are primarily based on data collected during semi-structured interviews with SFA farmers[128], non-structured interviews with JICA extension agents, researcher observation, and document analysis of governmental and non-governmental extension documents[129].

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[125] This includes data derived from the 2000 national census, JICA PROCESO documents, PRONAT land tenure data, and maps from various sources (IDIAP, Atlas of Panama, etc.).

[126] Primarily with regards to the SFA system and to a lesser degree the home garden system.

[127] Data will be presented using local units of measurement (e.g. hectares, degrees centigrade, and metric system). Some conversions are given to assist the reader if necessary.

[128] Both PPs and NPs.

[129] This includes data derived from the 2000 national census, JICA PROCESO documents (project reports and training & informational literature), and semi-structured interviews with SFA farmers, PROCESO participants, and a JICA extension agent.

5.1 Description of San Jose study area

5.1.1 Geography

The community of San Jose (8° N, 81° W) [130] is located in the sub-humid tropical lowland dry forest zones of Panama with an elevation range of approximately 100-200m above sea level, situated approximately 45km W of Santiago, the capital of Veraguas Province[131] (80°36′43″–81°53′43″ W, 7°12′07″–8°36′43″ N), just south of the Pan-American Highway and just east of the San Pablo River. The Province of Veraguas[132] covers an area of 10,677.2 km² (Contraloría General de la República 2002), the district of La Mesa[133] covers 515.7 km², the County of Bisvalles covers an area of 83.1 km², and San Jose covers an area of 215.6 hectares[134] (PRONAT 2006).

There are numerous interpretations and classifications of soil, climate, and vegetation types in Panama. Although most climate maps show San Jose lying in a humid equatorial climate with a short dry season (Am climate type, Köppen classification), due primarily to regional deforestation and resulting desertification, San Jose is actually closer to a humid equatorial climate with a dry winter (Aw climate type, Köppen classification). San Jose is on the more humid end of this Am climate type, as it lies on the western perimeter of the expanding "*Arco Seco*" (literally, dry arch) zone[135]. The area is characterized by a relatively long dry season during winter months from January to May and a rainy season during summer months from May to January[136], during which 85% of annual precipitation occurs. Overall, average annual precipitation is approximately 1500mm. All months are without frost and the potential evapotranspiration ratio (AIu)[137] in San Jose is approximately 1.5, thereby placing San Jose in the dry sub-humid aridity class (UNEP 1992). Temperatures range between 21° C and 31° C, with an average temperature for the coldest month of the year greater than 18° C, and a difference between the average

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[130] The precise location of San Jose is not given in order to protect the identities of study participants.
[131] See Map2: Poverty in Panama by province.
[132] The third largest out of 9 provinces in Panama.
[133] The eighth largest out of 11 districts in Veraguas.
[134] Or 2.156 km².
[135] See Map 3: Ecological map of panama.
[136] Rainy winter months have less than 60 mm of precipitation.
[137] This serves as an aridity index, where aridity (AIu) is measured by the ratio of average annual precipitation (P) and potential evapotranspiration (PET). Thus AIu=P/PET. (UNEP 1992).

temperature of the warmest month and that of the coldest month less than 5°C (Contraloría General de la República 2002; Instituto Geográfico Nacional 1988).

San Jose falls in the tropical dry forest (TAwb) Global Ecological Zone (GEZ)[138]. Its forest cover is primarily secondary forest, made up of tropical dry low deciduous and semi-deciduous forest and woodland[139]. Areas classified as TAwb generally have an average of 75 tree species with a high incidence of legumes dominating the tree flora (FAO 2001; Whitmore 1990). Remaining land cover is mostly pasture.

Using the Holdridge life-zone classification scheme (Holdridge et al. 1971), San Jose can be described as being in a sub-humid province, in the tropical latitudinal region, in the lowland altitudinal belt, characterized by dry forest (savanna association) with a biotemperature greater than 24°C, an annual precipitation between 1000mm and 2000mm, and a potential evapotranspiration ratio between 1 and 2.

5.1.2 Soils

Soils in a TAwb GEZ are generally composed of weakly developed A, B, and C horizons with variable soil depth ranging from shallow to deep, and are mainly from calcareous, metamorphic, sedimentary, and volcanic rocks (FAO 2001).

The following soils data is limited by the scale and detail of the study performed by IDIAP described below. A finer scale study would need to be conducted to get more precise data that would be useful for individual farmers at the farm plot level. The data presented below is intended to inform the reader of general soil characteristics of this region of Panama.

Based on a study performed by IDIAP (2006)[140] identifying agroecological zones of Panama, soil characteristics in the San Jose region are as follows:

- *physical characteristics*: soils tend to have a clay loam or sandy clay loam texture.
- *chemical characteristics*: soils tend to be highly acidic (pH=4.0 - 5.1) with low to medium levels of aluminum (Al) saturation (approx. 0.05), medium levels of aluminum (Al) (approx. 1mg/kg of soil), low levels of phosphorous (P) (0 – 18mg/kg of soil), low to medium levels of potassium (K) (approx. 45mg/kg of soil), low levels

[138] FAO Global Ecological Zones (FAO 2001).
[139] With an average canopy height of approximately 15m made up of two to three strata (or storeys).
[140] See Table 10: Soil classification used by IDIAP Soils Laboratory

of calcium (Ca) (0 – 2mg/kg of soil), low to medium levels of magnesium (Mg) (approx. 0.7mg/kg of soil), low to medium organic matter content (approx. 2%), low levels of copper (Cu) (approx. 2mg/kg of soil), low to medium levels of iron (Fe) (approx. 25mg/kg of soil), low to medium levels of manganese (Mn) (approx. 14mg/kg of soil), and low levels of zinc (Zn) (0 – 4mg/kg of soil). Soil fertility based on critical levels of soil bases (Ca, Mg, and K) and on critical levels of soil microelements (Zn, Cu, Fe) tends to be very low to low.

Table 10 Soil classification used by IDIAP Soils Laboratory (bold text denotes conditions in San Jose region)

Element	Values	Interpretation	Element	Values	Interpretation
P	**0 - 18**	**Low**	Fe	**0 - 25.0**	**Low**
	19 - 54	Medium		25.1 - 75.0	Medium
mg/kg of soil	55+	High	mg/kg of soil	75+	High
K	0 - 44	Low	Mn	**0 - 14.0**	**Low**
	45 - 150	**Medium**		14.1 - 49.0	Medium
mg/kg of soil	151+	High	mg/kg of soil	49.1+	High
Ca	**0 - 2.0**	**Low**	Zn	**0 - 4.0**	**Low**
	2.1 - 5.0	Medium		4.1 - 14.0	Medium
mg/kg of soil	5.1+	High	mg/kg of soil	14.1+	High
Mg	0 - 0.6	Low	Organic Matter	**0 - 2.0**	**Low**
	0.7 - 1.5	**Medium**		2.1 - 6.0	Medium
mg/kg of soil	1.6+	High	%	6.1+	High
Al	0 - 0.05	Low	Cu	**0 - 2.0**	**Low**
	0.06 - 1.0	**Medium**		2.1 - 6.0	Medium
mg/kg of soil	1.0 - 3.0	High	mg/kg of soil	6.1+	High
pH	**4.0 - 5.1**	**High acidity**			
	5.2 - 5.9	Acidic			
	6.0 - 6.9	Low acidity			
	7.0	Neutral			
	7.1+	Alkaline			

Adapted from: IDIAP 2006

In summary, according to IDAIP (2006), major soil limitations include: the presence of predominantly clay soils with high levels of the mineral Kaolinite which binds phosphorus; that aluminum, iron, manganese, and potassium are not generally deficient in these soils, but are at times found in excess concentrations. These moderate levels of iron and aluminum oxides also bind phosphorus; the high acidity of soils; the relatively low levels of available calcium and in certain areas magnesium; the low levels of available zinc and copper; and the low levels of soil organic matter.

According to (CATAPAN 1970), soils in the Santiago region (includes San Jose) tend to be a mix of mountain soils of the inceptisol order with a clayey texture, and red soils of the oxisol order with a skeletal texture. Soil fertility is generally low to moderate. Surface slope tends to be steep with erosion risk. The agricultural capabilities (VI and VII)[141] of these soils are described as non-arable with severe limitations; with qualities most suited for pasture, forest, and tropical fruit.

Table 11: Soils of the San Jose region

Name	Agricultural Capability	Order	Texture	Slope	Special Hazards	Adaptable Crops	Fertility
Mountain Red Soils	VI VII	Inceptisol Oxisol	Clayey Skeletal	Steep	Erosion	Pastures, Forest, Tropical Fruit	Low to Moderate

Source: Catapan 1970

A more detailed description from CATAPAN (1970) describes the soils of the San Jose region as: having a light (ocher) colored top soil layer with low organic matter; having either cambic or oxic horizons; being well drained; having a fine clay texture; having moderately deep to very deep soils; having a soil parent material primarily composed of extrusive igneous rock; having soils with severe stoniness; having surface slopes ranging from 20% to 45% and others ranging from 45% to 75%; having a low to moderate risk of erosion; and having an agricultural capability (VI or VII) that is non-arable with severe limitations; with qualities most suited for pasture, forest, and land reserves.

5.1.3 Household and population characteristics

As minimal census data is available at the village-level ("lugar poblado"), the more available and detailed county-level ("corregimiento") and at times district-level ("distrito") census data will be analyzed.

[141] See Table 11: Soils of the San Jose region.

5.1.3.1 *Demographic data*

The County of Bisvalles covers an area of 83.1 km² with a population of 2147 in the year 2000 and a population density of 25.8 inhabitants per km² (Contraloría General de la República 2002). The village of San Jose covers an area of 215.6 hectares and is composed of 35 households (123 inhabitants; 65 men and 58 women) with an average household size of 3.5 inhabitants (Contraloria General de la República 2000)[142].

The populations of the County of Bisvalles[143] are projected to continue decreasing but at a decreasing rate (i.e. a decrease in negative growth rate). The populations of the District of La Mesa, the Province of Veraguas, and Panama are projected to continue increasing, but at decreasing rates. In the short-term, a decreasing population in San Jose may place decreasing population pressure on San Jose farm lands. However, other pressures such as decreasing soil fertility levels, continued conversion of farm land to pasture, labor shortages, and the unequal distribution of land, will likely continue to place increasing pressure on San Jose's already degraded farm land resources. Hence, a decreasing population may not necessarily result in decreasing population pressure on farm land resources. This is particularly the case if average farm land resources available per farmer and soil fertility (and hence plot productivity) are decreasing concurrently.

Table 12: The community of San Jose at a glance

Community	Population				Number of House-holds	Ave House-hold Size (inhabitants)	Ave Household Monthly Income (USD)
	Male	Female	Total	Adults over 18			
San Jose	65	58	123	74	35	3.5	65.2

Based on data derived from: Contraloria General de la República 2000

Table 13: Population numbers and growth rates for areas of Panama in 2006

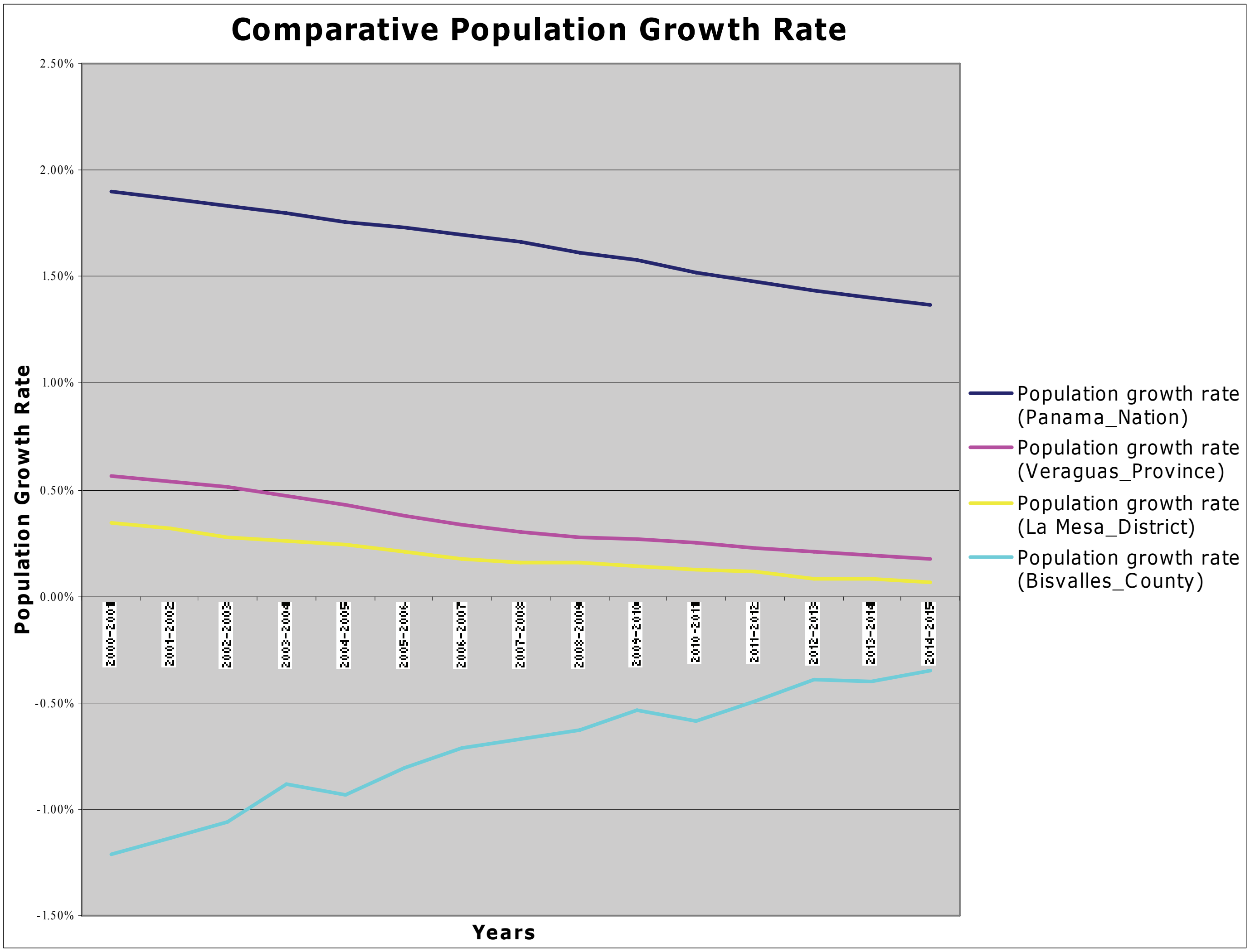
	Population	Population Growth Rate
Panama (nation)	3,283,959	1.73%
Veraguas (province)	224,186	0.38%
La Mesa (district)	12,392	0.21%
Bisvalles (county)	2,097	-0.80%

Based on data derived from: Contraloría General de la República 2007

[142] See Table 12: The Community of San Jose at a glance.

[143] See Figure 10: Comparative population growth rates (current and projected) and Table 13: Population numbers and growth rates for areas of Panama in 2006

Figure 10: Comparative population growth rates (current and projected)



Based on data derived from: Contraloría General de la República 2000, 2007

5.1.3.2 Livelihood and household economic data

San Jose residents can be described as cash-poor, relatively labor scarce due to increasing rural to urban migration, and almost entirely dependent on agriculture for their subsistence. All San Jose male heads of households (n=32) and the few women heads of households (n=3) practice SFA farming as their primary economic activity. All of these individuals' parents were also SFA farmers.

The median monthly household income in San Jose is $65.2[144] (Contraloria General de la República 2000). This places San Jose's inhabitants within the World Bank's extreme

[144] Or $782.40 USD per year.

poverty category[145]. Veraguas province is ranked as the 4th poorest of the 10 provinces in Panama, with a poverty index level of 0.74 (Dirección de Políticas Sociales del Ministerio de Economía y Finanzas 1999). Out of a population of 506 farmers **(**Contraloria General de la República 2000) in the County of Bisvalles, farmer age ranges[146] from less than 21 years old to over 65 years of age, with over 65% of farmers over the age of 44 (MIDA 2007b). The small number of farmers under the age of 35 (16.2%) is likely primarily a result of rural to urban migration of youth to Santiago and Panama City in search of employment. The top reasons given by farmers interviewed in San Jose as to why the majority of the village youth no longer practices agriculture as their primary activity is that (1) they would rather earn a cash income (as opposed to being cash poor when practicing traditional subsistence farming), and (2) that they would rather find work that is less physically demanding (i.e. less labor intensive) than traditional farming.

Table 14: Farmers by age group (County of Bisvalles)

Total	Age Groups (years)						
	<21	21-24	25-34	35-44	45-54	55-64	≥65
N=506	6	10	66	84	112	108	120
100%	1.2%	2.0%	13%	16.6%	22.1%	21.4%	23.7%

Based on data derived from: MIDA 2007b

Table 15: Poverty in Panama by province

Province	Poverty Level	Poverty Rank
Comarca de San Blas (Kuna Yala)	0.98	1
Darién	0.83	2
Bocas del Toro	0.75	3
Veraguas	**0.74**	**4**
Coclé	0.68	5
Chiriquí	0.60	6
Herrera	0.53	7
Los Santos	0.51	8
Colón	0.48	9
Panamá	0.28	10

Based on data from: Dirección de Políticas Sociales del Ministerio de Economía y Finanzas. 1999. Based on data from: Encuesta de Niveles de Vida 1997 y los Censos Nacionales de Población y Vivienda de 1990. Retrieved July 18th, 2007 from, http://www.contraloria.gob.pa/dec/sid/.

[145] Individuals living on less than $1/day. See Table 15 and Map2: Poverty in Panama by province.

[146] See Table 14: Farmers by age group (County of Bisvalles) and Figure 15: Farmers by age group (County of Bisvalles)

5.1.3.3 Description of San Jose landholdings and land tenure arrangements

The land that makes up the community of San Jose is officially (administratively) separated into six parcels[147] (PRONAT 2006), totaling 215.6 hectares (or 532.75 acres[148]). Although the mean area of farm land potentially available per San Jose household if land was distributed exactly evenly is 6.16 hectares[149], this figure does not adequately reflect the disparity that exists among San Jose households in regards to the amount of land available to each for farming. Household land holdings range in size from 0 to 53.41 hectares. As a result, certain households are left with no possession rights and have no other choice but to rent land on which to farm, in addition to supplementing their household income by working as farm laborers in order to earn a wage on which to subsist.

According to PRONAT (2001: 111), "the majority of the population of Panama occupies land owned by the national government (whether land occupied for generations or land acquired by the State for agrarian reform purposes) and enjoy possession rights but do not have legal titles. The PRONAT is designed to establish the necessary conditions to legalize such possession. Some 70% of rural producers do not have titles to their farms. Panamanian legislation provides the opportunity for these farmers to convert their possession into legal title if their occupancy dates from before the Agrarian Law[150]. While the majority of lands have the legal status of "possession" by an individual, there are several forms of property rights which are recognized, depending upon how the possession was acquired (for example, by inheritance, by concession of the State, purchase or usufruct)" (PRONAT (2001: 111).

At the time research for this study was conducted, a series of communal plots had been measured and demarcated based on inheritance rights. This process was completed during the Panamanian agricultural reform. Paperwork had been drawn up describing those San

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[147] These six parcels are of approximately 110.32 hectares, 53.41 hectares, 18.17 hectares, 16.76 hectares, 11.59 hectares, and 5.35 hectares.

[148] 1 hectare=2.471 acres= 10,000 square meters
1 acre = 0.404685 hectares=4840 square yards

[149] minus any common lands used for schools, a church, or other community services or projects

[150] This law was the basis for the Agrarian Reform during which the government attempted to redistribute land in Panama between 1969 and 1977.

Jose residents with legal land claims. Land had then been distributed informally among San Jose households based on possession claims (primarily inheritance claims). The legal titling process and issuing of official legal titles to recognized landowners had not been carried out as of yet. Based on several interviews with PRONAT staff, JICA staff, and San Jose farmers, the lack of official titling was primarily due to the majority of San Jose residents' inability to afford to pay for land titling processing costs and to PRONAT's inefficiency in its ability to handle the amount of land claims it was receiving. The land was therefore still described as officially having a communal status by PRONAT even though those with inheritance claims had been identified.

During the course of several informal conversations, certain San Jose residents stated that their situations had improved as a result of each household having a designated section of land to farm; pointing to the fact that this made people take better care of their individual landholdings. Others, who were left with little or no land, claimed that their situation had worsened as a result of the agrarian land reform; stating that previously communal forest lands with equal access by all San Jose residents were now only accessible to those with inheritance claims. Many of the latter were active PROCESO Participants (PPs), in part because they had little or no other land on which to farm.

In the County of Bisvalles[151], 87.3% (n=449 out of N=514) of farms are without a land title, making up 64.5% (n=3633 hectares out of N=5629 hectares) of farmed area. Twelve percent (n=60 out of N=514) of farms in the County of Bisvalles are on titled land, making up 30.1% (n=1992 hectares out of N=6629 hectares) of farmed area. Approx 15% of remaining total farmland is either in the process of being titled or under some other type of status (i.e. leased public lands, etc.). A relatively small number of titled farms make up a disproportionately large area of titled farmland. This is likely a result of large farmland owners being more likely to obtain a land title for reasons including increased access to land titling services and increased capital availability to fund the land titling process. This leaves many smallholder farmers (particularly the 18.5% of farms in the

[151] See Table 17: Farms with and without land tiles (County of Bisvalles) and Figure 14: Land titling in the County of Bisvalles

County of Bisvalles that are less than 1 hectare in size[152]), with comparatively less and more difficult access to land titling services.

Table 16: Farm sizes (County of Bisvalles)

Total	<0.1 hect.	0.1-0.49 hect.	0.5-0.99 hect.	≥1 hect.	<0.01 hect. (no land)
N=514	14	22	59	419	0
100%	2.7%	4.3%	11.5%	81.5%	0%

Based on data derived from: Contraloría General de la República 2001

Table 17: Farms with and without land tiles (County of Bisvalles)

	Total farms (number)		Farms with land title		Farms without land title		Other status	
	N	%	N	%	n	%	n	%
Number of farms	514	100	60	11.7	449	87.3	5	1
Farm area (hect.)	5629	100	1992	35.4	3633	64.5	4	<0.1

Based on data derived from: Contraloría General de la República 2001

5.2 Why the community of San Jose was selected

My primary objectives upon embarking on this research project included, (a) researching ways to assist SFA farmers in improving their livelihoods by increasing the sustainability of their agricultural systems, both in terms of improving food security and environmental sustainability, and (b) identifying and understanding obstacles to SFA farmers' adoption of agroforestry technologies promoted through agricultural extension programmes.

Upon my arrival to Panama, San Jose was recommended to me as a potential research site by Jason Cochran[153], who had also conducted his thesis research in Panama (Cochran 2003) and had included San Jose as one of his research communities. Initially, this study was to be a follow-up to Cochran's study, and was to include a number of his research sites. After visiting several communities during the month of April, I decided that an in-depth analysis of a single community would be more appropriate given the financial and

[152] See Table 16: Farm sizes (County of Bisvalles)

[153] During the early stages of my research Jason headed the Sustainable Agriculture Systems Project with the Peace Corps office in Panama. The focus of this project is the improvement of the lives of families in rural Panama through improved agricultural and agroforestry production. (http://www.peacecorps.gov/index.cfm?shell=learn.wherepc.centralamerica.Panama.workarea)

time constraints[154] involved, as well as my desire to obtain an in-depth understanding of SFA farming systems at the village (or community) level.

Peace Corps Panama (under Jason's recommendation and by invitation of the village) had placed two Peace Corps volunteers in the community between 2003 and 2006. By the time I had begun my field research in San Jose, both Peace Corps volunteers had finished their posts in the community[155]. From numerous interviews with Jason Cochran and others, I learned that: (a) both MIDA and JICA were currently involved in agricultural extension activities in this community, (b) the community is accessible from and relatively close to Santiago (the capital of Veraguas Province), (c) several members[156] of the community had cooperated with researchers and development workers in the past and were therefore likely to be willing to facilitate further studies[157], (d) traditional swidden-fallow agriculture was widely practiced by resident farmers of San Jose, (e) the area surrounding San Jose (and the lowlands of Veraguas Province in general) has been severely deforested and resident farmers struggle with decreasing agricultural productivity and soil fertility, (f) the majority of residents of San Jose are primarily involved in subsistence farming and face conditions of extreme poverty[158]. Several additional observed characteristics of the San Jose Community influenced the decision to choose San Jose as the research site for this study. During formal and informal interviews, several Peace Corps staff members reported a lack of motivation and participation in extension activities by San Jose farmers. Through participant observation and informal conversations, heterogeneity in San Jose farmers' participation rates in agricultural extension projects and associated adoption rates of promoted agricultural

[154] My research was entirely self-funded. Funds available to cover research costs such as transportation, lodging, and equipment were extremely limited. San Jose's proximity to Santiago, and Santiago's relative proximity to Panama City (where I was based) helped to reduce costs and the amount of time needed for research and data collection purposes. Thus, a lack of funds and time limited my ability to conduct a study on several communities or even on a single community more difficult to access.

[155] I was able to interview the last of these two volunteers prior to her departure from Panama. This also helped me identify San Jose as a community of interest for my thesis research.

[156] One community member in particular had acquired extensive agricultural development experience, having participated in several agricultural and rural development projects that had come to San Jose over the course of approximately 15 years and having received extensive training in sustainable agriculture education and training methods. This resident farmer had also assisted Jason Cochran during his thesis research and would become a key informant in my own research.

[157] Upon conducting an initial visit to San Jose, I was very well received by several residents of the community, including those having been identified as potential key informants.

[158] This signified an acute need for continued research and technical assistance in this community in order to alleviate these hardships.

technologies was observed. Issues concerning the appropriateness of promoted agricultural extension technologies were also observed. Finally, the fact that the PROCESO Project had an active satellite farm in San Jose provided first hand observation of agricultural extension in a community of SFA farmers.

As there is immense variation in agricultural systems used across Panama as well as within the Province of Veraguas, the San Jose SFA system cannot be said to be representative of all agricultural practices used at the national or provincial levels. However, it can be said to be representative of the dominant agricultural system used in the county of Bisvalles[159]. It should be noted however, that even at the county-level considerable variation exists in practices used by SFA farmers. According to Scatena et al. (1996: 29), the forms in which these practices are implemented can be said to be determined by the following general constraints:

> (1) the productivity of the landscape as determined by soil, water and climate; (2) ecological requirements and risks associated with particular crops; (3) land availability and the costs of site preparation, and cultural treatments; (4) the availability of hired labor; (5) the age structure of the families, their subsistence requirements and preferences for particular crops, leisure and non-farm-related production activities; and (6) local economic conditions including land values, access to credit and non-farm-related employment, and the conditions of commodity markets.

Variation in these constraints will influence: (1) fallow length; (2) the selection of crop types and cropping sequences planted on a swidden plot; (3) the clearing and cultivation practices used; (4) the nature and intensity of fallow management practices[160]; (5) the degree of diversification in land use systems containing combinations of pasture, perennials, semi-permanent annuals, areas of extractive reserves, and true shifting cultivation; and (6) agricultural productivity levels through the use of external inputs such as fertilizer, irrigation, and farm machinery (Scatena et al. 1996: 29). As in Scatena et al.'s (1996: 29) study, the majority of San Jose SFA farmers have chosen to modify cropping sequences and vary natural fallow length, external inputs being generally too expensive for them to purchase. Specifically, San Jose SFA farmers have shortened fallow lengths and increased swidden frequencies as a result of decreased land

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[159] Cattle ranching and commercial farming are also important land uses at the county-level.

[160] e.g. natural forest regeneration, accelerated forest regeneration, improved fallow, etc.

availability and diminishing land productivity. San Jose can be said to be representative of communities located in the sub-humid tropical lowland regions of Panama in which traditional SFA is used, and its practitioners face similar socio-economic, environmental, cultural, institutional, and political constraints.

5.3 Agricultural systems practiced by San Jose farmers

Given that the identification of cropping, fallowing, and forest clearing practices is critical to developing sustainable land uses (Scatena et al. 1996: 31; Staver 1989; and Serrao and Homma, 1993) and maximizing agricultural production and general household utility (Scatena et al. 1996: 29), an analysis of these practices should be prioritized by agricultural extension agencies when designing agricultural extension projects intended to improve agricultural sustainability in communities using SFA as a primary agricultural system. This section provides detailed descriptions of the San Jose (a) SFA[161] and (b) PROCESO satellite farm systems, as well as a general description of the San Jose (c) home garden system. Implications of the characteristics of these agricultural systems are discussed.

5.3.1 The San Jose SFA system

The SFA system practiced by traditional *mestizo* farmers of San Jose is a rainfed agricultural land use system. Farmers typically begin by using machetes, axes, and fire to slash and burn a patch of secondary forest or brush in various stages of growth. SFA plots are then cultivated during a swidden phase (generally two to three years in length) of annual subsistence crops. These subsistence crops include: (a) annual grain crops which include several varieties of corn and upland (dry) rice[162], (b) leguminous crops which include several varieties of climbing bean (frijol de bejuco), dry bean (poroto or habichuela), and pigeon pea (guandú), and (c) tuberous crops which include cassava (yuca), giant taro or giant elephant ear (otoe), taro or elephant ear (ñampí), and yam

[161] The data presented in this section is meant to inform the reader's understanding of San Jose SFA system variability at the household and village (or community) levels. Additional data on SFA farming practices used by individual farmers and farm plot data would be needed in order to provide a more detailed description of SFA system variability at household farm- and plot-levels.

[162] Of these, corn was identified as the preferred crop by the majority of SFA farmers, as it requires less care and work than rice, has less disease infestation problems, has a higher market value per unit of labor invested, and gives better yields in terms of nutritional value. See Table 18.

(ñame). Farmers have several individual techniques as to how they arrange their crops (e.g. intercropping, row crops, etc.), but for the most part, a mixed intercropping of corn, rice, and bean is used. Several SFA farmers also have hard and soft wood tree species[163] either bordering their swidden plots or found within the plot itself (the latter is for the most part avoided due to a fear of trees being damaged during burns, as well as taking up needed crop land intended for subsistence crops). Several non-timber forest products (NTFPs)[164] are also harvested, and to varying degrees, the trees from which they are harvested may also be found on or bordering an annual swidden plot. After annual crops are harvested, swidden plots are then allowed to fallow[165], and may be used as forest fallow with some harvesting still occurring. Depending in part on the amount of land an individual farmer has access to (whether rented or owned), he may have several fields in different phases of swidden or fallow simultaneously. Harvests are primarily intended to meet household subsistence needs, and to a lesser extent cash-income generation needs through market sales.

Table 18: Why is planting corn preferred to planting rice? (asked to PP and NP households, N=21)

Top answers by rank:
(1) requires less care and work than rice
(2) has less disease infestation problems
(3) has a higher market value per unit of labor invested (rice prices are too volatile)
(4) gives better yields in terms of nutritional value

See Figure 16 for detailed breakdown of responses

In the San Jose SFA system[166], men take primary responsibility for the slashing (or clearing) & burning of fallow plots as well as for the harvesting of corn, while taking secondary responsibility for sowing tuberous crops. Women on the other hand, take primary responsibility for the sowing of tuberous crops, while taking secondary responsibility for the burning of fallow plots and the harvesting of corn. Men and women

[163] These are primarily used for wood to cook with and for the construction and maintenance of houses. Certain traditional tools such as rice hulling tools are also carved from these woods. The rest is often sold on an irregular basis to occasional buyers for much less than the fair market price.

[164] The other major sources of NTFPs are home gardens and small forest plots.

[165] Most swidden farmers in San Jose will allow their plots to fallow for 2-6 years, in rare cases you may find a small number of farmers using longer fallow periods ranging from 8-12 years. Reduced availability of and access to land is cited by SFA farmers as a major factor in the reduction of fallow lengths in San Jose. On average, interviewed farmers estimate that the previous generation of San Jose SFA farmers allowed their plots to fallow for approximately 10-15 years.

[166] See Table 19: Agricultural calendar for San Jose.

participate equally in weeding and light clearing, the sowing of rice, corn, bean and pigeon pea crops, and harvesting pigeon pea, bean, and rice crops. Hence, both men and women play important roles in the practice of SFA.

Table 19: Agricultural calendar for San Jose

Agricultural Products	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rice	Slash clearing(a)	→	Burn (a)(d)	Sow seed (a)(b)	→	Weeding (a)(b)	Light clearing (a)(b)	Harvest (a)(b)	→	→		
Corn (1)	Slash clearing(a)		Burn (a)(d)	Sow seed (a)(b)	→	Weeding (a)(b)	Harvest (a)(b)	→				
Corn (2)	Harvest(a)(d)	→	→						Light clearing & Sow seed (a)(b)		Light clearing (a)(b)	Harvest (a)(d)
Bean (1)	Slash clearing(a)	→	Burn (a)(d)	Sow seed (a)(b)	→	Weeding (a)(b)	Harvest (a)(b)					
Bean (2)	Harvest(a)(b)	→									Light clearing & Sow seed(a)(b)	Light clearing (a)(b)
Pigeon pea (1)	Slash clearing(a)	→	Burn (a)(d)	Sow seed (a)(b)	→	Weeding (a)(b)					Light clearing (a)(b)	Harvest (a)(b)
Pigeon pea (2)	Harvest(a)(b)	→	→			Sow seed (a)(b)					Light clearing (a)(b)	Harvest (a)(b)
Cassava, taro, yam	Slash clearing(a)	→	Burn (a)(d)	Sow seed (b)(c)	→	Weeding (a)(b)	Light clearing (a)(b)					

Translated and derived from JICA 2006 extension document.

(1) Primary harvest (2) Secondary harvest (a) Man's work (b) Woman's work (c) Man assists (d) Woman assists
→ indicates activity continues

Based on researcher observation and data collected during semi-structured interviews, three primary types of fallow vegetation were identified and used by San Jose SFA farmers. These can be described using Scatena et al.'s (1996) classification of fallow types: (1) secondary forest vegetation 8 to 12 years old; (2) young secondary forest vegetation 3 to 6 years old; (3) brushy vegetation 2 to 4 years old.

Among SFA farmers of San Jose:

-PPs allow their SFA plots to fallow for an average of 5 years and a median of 2 years, with fallow lengths ranging from 2 to 12 years[167]; 50% of PPs (n_{pp}=2) allow their plots to

[167] See Table 20: Fallow lengths of San Jose SFA farmer households.

fallow for 2 to 4 years, 25% (n_{pp}=1) allow their plots to fallow for 3 to 6 years, and another 25% (n_{pp}=1) allow their plots to fallow for 8 to 12 years[168].

-NPs allow their SFA plots to fallow for an average of 3.65 years and a median of 4 years, with fallow lengths ranging from 3 to 5 years[169]; 41% of NPs (n_{nph}=7) allow their plots to fallow for 2 to 4 years, 59% (n_{nph}=7) allow their plots to fallow for 3 to 6 years, and 0% (n_{nph}=0) allow their plots to fallow for 8 to 12 years[170].

Table 20: Fallow lengths of San Jose SFA farmer households

	PPs (n_{pp}=4)	NPs (n_{nph}=17)	Combined (n_{sfah}=21)
Mean fallow length (yrs)	5	3.65	3.9
Median fallow length (yrs)	2	4	4
Range (yrs)	2 to 12	3 to 5	2 to 12

PPs=PROCESO Participants; NPs=PROCESO Non-participants

Table 21: San Jose SFA farmer groups categorized by fallow length class

Fallow length classification[171]	PPs (n_{pp}=4)		NPs (n_{nph}=17)		Combined (n_{sfah}=21)	
	Frequency	% of group	Frequency	% of group	Frequency	% of group
2-4 yrs	2	50%	7	41%	9	43%
3-6 yrs	1	25%	10	59%	11	52%
8-12 yrs	1	25%	0	0%	1	5%

PPs=PROCESO Participants; NPs=PROCESO Non-participants

All San Jose farmers interviewed assert that fallow lengths used currently are shorter than in the past. Reasons given by San Jose SFA farmers as to why fallow lengths are decreasing are displayed in Table 22. PPs overwhelmingly pointed to limited land availability as the primary reason for this trend, whereas NPs tended to point to decreasing farm productivity resulting from low soil fertility as the primary cause.

Table 22: Why are fallow lengths shorter than in the past? (asked to PP & NP households, n_{sfah}=21)

Top answers by rank: (1) Less land is available per farmer since the agricultural land reform recognized land ownership rights of a limited number of San Jose inhabitants (2) Soils are less productive and therefore more frequent harvests are needed (3) The population of San Jose has increased and therefore food production needs have increased

See Figure 17 for detailed breakdown of responses

168 See Table 21: San Jose SFA farmer groups categorized by fallow length class; and Figure 12: Fallow lengths of San Jose SFA farmers.

169 See Table 20: Fallow lengths of San Jose SFA farmer households.

170 See Table 21: San Jose SFA farmer groups categorized by fallow length class; and Figure 12: Fallow lengths of San Jose SFA farmers.

171 Based on Scatena et al.'s (1996) classification of fallow types.

Although sample sizes used in this study are too small to demonstrate a statistically significant relationship between farmer participation in PROCESO and increased fallow lengths, it would be interesting to test this hypothesis by performing a multi-community study allowing for statistical comparisons between fallow lengths used by PPs and NPs.

5.3.1.1 Classification of the San Jose SFA system

This section will describe the San Jose SFA system using the SABA, SFA, and AF classificatory schemes presented in the literature review section of this paper. Additional classificatory approaches that could be used for describing the San Jose SFA system will also be briefly discussed. The San Jose data used in this section was collected by means of researcher observation (i.e. personal observation of land cover at landscape- and plot-levels) and informal conversations held with San Jose farmers.

5.3.1.1.1 Classification based on four variables of SABA systems identified by Fujisaka et al.

The San Jose swidden-fallow system can be classified using the four variables relevant to contemporary slash-and-burn systems as identified in the classificatory system developed by Fujisaka et al. (1996b, 1997)[172]. These four variables are: initial vegetative cover, type of user, final vegetative cover, and fallow length. *Initial vegetative cover* prior to burning for San Jose SFA plots is primarily a mix of secondary regrowth, bush-fallow, young forest fallow, and degraded forests. The *type of user* can be described as traditional *mestizo* farmers. *Final vegetative cover* once the swidden period has ended is characterized by natural fallows and secondary re-growth. Average *fallow length* can be classified as being of medium length (mean of 4 years)[173]. In San Jose, the most common initial vegetative cover prior to clearing is secondary forest in varying stages of succession, from bush fallow to high-secondary forest. Although generally, slash-and-burn farmers tend to avoid the deforestation of primary forests because it is more labor-intensive to clear than secondary vegetation (Metzger 2002), the almost complete absence of primary forest remaining in San Jose points to its historical clearing by resident farmers. To a large extent, the nearly complete deforestation of primary forests in this

[172] See Table 3: Fujisaka et al's 4 distinguishing variables of SABA systems.
[173] See Table 20: Fallow lengths of San Jose SFA farmer households.

region is due to increasing population densities. Although the steady increase in regional population density may not be paralleled by a recent increase in real population numbers in San Jose, a reduction in land access and land availability has occurred in San Jose primarily as a result of the redistribution of land to a select few through the agrarian land reform programme[174] and of competing land uses[175] 'winning out' over swidden-fallow agriculture. The overall result of these influences in San Jose has been a reduction in the average land holding per farmer. Current cultural and political values in the region which place a high value on ranching as a land use and livelihood strategy have also caused extensive regional deforestation through land-cover conversion of forested land to pasture associated with the abandonment of SFA for cattle ranching.

5.3.1.1.2 Classification based on Sunderlin's forest farming continuum

On Sunderlin's (1997) 'forest farming continuum'[176], the San Jose swidden-fallow system falls somewhere in between short-fallow shifting cultivation and long-fallow cultivation. Its associated characteristics within the framework of this continuum are: medium-fallow rotation ($\simeq$ 4 years), traditional (or semi-traditional) farmers, production of mainly subsistence crops, primarily self-generated capital (other than a small amount of urban remittances from family members living in urban centers), relatively far from urban areas in terms of time and money required to reach an urban center (approx. 3-4 hours combining transport by foot and public buses).

5.3.1.1.3 Classification based on Nair's criteria for classifying and grouping agroforestry systems and practices

Based on Nair's (1990) criteria[177] to be used to classify and group agroforestry systems and practices, the San Jose swidden-fallow system's structure, function, socioeconomic scale, ecological spread, and level of management will be described.

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[174] The PRONAT programme, operating under the Panamanian Agrarian Reform Plan (Reforma Agraria), is responsible for the redistribution and titling of land that was previously state owned and considered to be an open access resource or communal lands. A brief discussion on land tenure will be presented in this paper, although it is not within the scope of this paper to perform a complete review of issues related to land tenure.

[175] Primarily ranching and silvopastoral systems and to a lesser extent commercial and mono-crop based agricultural systems.

[176] See Figure 1: Idealized typology of farming systems on the forest farming continuum.

[177] See Table 4: Major approaches in classification of agroforestry systems (and practices).

The San Jose SFA system can be classified as an agrisilvicultural system, as it incorporates crops, including tree-shrub crops, and trees[178]. The arrangement of the components of this swidden-fallow system varies from farmer to farmer, but the swidden phase tends to be primarily based on a mixed-intercropping production of subsistence crops. The function of the swidden phase is primarily productive characterized by the production of subsistence crops, whereas that of the fallow phase is primarily protective, restoration of soil fertility of SFA plots being the primary goal. Fallow plots tend to be unmanaged, with successional stages[179] marked by weed invasion, followed by the establishment of pioneer species and occasionally (although fallow lengths are rarely long enough for fallow plots to reach this successional stage), the establishment of low secondary and high secondary forest species. Spatial (land cover) and temporal (land cover change) aspects of the San Jose swidden-fallow system will not be discussed in this paper due to insufficient data collected by the researcher as a result of time and funding constraints. Spatial and temporal aspects could however be studied as a part of future research by collecting detailed oral histories and chronosequences from SFA farmers and analyzing satellite imagery and aerial photography, in conjunction with field visits to a large sample of SFA plots in different stages of swidden and fallow.

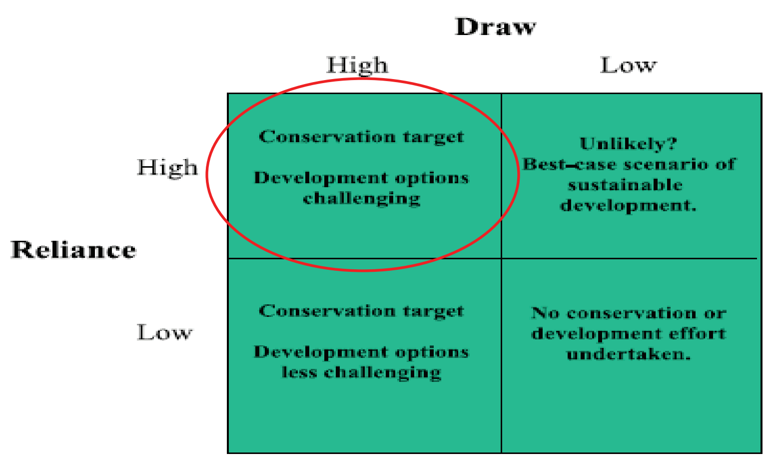
5.3.1.1.4 Additional classificatory approaches for describing the San Jose SFA system

Metzger's (2002) classification of the three main phases of the history of landscape occupation by slash-and-burn agriculture is a useful typology to describe the evolution of SFA systems. The first phase is said to usually occur in the first 15-20 years of occupation, during which agricultural expansion is characterized by the clearing of primary forest. The second phase is identified as one of expansion or intensification of agriculture. The former leading to a continued clearing of primary forest and the latter to an increase in the intensity of use of agricultural areas, generally through the reduction of fallow period (Metzger 2002, Lawrence et al. 1998). In the third phase, forests become scarce and an increase in agricultural production can only be obtained by a reduction in

[178] Agrosilvopastoral land use systems (with an important cattle ranching component) are also found in San Jose, but to a much lesser degree than are agrisilvicultural systems. Agrosilvopastoral systems will not be analyzed in this study.
[179] Figure 3: Sequence of land covers during fallow and forest succession.

fallow period. In the case of San Jose, intensification of agriculture and a reduction in fallow period are occurring, and available forest lands have become scarce primarily as a result of government land reform and increasing conversion of land to pasture for ranching. Increasing regional population densities are also attributable to the relatively long-term settlement of the region by humans due to relatively easy access facilitated by topography, development of nearby transportation infrastructure, and proximity to a large urban center (Santiago). San Jose appears to be in the early stages of Metzger's third phase. "The question", Metzger states, "is up to what point the fallow period can be reduced in the traditional [swidden-fallow] system without becoming unsustainable."
Using a framework developed by Coomes et al. (2004)[180] which considers the resource draw and economic reliance of communities on their local natural resources, San Jose can be considered a conservation target zone with challenging development options due to residents being highly forest reliant[181] and forest extractive[182].

Figure 11: Targeting Conservation and development initiatives across communities



Source: Coomes et al. 2004: 60 (red circle indicates where San Jose falls within this framework)

5.3.2 The San Jose home garden system

The San Jose home garden system will not be described in detail as this does not fall within the scope of this paper. As a result, limited data was collected regarding the home gardens of San Jose households.

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[180] See Figure 11: Targeting Conservation and development initiatives across communities.
[181] i.e. San Jose farmers rely heavily on the soil restorative properties of forests for their food production.
[182] i.e. San Jose residents extract high amounts of useful timber and NTFPs from surrounding forests.

Women are primarily responsible for managing home gardens, although men may also take part to varying degrees. The San Jose home garden system often includes perennial tree crops (e.g. lemons, mangos, and avocados); horticultural fruit and vegetable crops (e.g. peppers, tomatoes, melons); several varieties of plantain and banana; and to a lesser extent, traditional tuberous crops such as cassava, taro, and yam. The plots also include several tree species grown for their timber or NTFPs. Plots are generally adjacent to farmers' houses and tend to be less than 1 hectare in size. Occasional burning is used by certain farmers to control weeds, but for the most part, fire is not a major component of the San Jose home garden system. Animals such as chickens and fowl, as well as an occasional pig, may be found being raised alongside the house as well. Homegardens provide San Jose residents with a significant[183] proportion of their dietary needs, particularly with respect to household consumption of fruits and small farm animals.

5.3.3 The San Jose PROCESO satellite farm system

In its initial stages, the San Jose PROCESO Project and its satellite farm counted the participation of 15 adult residents[184] (n_r=15) from 12 San Jose households[185] (n_h=12) out of a population of 74 adult residents[186] (N_r=74) from 35 households[187] (N_h=35). For various reasons[188], several farmers subsequently ended their participation in PROCESO, bringing the total number of PPs upon my arrival to the community to 8 adult residents[189] (N_{pp}=8) from 6 households (N_h=6). Interviews were conducted with 7 PPs (n_{pp}=7) from 5 households (n_{pph}=4) out of a sub-population of 8 PPs (N_{pp}=8) from 6 households (N_{nph}=6).

Interviews were also held with 17 (n_{nph}=17)[190] of the estimated 24 (N_{nph}=24) SFA farmer heads of households[191].

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[183] Insufficient data was collected to determine the exact percentage of household food derived from homegardens. Although this amount is significant, SFA crops provide households with the majority of their staple foods of cassava, corn, and rice.
[184] MIDA, INA, and JICA 2004.
[185] MIDA, INA, and JICA 2004.
[186] Contraloría General de la República 2000.
[187] Contraloría General de la República 2000.
[188] See Table23: Why did you not participate in the PROCESO Project?
[189] Here PPs are considered to constitute their own sup-population (hence the use of 'N_{pp}').
[190] From 17 households.
[191] See section entitled 'Participant selection for semi-structured interviews with PPs and NPs' for more detailed information regarding interview samples.

The primary characteristics of the San Jose PROCESO satellite farm system[192] are that:

-it is practiced on a plot that is 3 hectares in size;

-it is a permanent agricultural system intended primarily for subsistence purposes with minimal market orientation;

-it is completely man-powered (i.e. no machinery or animal traction is used) and farmers use a set of basic farming tools to farm the land (e.g. shovels, hoes, wheel-barrows, etc.);

-it uses an irrigation system composed of a wind-powered water pump, a dam, irrigation PCV piping, a water tank, a hammer pump, drip irrigation lines for horticultural crops, and water retention ponds for the production of wetland rice, fish, and ducks.

-an intermittent stream runs through the plot during the rainy-season and fills a small cemented dam when running (when the stream is dry such as during most of the dry-season, the wind-powered water pump is meant to fill the dam);

-a high proportion of horticultural crops (including tomatoes, peppers, and pineapple) are produced; moderate proportions of corn, rice, tuberous crops, and fish are produced; and low proportions of coffee, medicinal plants, plantain, duck, and pig are produced;

-fire is used minimally for the initial clearing of the plot prior to the first cropping (this is followed by the subsequent abandonment of burning as a system component);

-several soil conservation and soil fertility enhancing technologies are used;

-it is located on relatively steep sloping land and was converted from pasture to its current land use; and

-PPs' land tenure on this plot is not officially secure, but they have received a verbal promise from the landowner that they may use the plot indefinitely; (efforts were made to obtain an official land title, but the process was deemed too expensive by JICA staff and PPs, and the landowner expressed that he was not interested in selling his land).

5.4 PROCESO technologies and their appropriateness for San Jose farming systems

The following sections will describe the technologies taught to PPs through the PROCESO project both at the San Jose satellite farm and at the 'mother farm'[193].

[192] See "Figure 18: Schematic diagram of the San Jose PROCESO satellite farm system" for a visual depiction of the primary components of this farming system.

Adoption of these technologies by PPs and NPs on SFA and home garden plots[194] will be presented. An assessment of their appropriateness for the three land-use systems[195] practiced in San Jose will also be performed.

5.4.1 Natural insecticides and fungicides

Natural insecticides and fungicides are used by all PPs in their home gardens and on the satellite farm, but no PPs use this technology on SFA plots. One of the PP households was already familiar with this technology prior to participating in PROCESO, having learned of it by participating in a previous agricultural extension project. NPs do not use these technologies at all and most NPs interviewed were unfamiliar with such techniques or had vague knowledge of them. These technologies are appropriate for home gardens and the satellite farm because: (1) they are cheap and easy to prepare; and (2) both of these farming systems have a significant proportion of available land dedicated to the production of horticultural crops, and such technologies are particularly effective when applied to horticultural crops. However, natural insecticides and fungicides have limited effectiveness against a variety of pests and diseases and are therefore not considered by most PPs as a reliable means of fighting them. In addition, it is not practical (due to the extensive nature of SFA agriculture) to apply these technologies on staple crops grown on SFA plots. These technologies are therefore deemed inappropriate for use in the San Jose SFA system. None of the PPs claim to use chemical pesticides, insecticides, fungicides, or herbicides, yet all admit to using chemical insecticides against leaf-cutter ants (primarily in home gardens, but also on SFA plots and on the satellite farm[196]).

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[193] See Table 27 for a list of PROCESO technologies and their use by PPs and NPs. In all, 36 technologies were taught through the PROCESO Project; 34 of these were being practiced on the San Jose satellite farm at the time of this study.

[194] Although limited data was collected on homegarden plot characteristics of individual San Jose households, the appropriateness of PROCESO technologies for the San Jose homegarden system generally will be assessed.

[195] The SFA system, home garden system, and PROCESO satellite farm system.

[196] Based on interviews with JICA extension staff, it was discovered that they are aware of the use of chemical insecticides against leaf-cutter ants on the satellite farm and that they agree that the use of such chemicals is the only means to fight these ants.

5.4.2 Organic fertilizers and soil building technologies

Organic fertilizers and soil building technologies are not used by PPs on their SFA plots because they consider these technologies to require too much labor to produce and apply in the quantities needed to cover such extensive areas (although all PPs stated that they believe these technologies would benefit soils on SFA plots). They are used to varying degrees in home gardens (bokashi=25%; compost=100%; mulching=75%; vermicompost/vermiculture=25%; green fertilizers/manures=0%), and are used by all PPs on the satellite farm. All PPs claim to have been familiar with these technologies prior to participating in PROCESO, but state that PROCESO has enabled them to improve their technical knowledge of how to prepare and apply them. NPs do not use these technologies on their SFA plots either, because they also consider these technologies to require too much labor to produce and apply in the quantities needed to cover such extensive areas, as well as because many NPs (76%) are not convinced these technologies are effective in improving soil properties on SFA plots. The production and application of compost *is* practiced by 65% of NPs in their home gardens however; but conversations held with several NPs seem to point to a very basic understanding of compost science which appears to be practiced more out of habit and tradition than because of a recognition and understanding of its benefits. Therefore, although both PPs and NPs practice organic composting in their home gardens, there may exist variation in quality among household composts. Through the PROCESO Project and other agricultural extension projects that have come to the village of San Jose, almost all San Jose farmers have been exposed to a variety of techniques for making compost. In addition, PPs learned how to make bokashi and vermicompost, as well as how to best balance carbon:nitrogen ratios, and humidity and aeration when making compost. PPs' compost may therefore be of superior quality[197] as compared to that of NPs.

Organic fertilizers and soil building technologies are deemed appropriate technologies for the San Jose home garden system, as associated small plot sizes allow for practical

[197]A future study could interview household individuals who practice home gardening as a primary agricultural activity in order to obtain detailed data on agricultural practices used in home gardens. Female adult members of San Jose households are usually the primary home gardeners. Therefore, female household members rather than male household members, who generally assume the majority of SFA farming activities, should be interviewed regarding home gardening. This approach was not taken in this study as its focus is primarily on SFA farming.

application requiring minimal labor inputs and levels of use of composting among San Jose households is relatively high. They are not deemed appropriate for use in the San Jose SFA system unless accompanied by recommendations for the incorporation of appropriate trees and other vegetation which would allow for on-site (*in-situ*) production and application of these technologies, thereby reducing the amount of labor inputs required for their application and production and increasing raw materials available for their production. With regards to the promotion of the introduction of azola (*azolla cristata*) in water bodies as a food source for ducks and a source of green fertilizer, one must beware of potential negative environmental impacts of releasing such algae into water bodies. There is a risk that when such algae bloom, they may cause nitrification of lakes and rivers. One must therefore be aware of the degree of invasiveness of such algae, particularly during periods of flooding or heavy rains when runoff could serve as a vector for the contamination of surrounding water bodies. However, if properly controlled and contained, azola can be considered an appropriate technology as it serves multiple uses (e.g. food for ducks and fish, weed control, source of nitrogen for organic compost and fertilizers, etc.) and requires little investment of cash or labor.

Overall, o*rganic fertilizers and soil building technologies* are deemed appropriate technologies for San Jose farming systems, particularly given that 'tired soils' was given as the primary agricultural production constraint faced by San Jose farmers[198].

5.4.3 Earth works & soil conservation technologies

Earth works & soil conservation technologies are not used by PPs on their SFA plots. Some are used to varying degrees in home gardens (terracing 25%; contour cropping 50%; live vegetative barriers 25%; dead barriers 25%). These technologies are all used by PPs on the PROCESO satellite farm. NPs do not use these technologies on their SFA plots either, and very few use any of them (live vegetative barriers 6%) in their home gardens. Adoption of these technologies by San Jose farmers depends on several factors, including the topography (i.e. slope, aspect, etc.) of individual plots. Those farmers with the highest level of risk of soil-erosion due to their plots having steep slopes, having a high degree of wind or water-runoff exposure, or being bare of vegetative cover may be

[198] See Table 25: What are the primary agricultural constraints you face?

more inclined to adopt these technologies. For example, one of the PPs interviewed stated that he used all of these technologies on his home garden plot because it was located on steep land and he had observed high levels of erosion.

Another consideration when assessing the appropriateness of earth works & soil conservation technologies is land tenure. The majority of farmers will not make major capital or labor investments in permanent infrastructural changes (e.g. terracing, extensive composting, or tree planting) without secure land tenure, as they would lose their investments if forced to abandon their farm land. Therefore, these types of technologies are most appropriate for plots on which farmers have secure land tenure (such as home garden plots or SFA plots for which farmers have secure tenure).

5.4.4 Crop management technologies

Crop management technologies are used to varying degrees buy PPs on their SFA plots. The use of *complementary crop associations* is a traditional SFA farming practice used by all PPs and NPs, on both SFA plots and in their home gardens. This practice is also used more intensively and with more specialization (or expertise) by PPs on the PROCESO satellite farm. Corn, rice, and different varieties of climbing bean are traditionally intermixed on SFA plots. Certain nitrogen fixing plants are sometimes planted alongside horticultural and tuberous crops in home gardens. Different varieties of flowers are also often planted in home gardens to attract beneficial insects, as well as for their aesthetic beauty. There are varying degrees of knowledge of beneficial plant associations among San Jose farmers.

Crop rotation and planned cropping sequences[199] are used by all PPs and NPs on their SFA plots. It is a traditional practice in San Jose to alternate where crops are planted during a swidden period. If part of a plot has yielded 1 or 2 crops of corn, beans, and rice, tuberous crops will often be planted there afterwards as they are more adapted than staple crops (corn and rice) to soils of low fertility and low organic matter content. This practice is used by all PPs and by 76% of NPs in their home gardens. Horticultural crops grown in home gardens will often be alternated so that once a crop has been harvested from one

[199] At times, crop rotations are used when a particular cropping sequence is repeated on an individual plot (this tends to be the case more frequently on SFA plots than in homegardens where cropping sequences tend to have greater spatial and distributional variance).

location, a different crop is planted in its place or the area is left to fallow for a certain period of time. This practice is also used by all PPs on the PROCESO satellite farm.

Row cropping is only used by 25% of PPs on their SFA plots and 50% of PPs in their home gardens. The individual who used this technique on his SFA plot primarily used it when planting tuberous crops. All PPs use this technology on the PROCESO satellite farm with various horticultural and tuberous crops, as well as with certain dry land rice crops. NPs do not use this technology on their SFA plots or on their home garden plots.

The incorporation of nitrogen fixing edible cover crops into swidden SFA plots is performed by only 1 PP (25%) and no NPs. This same PP also uses this technology in his home garden both as a source of nitrogen for his plants as well as a source of feed for his chickens. No NPs use this technology in their home gardens. All PPs use this technology on the satellite farm.

Crop management technologies are considered appropriate for all three farming systems as they can be implemented with low labor and capital inputs, are already in use by many San Jose farmers, and require low to moderate levels of technical knowledge.

5.4.5 Horticultural and tuberous crop technologies

Other than in the home gardens of PPs (propping/training of horticultural crops 100%) and on the satellite farm (100%), horticultural and tuberous crop technologies are not used by PPs or NPs. Seeds are generally directly planted on SFA and home garden plots and therefore seed beds are not used. The *planting of yam in burlap bags*[200] was a newly introduced technology at the time this study was conducted and may have higher adoption rates over time. These technologies are deemed appropriate for the three primary farming systems practiced in San Jose. The availability of sufficient burlap bags for widespread use and the potential for discarded bags to pollute the surrounding area are concerns with regards to this technology's appropriateness. The availability of a steady and cheap supply of these bags and proper management of waste produced from their use should be considered. The use of bags made from natural fibers rather than plastic should be promoted. *Seed beds and propping techniques* require low inputs of cash and labor and are therefore deemed appropriate for use in all three San Jose farming

[200] This technique was used to provide biodegradable, porous, and affordable 'containers' in which to plant yam so as to reduce the need for soil preparation and to better control soil composition and limit erosion.

systems. *Value added fruit processing* is used traditionally by all NPs and PPs on their home garden plots. This is done particularly with the *nance* (Byrsonima crassifolia L) fruit. No additional value added fruit processing technologies are currently practiced on the satellite farm. However, a small amount of coffee had been planted during the course of this study and could lead to a potentially marketable product. San Jose's low elevation and high ambient temperatures make it unlikely that high quality coffee will be produced on the satellite farm (other than perhaps certain low altitude *Robusta* varieties). In addition, coffee is an unfamiliar crop to San Jose farmers, the majority of whom lack the technical knowledge needed for optimal production of this crop.

5.4.6 Rice technologies

Seed selection and the b*reeding of rice varieties* are used by all PPs and NPs on SFA plots. PPs have been trained in certain advanced techniques for seed selection and the breeding of rice varieties which NPs may not be familiar with. It is however, a tradition among SFA farmers to select the best seeds from their rice harvests for future planting. Advancing San Jose farmers' knowledge of seed saving and breeding techniques is considered an appropriate technology for rice production in all San Jose farming systems. It is however a tradition among San Jose SFA farmers to select the best seeds from their rice harvests for future planting. Rice breeding techniques are traditional practices among San Jose farmers and their traditional technical knowledge should be incorporated into promoted technologies.

Seed and grain storage in silos is not used by NPs and only used by PPs on the PROCESO satellite farm. This technology requires a large capital investment from potential users and is therefore deemed inappropriate for San Jose farming systems due to the cash-poor status of most San Jose farmers and to often insecure land tenure.

Seed starting beds for rice are only used on the satellite farm by PPs. Rice is generally directly sowed onto SFA plots by both PPs and NPs. This technology is deemed appropriate for use in the SFA system, but adoption by San Jose farmers may be slow due to the long-term use of traditional sowing practices and to the extensive area of land that is be planted with rice which would require a high investment in labor for dry land rice to be started entirely in seed beds. This technology is more appropriate for wet land rice varieties that are planted more densely than dry land rice and over smaller, more concentrated areas.

Rice Ponds are only used by PPs on the satellite farm. They are used for growing wet-land rice and to provide food and habitat for the raising of ducks and koi. This technology is highly labor intensive and would be most appropriate for farmers with secure land tenure. An attempt was made by a member of the NP group to construct one on his land. The use of the constructed rice pond was later abandoned by this farmer as he was unable to maintain adequate water levels on a consistent basis.

Its appropriateness for a community with a relatively long dry season and an unreliable supply of municipal water due to a poor water delivery system is questioned. The wind powered water-pump installed so as to provide sufficient water supply to cultivate wet-land rice varieties year round has proved unreliable as well. This results in a high risk of crop failure if water supply is insufficient. In addition, the promotion of wet-land rice varieties and their associated cultivation practices are foreign to San Jose farmers who traditionally plant dry-land rice varieties. Overall, this technology is deemed inappropriate due to its incompatibility with available local water resources and traditional cultivation practices, and to the high labor investment required to build it. A positive aspect of this technology is that when an adequate water supply is present, it allows for higher rice yields per area of farm land and serves multiple purposes through its role in the raising of ducks and koi.

5.4.7 Water resources management technologies

Water resources management technologies are only used by PPs on the satellite farm.

They are not used by PPs or NPs on either home garden or SFA plots.

The building of a *dam* requires high labor investment and substantial capital investment in concrete if this is to be used in its construction (as is the case for the dam on the satellite farm). This technology also requires a moderate level of technical dam building knowledge. The dam also requires a minimum level of water supply on a year round basis in order to store sufficient water for watering crops. In San Jose, the dam is often dry due to a lack of adequate water supply. This technology is therefore considered inappropriate for San Jose.

A *hammer pump* is only used by PPs on the satellite farm. It is an appropriate technology for San Jose farming systems in that it increases the efficiency of water usage, does not require electricity to work but rather works using the force of gravity, and is a relatively simple technology to use and maintain. It is deemed inappropriate however, due to: (a) heavy initial capital investment requirements for the purchase of the unit itself and of associated irrigation piping; (b) the unfamiliarity of the technology (and of irrigation systems in general) to San Jose farmers who traditionally use only rain-fed farming systems; and (c) the potential for the technology to break down and the resulting risk of crop failure and loss of fish and ducks in the event that it does. This technology is also inappropriate for use in SFA systems as it can only be used in permanent cultivation systems that do not use fire for land clearing. This technology would be damaged if used in a farming system which uses fire and would require high investments in labor if it is was to be moved from one plot to another so as to follow shifting cultivation cycles. It is also inappropriate for farmers with insecure land tenure and/or farmers with plots on flat terrain which would not provide sufficient forces of gravity for the technology to work efficiently.

The satellite farm is the only farm in San Jose with a *wind powered water pump.* This technology involves heavy capital investment in parts and one must ensure that initial material and replacements parts are available and affordable. This is an unfamiliar technology to San Jose SFA farmers and therefore potential adopters would have very little knowledge of its upkeep and maintenance procedures. This technology also requires sufficient wind force and a high enough water table to pump out water. This technology is also deemed inappropriate for San Jose, although it has improved water supply to sections of the community to a certain degree and, when functioning properly, it has provided water during dry periods to the satellite farm.

Water holding tanks and drip irrigation systems are also only used by PPs on the satellite farm. These can generally be moved if necessary, and therefore may be appropriate for farmers with insecure land tenure. These technologies can still be considered 'semi-permanent' installations, as they would require intensive labor investments if moving and reinstalling them onto another farm plot was required. Both of these technologies require substantial capital investment for initial purchase as well as for the purchase of replacement parts for maintaining drip irrigation systems. These technologies are also unfamiliar to San Jose farmers and are not very compatible with the burning and shifting aspects of SFA systems.

5.4.8 Raising of animals and fish

The *raising of fish and other animals (ducks and rabbit)* is only used by PPs on the satellite farm on an occasional basis. Animal raising was listed as the top response for types of desired future development projects San Jose farmers would like to see in their community[201].

Several attempts in raising fish and animals on the satellite farm have resulted in animals perishing due to extreme heat, lack of water, attack by predators (snakes, etc.), illness, and other accidents.

Rabbits, fish and ducks are high potential sources of protein and animal fat for San Jose households. Rabbit fur could also be of potential use for farmers or a potential product to be sold in local markets. However, most of the rabbit species bred are non-native and could potentially become an invasive pest if released in the wild.

Ducks require a continuous supply of water and food. If the rice ponds in which they live go dry, this could result in animal losses. *Fish* are even more dependent on adequate water supply and are also a risky technology to adopt because of possible losses due to insufficient water and extreme heat.

The raising of such animals is an unfamiliar technology to San Jose farmers, who usually raise chickens, dogs, and pigs around their homes or to a lesser extent, cattle and horses on pasture.

Overall, the raising of animals (duck and rabbit) and fish are considered inappropriate for San Jose as they require technical knowledge and a substantial investment of labor when practiced, and involve animals that are ill adapted to the natural environment of San Jose.

5.4.9 Other technologies

Other PROCESO technologies taught at the San Jose satellite farm include *building clay ovens, planting medicinal plants, building ranch structures, and building a biodigester*.

[201] See Table24: What type of future development project would you like to see in San Jose?

The satellite farm is the only place to have an efficient *clay oven* ('*estufa lorena'*) in San Jose. The ovens are designed to be more efficient and therefore require less fire wood consumption for cooking. An added benefit is that less smoke is produced in these ovens than in traditional ovens, therefore making cooking environments less harmful to human health. This technology is best suited for use around the home as SFA may not be compatible with its use due to potential fire damage to the oven during burns and to the shifting nature of SFA.

The *planting of medicinal plants* in home gardens is a traditional practice for San Jose farmers (100% of PPs and 59% of NPs report planting them in their home gardens). The PROCESO project has introduced several potentially useful medicinal plants to PPs. Traditional knowledge of medicinal plants by San Jose residents should also be incorporated into the development of this technology.

The building of ranch structures using traditional building technologies and materials is used by all PPs and NPs around their homes. This technology is appropriate for permanent cultivation systems and therefore best suited for farmers with secure land tenure. It may also be incompatible with SFA systems because of potential fire damage to the structure during burns and of the shifting nature of SFA which may at times place the structure in a location that is inconvenient for SFA farmers. Aspects that make this technology appropriate for use in San Jose include that it is a traditional practice and that it uses readily available, local, and natural materials. Construction of such a structure may also help farmers strengthen their land tenure claims.

Biodigesters are not used by PPs or NPs in San Jose. Although this technology was planned to be implemented on the satellite farm, time constraints associated with the ending of the initial 3-year phase of PROCESO prevented this from happening. This technology is useful in that it provides a source of cheap and naturally produced fuel for San Jose farmers to cook and operate certain tools with. However, this technology is unfamiliar to San Jose farmers and requires moderate to substantial technical knowledge to implement.

5.4.10 Conclusion drawn from survey results

Perhaps given more time, the promotion of PROCESO technologies by trained promoters to farmers via farmer to farmer training will result in higher adoption rates of PROCESO technologies among San Jose farmers. With the PROCESO Project in the process of completing its initial 3-year phase and handing over operations to MIDA at the time of this study, project momentum may decrease as MIDA adapts to its new role as project administrator.

More generally, several technologies promoted through the PROCESO project are not well suited to the San Jose SFA system. The most appropriate technologies for improving the ecological sustainability of the San Jose SFA system have the following characteristics:

-they require minimal investments of labor and capital;

-they require minimal technical knowledge for implementation/operation;

-they lead to visible short-term improvements;

-there is a low failure risk when a technology is implemented;

-they are well suited/adapted to the ecological constraints of the area both at plot- and landscape-levels (e.g. water availability, ambient temperatures, soil fertility levels, etc.);

-they are well suited/adapted to the socio-economic constraints of the area both at household- and village-levels (e.g. cash and labor availability, land tenure status, educational level, etc.);

-they build on existing knowledge (including traditional technical knowledge);

-they provide San Jose farmers with ways to improve their individual farm plots (i.e. not a as a part of a group/community project[202])

-they promote the restoration of natural ecological cycles (e.g. restoring the natural water retention and drainage capacities of soils by increasing soil organic matter content through the planting of perennial MPTs); and

-they serve multiple purposes.

[202]When asked if they prefer to perform farm work in groups or individually, 100% of NPs (N_{np}=17) said that they preferred to work individually and 100% of PPs (N_{pp}=7) stated that they preferred working in groups. Although group-based projects do facilitate the exchange and development of ideas, if the majority of community members would rather work individually because they traditionally do so or because of personal differences with other community members, group-based projects may not achieve high levels of participation.

6 Conclusion and final recommendations

There exist numerous social, cultural, economic, and environmental factors that limit or facilitate the adoption of new agricultural technologies in SFA communities. This study identifies several of these factors and offers an analytical framework intended to assist extension officers in understanding contexts (such as San Jose) in which new agricultural technologies are introduced to SFA farmers. This study provides an analysis of agricultural practices employed by SFA farmers in San Jose and of their perceptions of an extension programme (PROCESO) that aims to introduce new appropriate technologies.

One of the author's intents is to leave an account of difficulties encountered in conducting field work, in contexts such as San Jose, so as to inform future studies conducting similar research. Thus, appropriate AF technologies are identified and intend to serve as a reference for extension workers and academics conducting community interventions and research in contexts similar to San Jose.

When approaching a community for participation in an agricultural extension project, agricultural extension agencies should not take a cookie-cutter, one-size-fits-all approach to the type of project to propose. Rather, in collaboration with target beneficiaries, specific land use systems practiced in a community should be identified and individual systems targeted for agricultural extension using a diagnosis and design approach as described in this paper. Once a land use system has been targeted for improvement, appropriate agricultural (including agroforestry) technologies should be designed so as to promote a phased transition from technologies and practices currently used by target beneficiaries towards improved ones. This type of phased approach should be taken over an approach promoting a categorical shift from one land use system to another[203].

In the case of San Jose SFA farmers, the major obstacles to the adoption of PROCESO technologies seem to derive either from the introduction of technologies that are either ecologically or culturally inappropriate, or those that are too labor or capital intensive when compared to current practices[204]. Most San Jose SFA farmers will tend to avoid high risk and capital intensive technologies because of the economic constraints that they

[203] As in the promotion of permanent agricultural systems as a strategy for improving SFA systems.
[204] Or a combination of these.

face. There tends to be very little or no surplus production for San Jose households during the course of a year and therefore, in terms of food security and human health, a small decrease in food supply at any given time can have a significant impact on the health of household members. In addition, most households are cash poor and have very little savings, opportunities for off- or on-farm cash income generation being scarce.

Worth noting, is the fact that most San Jose youth learn how to practice SFA farming by assisting their parents with their plots. What children learn from their parents is often the basis of future farmers' agricultural practices. Technologies diffused through intergenerational transfer are thus much more likely to be adopted by future farmers than those diffused otherwise. Hence, the promotion of appropriate agricultural technologies via intergenerational transfer should be a strategy of agricultural extension agencies working in San Jose.

In the case of San Jose, care must be taken to recognize the primary land use systems practiced by its farmers: SFA and home gardening. These should be considered as distinct farming systems requiring distinct extension approaches and sets of technologies. An extension project (such as PROCESO) which promotes agricultural technologies intended for use in both types of land use systems can be appropriate. However, it must be made clear to beneficiaries receiving extension when a certain technology is better suited for use in one type of farming system over another. Preferably, an extension project will target a single land use system and promote associated appropriate technologies rather than targeting several land use systems for improvement.

If demonstration plots are a component of an agricultural extension project (such as in the case of the PROCESO project), this author recommends using a demonstration plot that is representative of plots used for a targeted farming (or land use) system[205]. For any farming system being targeted, a plot with similar characteristics to the plots on which the farming system is applied locally should be used as a demonstration plot. In the case of the PROCESO satellite farm demonstration plot, the selected plot was surrounded by

[205] For example, if most farm plots on which a particular land use system is practiced are found on land with steep slopes, plots on flat land should not be selected as demonstration plots; or if a home garden system is targeted for improvement, a demonstration plot should ideally be located around a home or similar environment (e.g. a school). In the case of the PROCESO Project, the San Jose Satellite farm was located on representative steep slopes, whereas the 'mother' farm demonstration site was not and can therefore be considered a less appropriate demonstration site.

SFA plots and would, typically, also have been used as an SFA plot. However, this plot was used to demonstrate a permanent agricultural system when permanent agriculture is only practiced under the form of home gardens in San Jose.

The San Jose SFA system was chosen as the main focus of this paper because it is the primary agricultural system practiced in San Jose with regards to: (1) its number of practitioners; (2) its importance as a food source in terms of meeting the food security needs of San Jose residents; and (3) the amount of land area under this land use. In addition to the bulk of San Jose residents' subsistence needs being met by SFA, this agricultural system, as practiced by San Jose farmers, is causing severe environmental degradation and has lead to decreasing agricultural production yields. This author therefore recommends that extension efforts focus on improving the San Jose SFA system, rather than other land use systems practiced in San Jose. Unfortunately, a large proportion of extension projects carried out across Panama (in communities where SFA is practiced in a similar manner as in San Jose) promote technologies primarily appropriate for use in either home garden systems (which play a much smaller role in meeting household subsistence needs of such communities than SFA systems do) or permanent agricultural systems (which are rarely used by smallholder farmers in such communities).

If the San Jose SFA system is targeted for improvement by an extension agency, care should be taken if a demonstration plot is to be selected for use in an extension project. One approach would be to select a demonstration plot which is not so degraded that it will require an extended period of time to show positive results of applied technologies. Therefore, a field with relatively developed vegetative regrowth should be chosen so that associated soil fertility levels are high and so that soil structure benefits from high organic matter content. On the other hand, selecting a plot with low soil fertility and poor soil structure (such as pasture often is) can serve at least two purposes: 1) when improvements resulting from the application of appropriate technologies become noticeable, they can serve as proof to skeptical observers that even a nutrient deficient, overgrazed plot with compacted soils can be restored using appropriate technologies (particularly appropriate agroforestry technologies), and 2) environmentally, it is sounder to restore a plot of degraded land (such as degraded pasture) than to convert forested land. Regardless, a selected demonstration plot should aim to mimic to the greatest extent possible the conditions under which SFA farmers operate (i.e. farming forested land in swidden-fallow cycles), rather than operating under ideal or extraordinary conditions. Furthermore, demonstration plots should ideally be selected on land with clear land tenure[206].

As noted by Buckles et al. (1998), "high-yielding cropping systems can be devised by taking full advantage of the spontaneous ecological processes at work in a given environment, in sharp contrast to technologies that greatly modify the crop environment with external inputs." Hence, rather than investing in efforts to promote labor or capital intensive technologies, future extension projects targeting the San Jose SFA system should aim to "restore the productive capacity of [degraded] lands so that the need for deforestation and bringing new land under cultivation can be minimized" (Lal 1995: 59). According to Lal (1995: 59-60), "restoring these lands requires: controlling soil erosion through runoff management and ground cover establishment; improving soil structure through appropriate measures of soil surface management; establishing vegetative cover through growing an appropriate combination of aggressively growing cover crops and quick-growing perennials; replenishing plant nutrients lost out of the ecosystem; and preventing additional losses of water and nutrients from the ecosystem." Several agroforestry technologies appropriate to the San Jose SFA system and intended to facilitate the reaching of these restoration goals have been described in detail in this paper. These include improved fallow and improved swidden technologies; particularly, the incorporation of woody herbaceous species and perennials in association with food crops into SFA systems. "[This is] known to increase ecological diversity within a landscape unit and optimize the use of limited resources through the integration of complementary components (Lal 1995: 114-115).

Although an ultimate goal of an extension project may be that burning be completely eliminated from a SFA system, as mentioned previously, this should be approached as a gradual (or phased) abandonment. A phased replacement with alternatives such as slash-

[206] If a group-project extension approach (such as PROCESO) is taken, the selection of a plot with a clear land title and with a landowner willing to sell the land that the plot is on to project participants is recommended. Ideally such a plot would be purchased prior to technological improvements being implemented on it, so as not to provide an incentive for the landowner to subsequently not sell the land or to sell it at a higher price because of a perceived increase in the land's value as a result of implemented improvements.

and-mulch systems and eventually multi-storey intercropping with perennial multi-purpose trees (MPTs) should also be promoted, rather than promoting an immediate and definitive abandonment of SFA systems. Extension agents should rather recommend that burns be less frequent, better controlled, less extensive, and buffered by fire-resistant vegetation when possible. Such an approach will have a much better chance of technologies being well received, adopted, and diffused by SFA farmers. Introducing technologies developed in cooperation with SFA farmers[207] and incorporating SFA farmers' local (or traditional) technical knowledge will likely also lead to more accelerated innovation of agricultural technologies than would the introduction of non-participatory, top-down, foreign agricultural technologies. As noted by FAO (1985), "agroforestry is just one of many ways in which farmers faced both with the need to produce more food and with increasing scarcity of land and deteriorating soil can transform shifting cultivation into a more positive and productive cropping system which can be practiced in full harmony with the natural surroundings and the needs of their human occupants. Any changes should take into account local physical or socioeconomic constraints. There is need for more dialogue with farmers so that both foresters and agriculturists can learn from their considerable local experience, and so that alternatives proposed in particular areas may be well adapted to the particular needs and skills of the local inhabitants." Finally, "although general principles may be the same, technological packages (systems) for the sustainable management of soil and water resources are site-specific and depend on farming/cropping systems, farm size, the availability of essential inputs, and socio-economic factors." Thus, "locale-specific and on-farm synthesis of [appropriate technology] packages is needed" (Lal 1995: 52) and the sustainability of land use systems "must be assessed at different levels, [scales,] or hierarchies (e.g. technology, sub-system, or system) (Lal 1995: 54)."

As stated by Lal (1995: 6), "major attributes of sustainable land use are: using land resources on a long-term basis; meeting present needs without jeopardizing future potential; enhancing per capita productivity; maintaining/enhancing environmental quality; and restoring productivity and the environmental regulatory capacity of degraded

[207] Through the use of participatory methodologies.

and impoverished ecosystems." This paper has suggested ways by which such attributes can be realized for SFA land use systems in communities such as San Jose. It is this author's hope that the recommendations and analyses contained herein are taken as an attempt to simplify the decision-making process for agricultural extension agencies on how to allocate often limited agricultural extension resources towards the identification of appropriate extension approaches and technologies for agricultural extension projects carried out in communities located in the sub-humid tropical lowland, dry forest zones of Panama in which SFA is practiced. It is not this author's intent to criticize or cast a negative light on the agricultural extension projects carried out in such communities. Such projects have improved the standard of living of innumerable smallholder farmers throughout Panama and are most often run and implemented by extremely dedicated, knowledgeable, and compassionate extension staff[208]. Agricultural extension is extremely challenging work requiring the balancing of a multitude of complex and interrelated factors. Attempts to simplify decision-making processes involved in this work should take care not to over-generalize or over-simplify the realities of the contexts in which they operate. The information contained herein is therefore primarily intended for consideration in agricultural extension projects targeting SFA systems in the community of San Jose, or communities with similar ecological, socio-economic, and cultural characteristics as San Jose.

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[208] This was the case for the PROCESO project in San Jose.

Appendices

Appendix A: Survey questions used in semi-structured interviews

Although the actual survey questionnaires used for conducting semi-structured interviews are not included in this paper due to their excessive length, the following questions are those deemed most relevant by the author and presented in the results and discussion section of this paper. For a copy of the complete survey questionnaires used in this study, please contact the author. The questions are organized by major themes identified during survey design. These themes are: 'San Jose SFA land use system'; 'San Jose home garden land use system'; 'Farmer participation in the PROCESO Project'; 'Farmer use of PROCESO technologies; and 'General questions about San Jose'.

Theme: San Jose SFA land use system
(Questions asked to both PPs and NPs)
-Do you practice SFA?
-Why do you use SFA?
-Were your parents SFA farmers?
-What is the size of your SFA landholding?
-Do you rent, own, or share/borrow the land that you farm using SFA?
-What crops do you grow on your SFA plots?
-Why is planting corn as a crop preferred to planting rice?
-How long do you allow SFA plots to fallow?
-Are fallow lengths used currently shorter than in the past?
→If yes, why are fallow lengths shorter than in the past?
-What is the size of SFA plots currently in swidden?
-What is the size of SFA plots currently in fallow?
-Do you use chemical inputs on SFA plots?
-Do you use organic inputs on SFA plots?
-Do you prefer to work in groups or individually? Why?

Theme: San Jose home garden land use system
(Questions asked to both PPs and NPs)
-Do you have a home garden?
-Do you rent, own, or share/borrow the land that you farm as a home garden?
-Do you burn home garden plots?
→If yes, with what frequency?
-What crops do you grow in your home garden?
-What is the size of your home garden landholding?

-Do you use chemical inputs on home garden plots?
-Do you use organic inputs on home garden plots?

Theme: Farmer participation in the PROCESO Project
(Questions asked to NPs):
-Why did you choose not to participate in the PROCESO Project?

(Questions asked to PP):
-Why did you decide to participate in the PROCESO Project?
-Have you learned any new agricultural technologies from participating in PROCESO?
→If yes, what are these technologies?

Theme: Farmer use of PROCESO technologies
(Question asked to PP and NP households)
-Do you practice any of the following PROCESO technologies on your SFA or home garden plots?

(Question asked to PPs)
-Have you practiced or implemented any of the following technologies on the San Jose satellite farm?

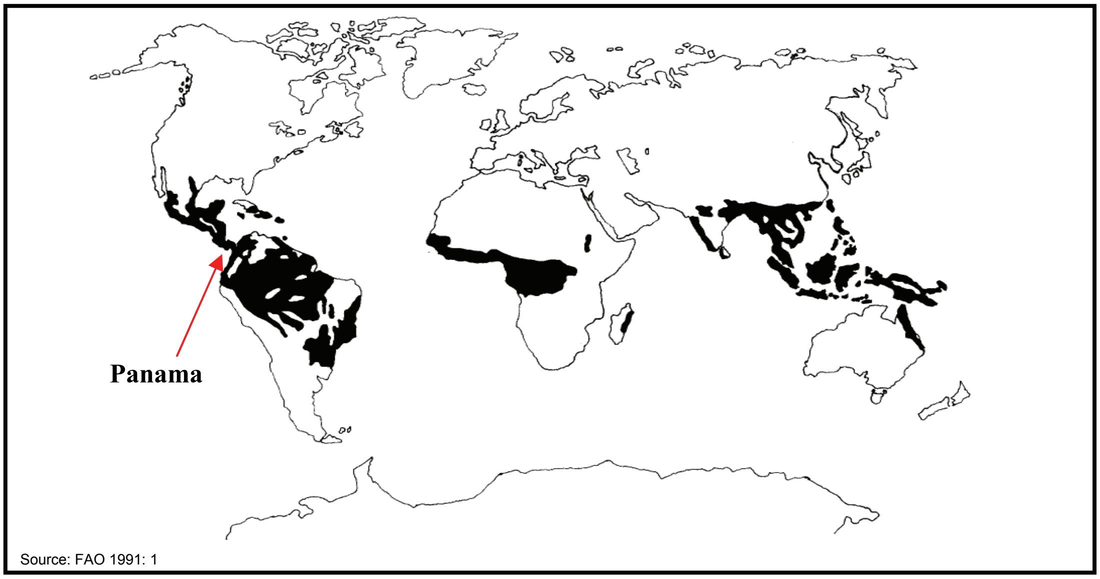
<u>PROCESO technologies:</u>
-Natural insecticides and fungicides (garlic extract, chili pepper extract, etc.)
Organic fertilizers and soil building technologies
-Bokashi
-Compost
-Mulching (e.g. leaf litter, wood chips, etc.)
-Vermicompost/vermiculture
-Green fertilizers/manures (e.g. azola)
Earth works & soil conservation technologies
-Terracing
-Contour cropping (using A-frame)
-Live vegetative barriers (e.g. vetiver, lemon grass)
-Dead barriers (e.g. wood, stone, etc.)
Crop management technologies
-Crop associations (complementary crops)
-Crop rotation
-Row cropping
-Nitrogen fixing with edible cover crops (e.g. mucuna with corn, pigeon pea)
Horticultural and tuberous crop technologies
-Plant nursery (seed beds)
-Propping/training techniques for horticultural crops
-Planting yams in burlap bags
-Value added fruit processing (nance)
Rice technologies

-Seed selection
-Seed storage (in silo)
-Seed starting (seed beds)
-Breeding of rice varieties
-Rice ponds
Water resources management technologies
-Hammer pump
-Water retention ponds (rice ponds and dam)
-Dam construction
-Wind powered water pump
-Drip irrigation
-Water holding tank
Raising of animals and fish
-Rabbit breeding and raising in cages
-Aquaculture (carp-koi) in rice ponds
-Duck breeding and raising in rice ponds
Other technologies
-Clay oven (*'estufa lorena'*)
-Medicinal plants
-Building of ranch structure using naturally available materials
-Biodigester

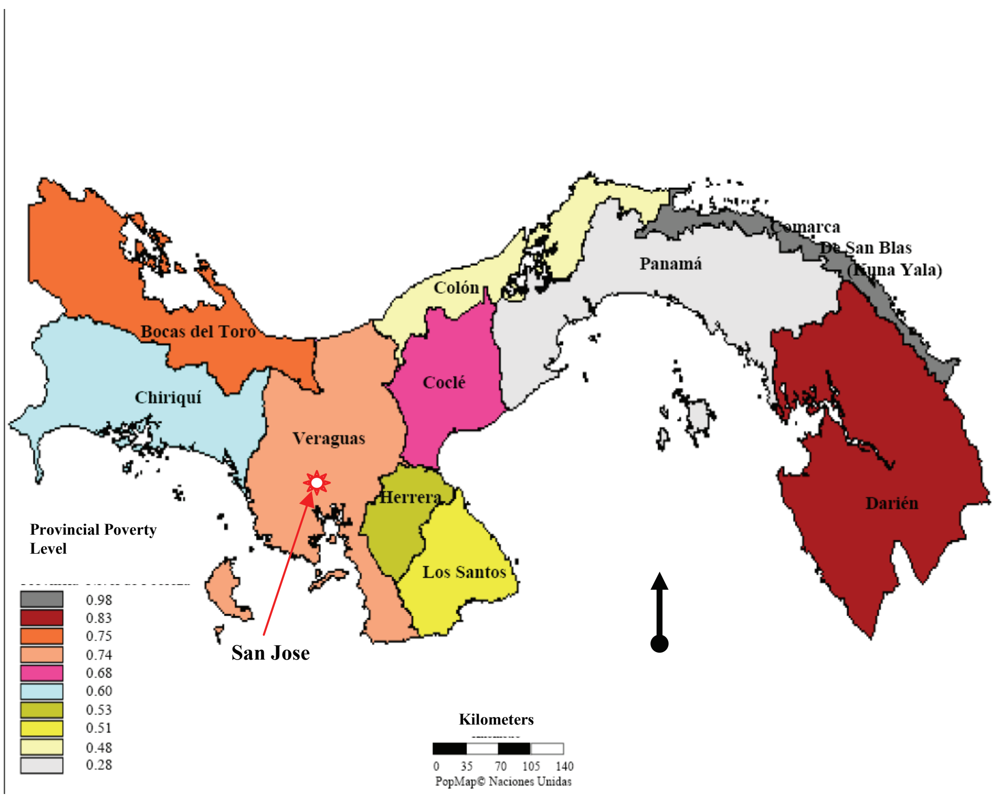
Theme: General questions about San Jose
(Questions asked to both PPs & NPs):
-In general, what are the most urgent needs of San Jose?
-What are the primary agricultural production constraints that you face?
-What type of future development project would you like to see in San Jose?

Appendix B: Maps

Map 1: Distribution of the humid tropics

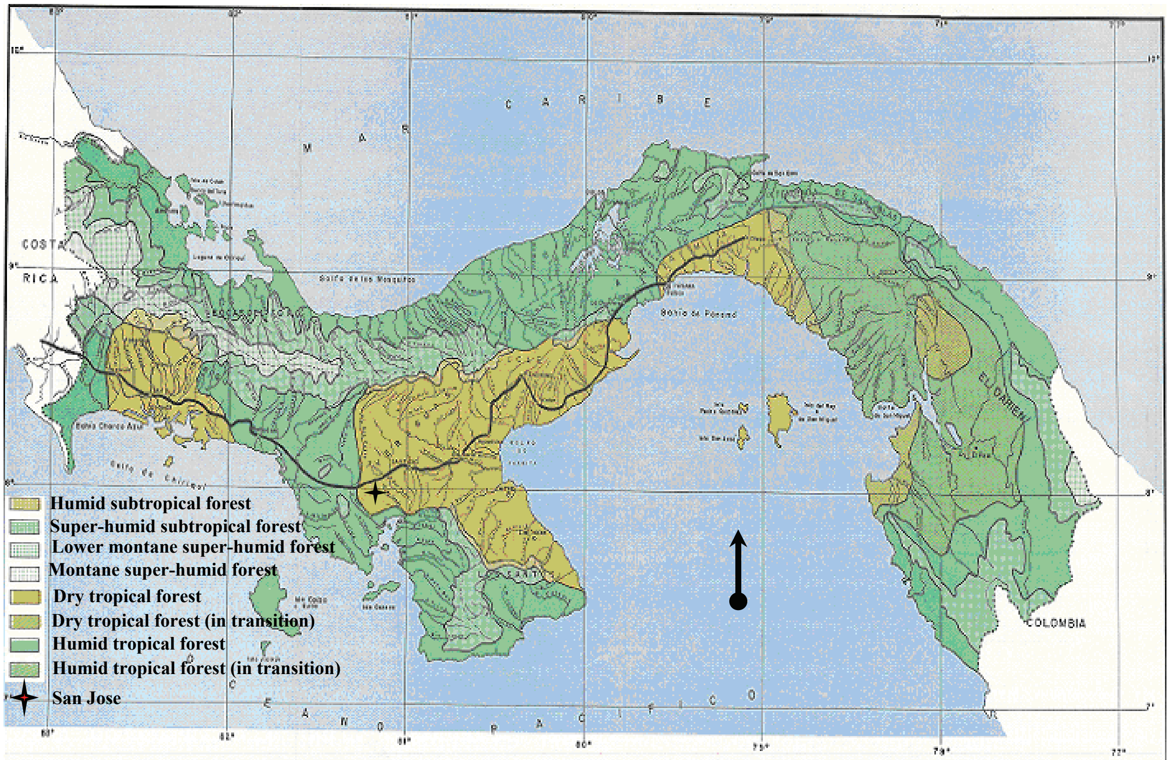


Map 2: Poverty in Panama by province



Source: Dirección de Políticas Sociales del Ministerio de Economía y Finanzas 1999. PopMap© Naciones Unidas.

Map 3: Ecological Map of Panama (According to Dr. L.R. Holdridge and Gerardo Budowski Engr.)



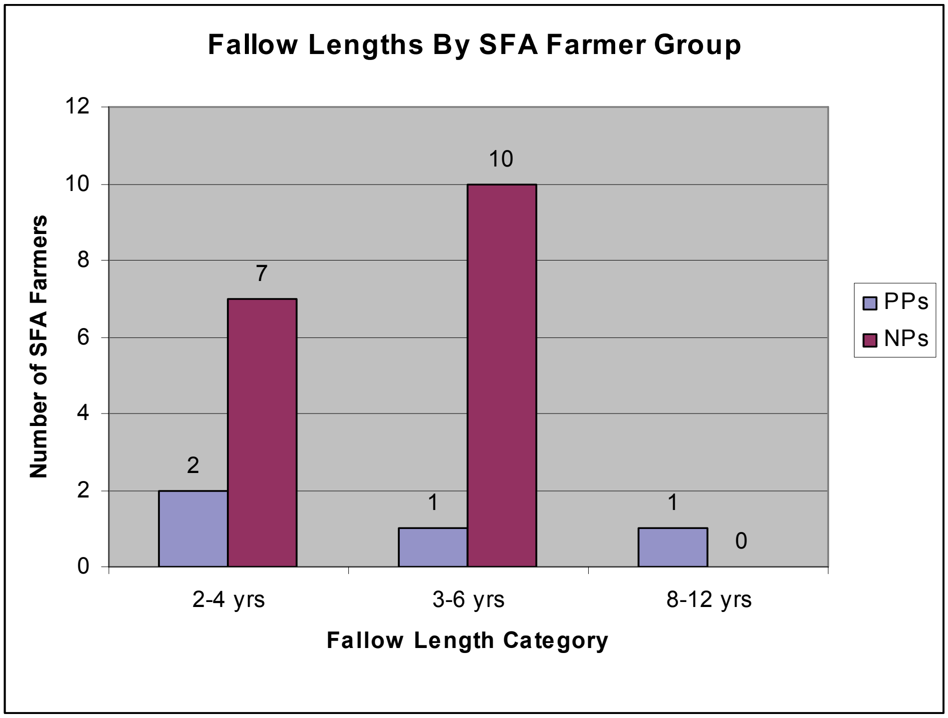
Source: O.A.S. 1959

Map 4: Topographical Map of San Jose Region

Source: Veraguas Central ARC Digitized Raster Graphics Coverage of TLM-50: NB1760 Approx. coverage: 8º00'N to 8º30'N, 81º45'W to 81º00'W National Imagery and Mapping Agency (NIMA).

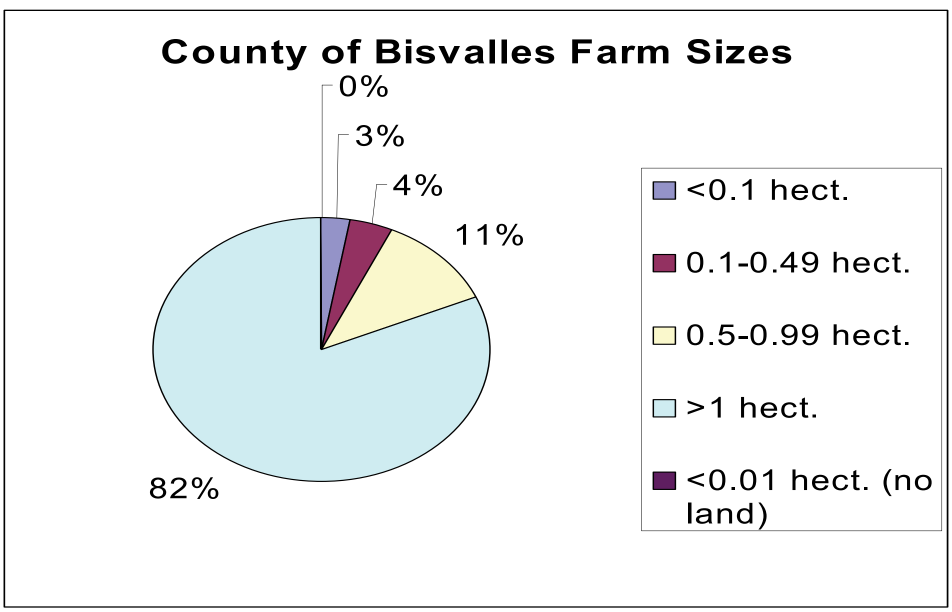
Appendix C: Charts, graphs, tables, and other figures

Figure 12: Fallow lengths of San Jose SFA farmers



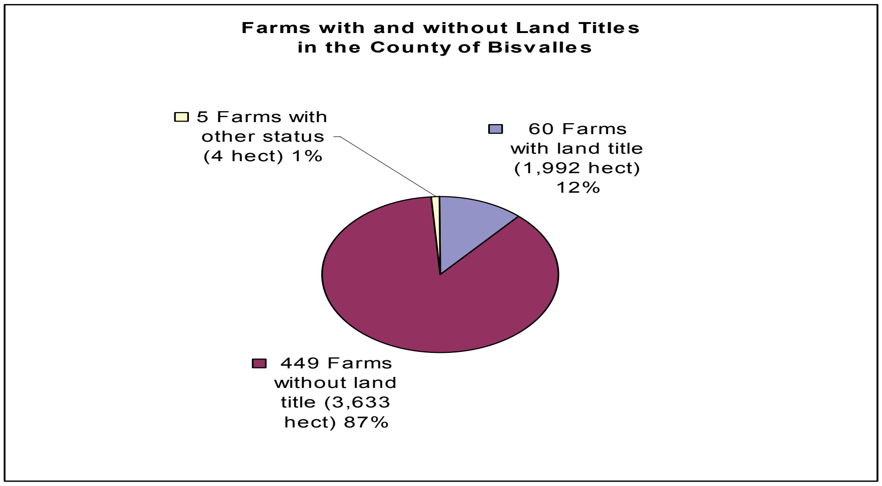
Based on data derived from: interviews with San Jose PPs and NPs

Figure 13: **Farm sizes in the County of Bisvalles**



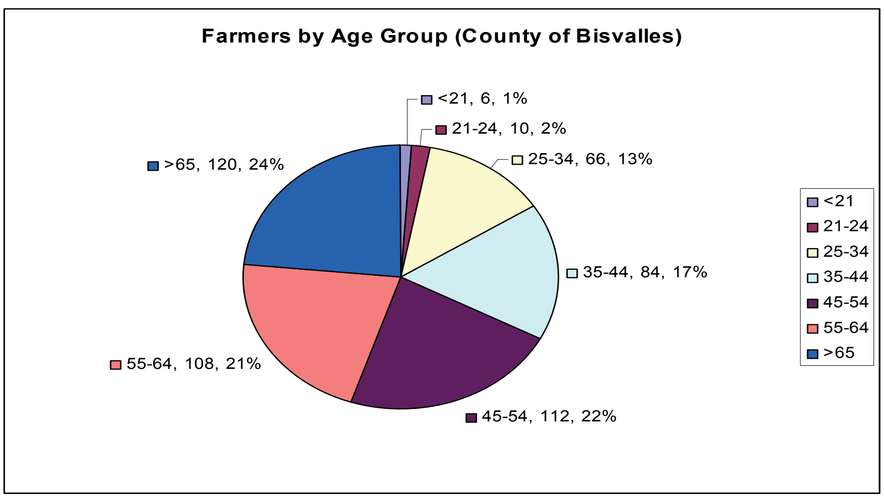
Based on data derived from: Contraloría General de la República 2001

Figure 14: Land titling in the County of Bisvalles



Based on data derived from: Contraloría General de la República 2001

Figure 15: Farmers by age group (County of Bisvalles)



Based on data derived from: Contraloría General de la República 2001

Figure 16: Why is planting corn as a crop preferred to planting rice?

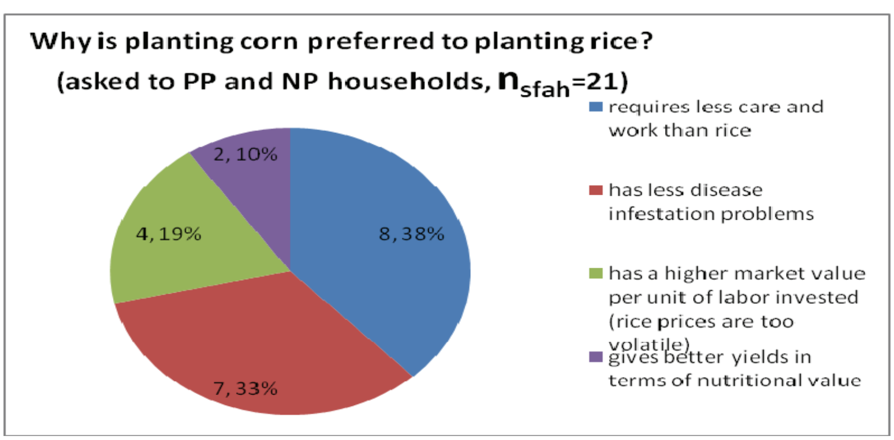


Figure 17: Why are fallow lengths shorter than in the past?

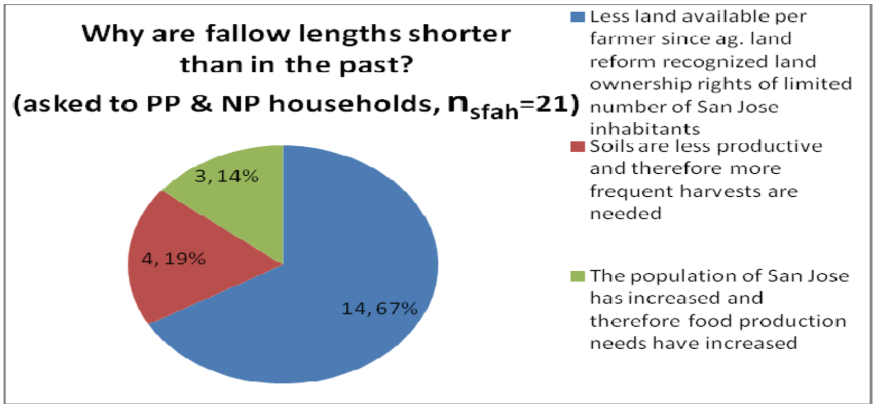


Table 23: Why did you not participate in the PROCESO Project? (asked to NPs, N=17)

Top answers by rank: (1) SA requires too much work and shows little results (2) Participating in the PROCESO project requires dedication and taking on responsibilities (3) Don't know

See Figure 19 for detailed breakdown of responses

Table 24: What type of future development project would you like to see in San Jose? (asked to PP & NP households, n_{sfah}=21)

Top answers by rank: (1) animal raising (2) house improvement project (3) sustainable agriculture project (4) home garden project (5) school environmental and agricultural education project involving youth

See Figure 20 for detailed breakdown of responses

Table 25: What are the primary agricultural production constraints you face? (asked to all San Jose households, N=35)

Top answers by rank: (1) Tired soils (2) Crop disease and fungus (3) Lack of financial capital (4) Lack of irrigation system (5) Lack of technical assistance **(Data derived from: MIDA, INA, and JICA 2004b)** (n.b. number of observations unavailable)

Table 26: In general, what are the most urgent needs of San Jose?

(asked to PP & NP households, n_{sfah}=21)

Top answers by rank:
(1) Reliable water supply for household use and crop irrigation (2) Electricity (3) An even redistribution of land

See Figure 21 for detailed breakdown of responses

Table 27: PROCESO technologies taught at San Jose satellite farm and their use by PPs & NPs

PROCESO Technologies	**Use of PROCESO Technologies by PPs & NPs on:**				
	SFA Plots		*Home garden plots*		*PROCESO satellite farm*
	PPs n_{pph}=4	*NPs* n_{nph}=17	*PPs* n_{pph}=4	*NPs* n_{nph}=17	*PPs* n_{pp}=7
Natural insecticides and fungicides (garlic extract, chili pepper extract, etc.)	0%	0%	100%	0%	100%
Organic fertilizers and soil building technologies					
-Bokashi	0%	0%	25%	0%	100%
-Compost	0%	0%	100%	65%	100%
-Mulching (e.g. leaf litter, wood chips, etc.)	25%	0%	75%	0%	100%
-Vermicompost/vermiculture	0%	0%	25%	0%	100%
-Green fertilizers/manures (e.g. azola)	0%	0%	0%	0%	100%
Earth works & soil conservation technologies					
-Terracing	0%	0%	25%	0%	100%
-Contour cropping (using A-frame)	0%	0%	50%	0%	100%
-Live vegetative barriers (e.g. vetiver, lemon grass)	0%	0%	25%	6%	100%
-Dead barriers (e.g. wood, stone, etc.)	0%	0%	25%	0%	100%
Crop management technologies					
-Crop associations (complementary crops)	100%	100%	100%	100%	100%
-Crop rotation	100%	100%	100%	76%	100%
-Row cropping	25%	0%	50%	0%	100%
-Nitrogen fixing with edible cover crops (e.g. mucuna with corn, pigeon pea)	25%	0%	25%	0%	100%
Horticultural and tuberous crop technologies					
-Plant nursery (seed beds)	0%	0%	0%	0%	100%
-Propping/training techniques for horticultural crops	0%	0%	100%	0%	100%
-Planting yams in burlap bags	0%	0%	0%	0%	100%
-Value added fruit processing (nance)	0%	0%	100%	100%	0%
Rice technologies					

PROCESO technologies taught at San Jose satellite farm and their use by PPs & NPs (cont.)					
-Seed selection	100%	100%	100%	100%	100%
-Seed storage (in silo)	0%	0%	0%	0%	100%
-Seed starting (seed beds)	0%	0%	0%	0%	100%
-Breeding of rice varieties	100%	100%	0%	0%	100%
-Rice ponds	0%	0%	0%	0%	100%
Water resources management technologies					
-Hammer pump	0%	0%	0%	0%	100%
-Water retention ponds (rice ponds and dam)	0%	0%	0%	0%	100%
-Dam construction	0%	0%	0%	0%	100%
-Wind powered water pump	0%	0%	0%	0%	100%
-Drip irrigation	0%	0%	0%	0%	100%
-Water holding tank	0%	0%	0%	0%	100%
Raising of animals and fish					
-Rabbit breeding and raising in cages	0%	0%	0%	0%	100%
-Aquaculture (carp-koi) in rice ponds	0%	0%	0%	0%	100%
-Duck breeding and raising in rice ponds	0%	0%	0%	0%	100%
Other technologies					
Clay oven (*'estufa lorena'*)	0%	0%	0%	0%	100%
Medicinal plants	0%	0%	100%	59%	100%
Building of ranch structure using naturally available materials	0%	0%	100%	100%	100%
Biodigester	0%	0%	0%	0%	0%

Figure 18: Schematic diagram of the San Jose PROCESO satellite farm

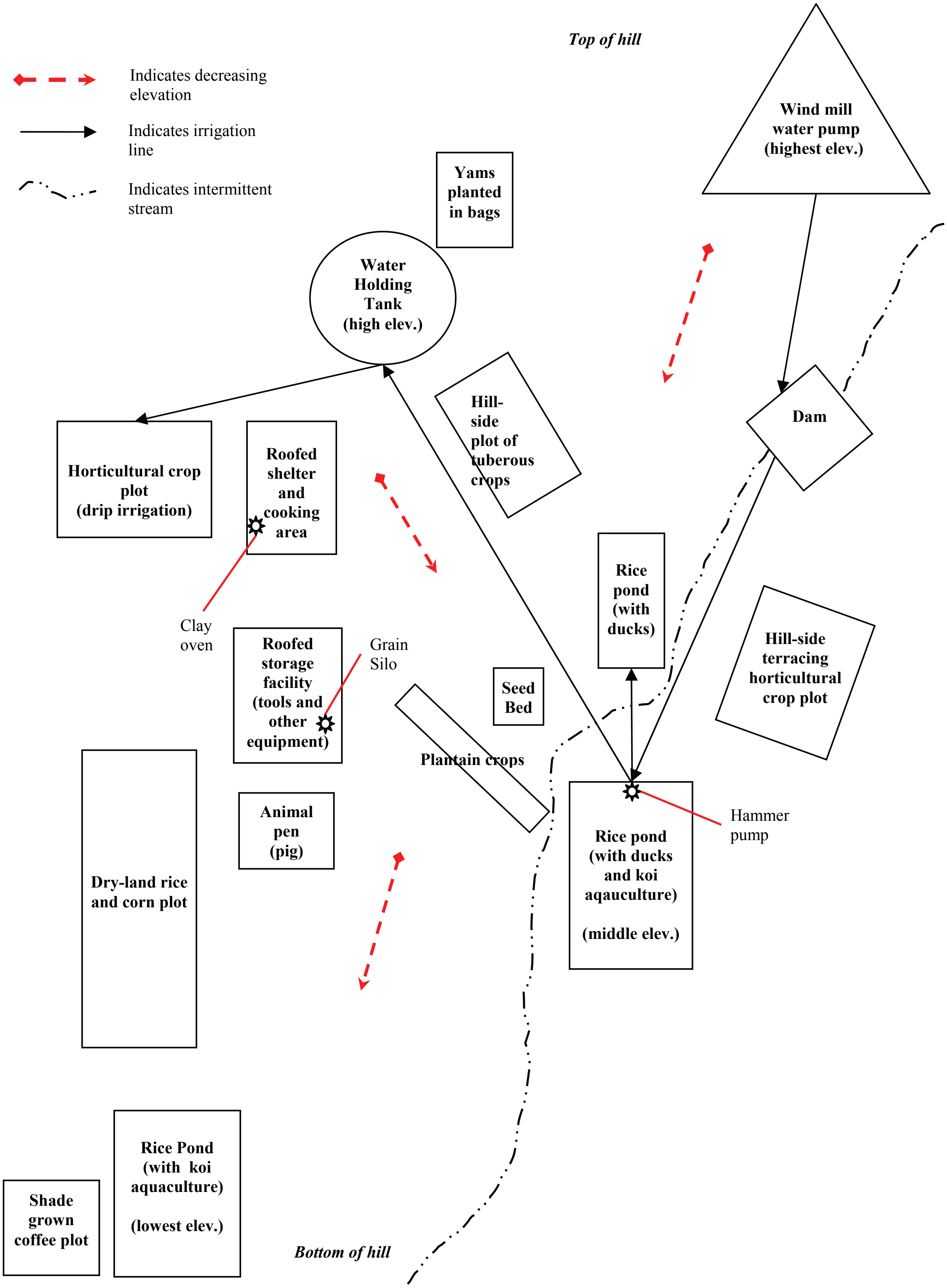


Figure 19: Why did you not participate in the PROCESO Project?

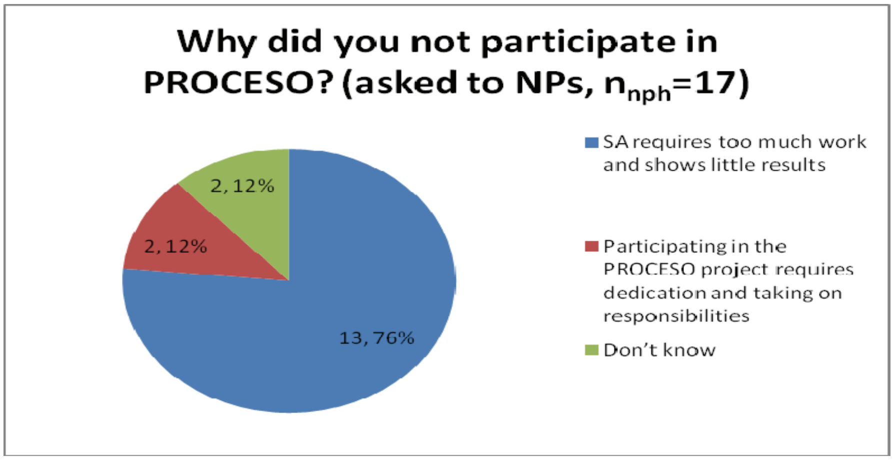


Figure 20: What type of future development project would you like to see in San Jose?

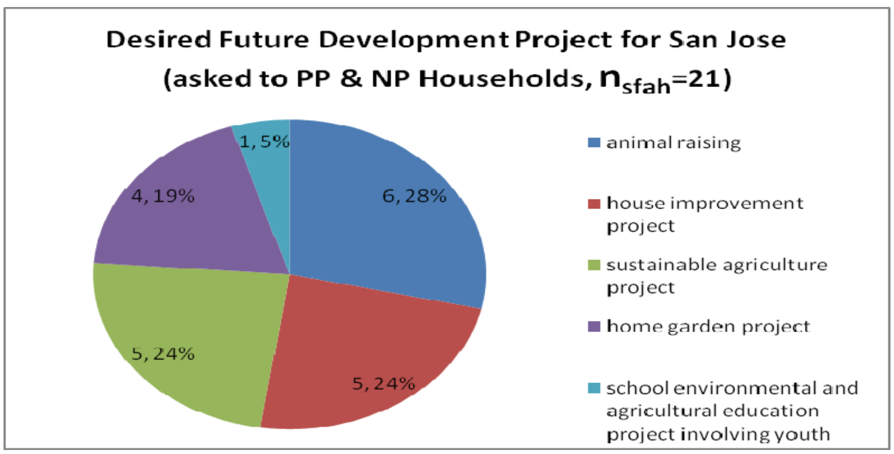
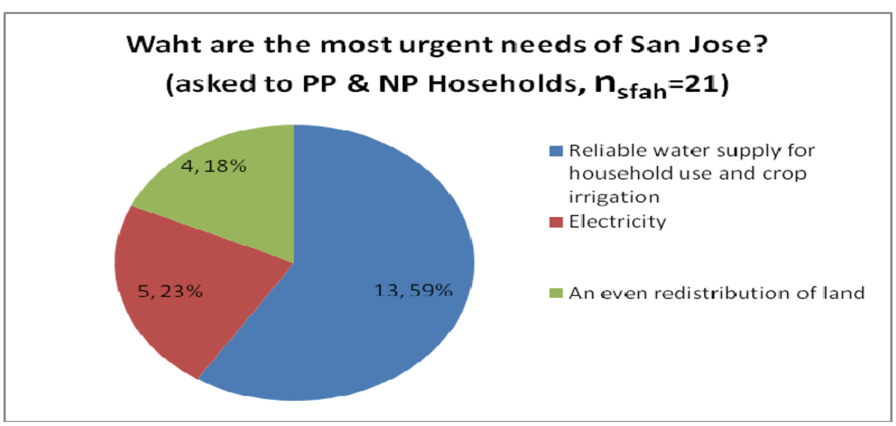


Figure 21: In general, what are the most urgent needs of San Jose?



Appendix D: Ethics certificate for research involving human subjects

MCGILL UNIVERSITY
FACULTY OF AGRICULTURAL AND ENVIRONMENTAL SCIENCES

CERTIFICATE OF ETHICAL ACCEPTABILITY FOR
RESEARCH INVOLVING HUMANS

The Faculty of Agricultural and Environmental Sciences Research Ethics Board consists of 4 members nominated by the Faculty of Agricultural and Environmental Sciences Nominating Committee and elected by Faculty, an appointed member from the community and an individual versed in ethical issues.

The undersigned considered the application for certification of the ethical acceptability of the project entitled:

Identifying and overcoming obstacles to the adoption and diffusion of sustainable agricultural technologies by smallholder farmers. A case study: the community of Los Valdeses in the County of Bisvalles, District of La Mesa, Province of Veraguas, Panama.

as proposed by: Alexander de Roode

Applicant's Name: Alexander de Roode   Faculty Supervisor's Name: Dr. Robert Bonnell

Applicant's Signature: A. de Roode   Faculty Supervisor's Signature: [signature]

Degree / Program / Course: MSc Bioresource Engineering (Standard Program Thesis Option)

Granting Agency: Department of Bioresource Engineering, McGill University

Grant Title:
(If different from project title)

For administrative use   REB # 870-0806

Approval Period: SEPT. 26, 2006 to SEPT. 27, 2007

The application is considered to be:

A Full Review ______   An Expedited Review x

Approval:

MANFRED RAU
Chair, Research Ethics Board, FAES

M. E. Rau   SEPT. 26. 2006
Signature   Date

To be submitted to:
Chair, Research Ethics Board, Faculty of Agricultural and Environmental Sciences
c/o Lynn Murphy
Macdonald Campus Research Office
Raymond Building, Room R3-032
Tel: (514) 398-8716

September 2005

Appendix E: JICA Background information

This section provides a general description of JICA's role as an international development agency. It is meant to provide readers with an understanding of: (1) how JICA is organized and operates at an institutional level and (2) the development activities in which JICA is involved.

General description of JICA's International Development Programme[209]

JICA is the Japan International Cooperation Agency. Its mission is to serve as a bridge between the people of Japan and developing countries. It aims to advance international cooperation through the sharing of knowledge and experience and works to build a more peaceful and prosperous world. JICA was founded in 1974 and was relaunched as an independent administrative institution in 2003, emphasizing greater results-orientation and accountability.

JICA attempts to decentralize the decision-making process and strengthen field-based initiatives by responding to the needs of people in developing countries in an efficient manner. In the implementation of its projects, JICA follows three important guidelines. These are: (1) taking a *field oriented approach* to development work by acknowledging that the problems that individual countries face vary widely according to their style of government, culture, and recent history, and that Japan's technical assistance should therefore be adapted to country-specific contexts; (2) supporting endeavors of developing countries and their people by promoting a *human security*[210] approach to its activities, advocating both a "protection" approach, meant to strengthen the recipient country's administrative capabilities, and an "empowerment" approach that engages communities and individuals at their own level and sharpens their drive to better their lives; (3) emphasizing *effectiveness, efficiency, and speed* in the implementation of its assistance projects by streamlining its activities through organizational reform and by simplifying procedures.

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[209] This section is based on a document review of (JICA 2007a) and (JICA 2007b).

[210] In terms of human security, JICA's assistance focuses on capacity building. This includes systems building, organizational strengthening, and human resource development, with the ultimate goal of promoting self-reliance so that developing countries may solve their problems by their own efforts.

JICA activities are funded by means of bilateral grants. It shares the responsibility for implementing the Japanese government's Official Development Assistance (ODA). JICA assumes the majority of the planning and implementation costs of recipient countries, as well as provides technical support during the planning phase of a project. JICA's status is therefore one of a cooperating partner. Once the cooperation period is over, recipient countries are expected to continue with development projects independently. Therefore, these projects are developed to suit the organizational and financial capacities of the implementing bodies of recipient countries so as to ensure that project costs can be covered after the cooperation period has concluded.

JICA takes a multi-faceted approach to its development assistance. One of those is a country-based approach[211], used when planning and implementing development projects by acknowledging that problems vary from country to country. Thus, programs must be adjusted to suit local circumstances and to ensure that local views are incorporated. This is accomplished for example, by JICA's participation in "ODA task forces" which are established locally in developing countries and involve the Japanese Embassy, the Japan Bank for International Cooperation, and other institutions. JICA also maintains close links with NGOs, universities, research institutions, the private sector, and other bilateral and multilateral aid organizations. JICA also takes an issue-based approach in order to comprehensively analyze issues to be resolved. This issue-based approach is carried out so as to ensure that developing countries' self-reliance and ownership of development projects is maintained. The approach includes the planning and implementation of *technical assistance projects*[212] and the *sending of volunteers* to developing countries to work in communities participating in technical assistance projects

JICA's Development activities

Technical assistance projects are one of JICA's primary types of international development activities. They are planned and implemented jointly by JICA and personnel

[211] In certain geographical areas JICA may also take a regional approach, particularly in regions composed of several small countries with similar economic and social development needs. This is the case for the Central America and Caribbean region.

[212] Also referred to as *technical cooperation projects.*

from recipient countries[213], and focus on resolving a specific issue or set of issues within a defined timeframe. Project plans are customized so as to meet the specific contextual needs of target communities in recipient countries. When needed, JICA provides technical support through the participation of Japanese experts and may invite recipient country personnel to receive training in Japan. JICA may also provide equipment when necessary to accomplish project objectives. In order to maximize recipient country ownership of technical cooperation projects, participatory methods are used to involve residents of a project's target area in project planning, administration, and evaluation. JICA's role as a cooperating partner is exemplified by the use and promotion of local knowledge, experience, and skills. JICA appoints its own personnel to fill any apparent gap in these.

With regards to the evaluation of technical cooperation projects, JICA uses what they refer to as an *ex-ante evaluation*. This type of evaluation is performed in terms of five criteria: *relevance, effectiveness, efficiency, impact,* and *sustainability*. It is designed to estimate the outcome of a project in a quantitative and objective manner to establish clear targets. Mid-term and terminal evaluations are carried out to analyze the project on the basis of the five aforementioned criteria in order to assess the accuracy of projections made during the project planning phase and to determine whether to terminate, extend, or follow-up on a project.

The *sending of volunteers* to assist in JICA technical cooperation projects takes several forms including: Japan Overseas Cooperation Volunteers[214] (JOCV), Senior Overseas Volunteers[215], and Volunteers and Senior Volunteers for Japanese Communities Overseas. The JOCV dispatch programme is the most important of the four volunteer programmes mentioned above and will be focused on in this paper. The JOCV dispatch programme began in 1965. As of the end of March 2004, 2,331 volunteers were deployed in 69 countries, making a total of 25,184 since the programme's inception. This programme provides development assistance based on specific requests made by

[213] Recipient country personnel can be from national and local governmental agencies, NGOs, public citizens, etc.
[214] JOCV volunteers range in age from 20 to 40.
[215] Senior Overseas Volunteers range in age from 40 to 69.

developing countries. Volunteers participating in this programme consist of young people with a desire to cooperate in the economic and social development of developing countries. They generally spend two years in these countries and offer their skills and experiences acquired in Japan through working and living with local people. Cooperation is provided in seven fields: agriculture, forestry and fisheries, processing, maintenance, civil engineering, health and hygiene, education and culture, and sport.

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