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Numerous development projects are implemented in developing countries to attain economic and ecological development. However, in most cases, the encouraging results observed during the implementation phase terminated with the project period, raising concerns on these projects' sustainability after the project period has ended. This study focuses on this sustainability issue in terms of continued benefit flows of the ecodevelopment project implemented in the Kalakad Mundanthurai Tiger Reserve, India. The ecodevelopment project aimed to attain both economic and ecological development in tandem by involving people in preserving forests. Econometric analysis of the data related to before, at the end, and three years after the project period revealed that the ecodevelopment project was sustainable in terms of reducing the forest dependency and improving the income status of the forest fringe dwellers. Accordingly, this study

provided empirical evidence that supports the novel idea that natural common property resources, such as forests, can be preserved by creating financial common property resources, such as village funds, and appropriate site-specific participatory institutions to maintain them.

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Sustainability of a Forest Preservation Project in India: The Case of the Kalakad Mundanthurai Tiger Reserve

by
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I understand that my thesis will become part of the permanent collection of Oregon State University libraries. My signature below authorizes release of my thesis to any reader upon request.

Maniselvan Balasubramanian, Author

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SUSTAINABILITY OF A FOREST PRESERVATION PROJECT IN INDIA: THE CASE OF THE KALAKAD MUNDANTHURAI TIGER RESERVE

1. INTRODUCTION

1.1 Background

Forests play a vital role in the development of a nation by providing numerous social, economic and environmental benefits. The latest estimate of forest cover in India is about 64 million hectares or 20 % of the total geographical area. However, the National Forest Policy (1952) stipulates that forest should occupy at least 33 %. Taking into account the low productivity level of forests as well as the increasing demand for forest products, the Government of India (GOI) has been making determined efforts to increase the forest cover for a long time[1].

Meanwhile, the failure of the traditional state-owned and market-based forest management systems forced the GOI to search for alternative approaches to manage and improve the forest cover efficiently (Naik, 1997; Heltberg, 2001). Realizing the importance of local communities' involvement in establishing sustainable forest management systems, the GOI implemented Joint Forest Management (JFM) programs in

[1] India needs 0.47 hectare of forest land per capita to meet the demand for forest products, whereas the actual per capita forest land in India is only 0.08 hectare which is 10 % of the world average of 0.8 hectare per person (Tata energy research institute, 1996).

1990s. The core concept of JFM is involving the local population in both management and resource sharing.

However, the JFM program cannot be implemented in Protected Areas (PAs) where resources extraction has been prohibited in an effort to preserve their biodiversity value. Hence, the GOI adopted a new approach to involve people in maintaining PAs by implementing the Ecodevelopment project (EDP) on an experimental basis in 1996 with the aid of the World Bank. The main objectives of this project were: 1) to reduce negative impacts of local people on biodiversity and 2) to increase the collaboration of local people in conservation efforts. The Kalakad Mundanthurai Tiger Reserve (KMTR) in south India was one of the two PAs where the EDP was implemented due to its rich biodiversity[2].

The major activity of the EDP was the formation of a village forest committee (VFC) in each village adjacent to the KMTR emphasizing the collaboration of villagers, the forest department (FD) and non-governmental organizations to preserve the PAs[3]. The FD provided monetary assistance based on the membership of each VFC, which, in turn, granted loans to member households to pursue alternate income generating activities (AIGAs). In return, the VFC helped the FD in the management of the KMTR by preventing people from collecting fuelwood and grazing their cattle in the PA.

[2] The other Protected Area was the Great Himalayan National Park in north India.
[3] The major pressure on the KMTR was from the adjacent 150 villages situated along its eastern boundary. People from these villages depend on the KMTR for fuel wood, grazing their cattle, etc.

1.2 Problem Statement

The EDP aimed to achieve ecological and economic development in tandem through participatory management. Unfortunately, the empirical evidence to support participatory natural resources management, which is now considered as a win-win solution for both the environment and economic development, is rather thin (Bluffstone, *et al.*, 2002). This insufficient empirical knowledge has hindered donors and governments from shaping the process of involving local institutions in natural resources management (Heltberg, 2001). Moreover, in most of the development projects implemented in developing countries, the encouraging results and benefits observed during the implementation phase terminated with the project period (Brown, 1998). Furthermore, the EDP was a pilot project with no direct incentives from the forests to local population, unlike other JFM projects. As such, a high level of commitment from the VFC in protecting the KMTR after the project period was necessary. Since there are no previous empirical studies ascertaining the sustainability of the EDP or projects similar to it, it is necessary to assess the sustainability of the EDP, which was completed in 2001[4].

[4] In this study, sustainability of institutions refers to the extent to which the communities influenced by intervention voluntarily want i) to pursue the activities used during intervention through the institutions created during intervention and ii) to continue to achieve the objectives of an intervention after project assistance from donors has been completed.

1.3 Objectives of the Study

The overall objective of the study is to assess the sustainability of the EDP in achieving its goals on economic development and ecological development in the project area. The specific objectives are:

- to quantify the impact of the EDP in improving the economic status and reducing the forest dependency of the surrounding villages;
- to determine quantitatively the impact of the EDP on households' labor allocation for fuelwood collection and alternate income generating activity (AIGA);
- to observe the types of fuel consumption patterns of the households and to identify the determinants of the households' primary fuel source.

1.4 Scope of the Study

This study will be helpful to forest planners, policymakers, governments, donors and scientists in many ways. First, it will provide evidence on environmental, social and economic consequences of the EDP, which will help improve the design of similar, future projects. Second, it will provide insights to solve the fuelwood scarcity problem by focusing on fuel consumption patterns and alternative fuel sources. Third, it will help in better targeting of VFC beneficiaries by providing information on the impact of the EDP on different member groups. Fourth, it will serve as a tool for dynamic learning by providing credible and useful information related to the EDP. Fifth, it will motivate the

staff and communities supported by the EDP. Sixth, it will provide information on the worth and effectiveness of the EDP to compare with alternative interventions, which in turn will contribute to an efficient allocation of resources among interventions. Finally, it will help both the GOI and the World Bank to justify their investment in the EDP by providing stronger and clearer evidence of their benefits.

1.5 Thesis Organization

This thesis is organized as follows. Chapter 2 provides a review of past studies on institutions, microfinance and fuelwood collection and consumption. Chapter 3 outlines the economic and empirical model used in this study. Chapter 4 explains the EDP and data collection. Chapter 5 provides the description of the data. Chapter 6 presents the results of the empirical analysis. Finally, Chapter 7 summarizes the findings of the study and provides conclusions and suggestions for future research.

2. LITERATURE REVIEW

The EDP investigated in this study is the first of its kind implemented in India. Hence, there are no previous empirical studies pertaining to the EDP or to projects identical to it. A holistic examination of the EDP indicates its emphasis on three major components: institutions, microfinance and forest resources utilization. Numerous studies specific to these areas are available and reviewing them will help understand the relevant issues and knowledge gaps, the research methods adopted and lessons learned. This, in turn, will be useful in specifying the focus of the present study and also in developing its theory, model and methodology. Hence, the literature relevant to institutions, microfinance and forest resources utilization is reviewed in this chapter. To facilitate understanding, first, a brief description on forest preservation, deforestation and related concepts used in this study is provided in section 2.1. Next, in section 2.2, a review of studies on institutions is presented, followed by a review on microfinance in section 2.3. Finally, studies related to fuelwood collection and consumption are explained in section 2.4.

2.1 Forest Preservation and Deforestation

A clear distinction between *forest preservation* and *forest conservation* is made in this study. Forest preservation emphasizes the protection of forests to maintain biodiversity and other ecological services without allowing any type of resource extraction. In contrast, forest conservation aims for the optimum utilization of resources, thus allowing

resource extraction from forests. Accordingly, the main management objective in PAs is forest preservation.

Finding a strategy tailored towards preservation of forests requires deliberate efforts to prevent the conflict between forest officials and adjacent villagers as the latter is deprived of extracting forest resources from PAs. The eco-development strategy aims to protect ecologically valuable areas from the people living in and around such areas by controlling their unsustainable or otherwise unacceptable pressures on forest resources (GOI, 1993). The GOI (1991), in its brief definition, claims eco-development to be a package of programs that express the Protected Area (PA) manager's interest in the socio-economic development of the fringe or buffer zone villages in order to gain their residents' greater co-operation to conserve and manage wildlife. An explicit definition provided by Panwar (1991) states eco-development as a "site-specific package of measures derived through people's participation, which addresses all aspects of land use and other resources in order to promote sustainable land use practices as well as off-farm income generating activities, which are not deleterious to PA values."

On the other hand, deforestation refers to the removal of timber and other non-timber forest products from forests. As forest preservation requires complete curtailment of deforestation, it is important to outline the set of factors on which deforestation depends. A framework of different variables that influence deforestation (Kaimowitz and Angelson, 1998) is depicted in Figure 1. It has three categories of variables. First, the

direct sources of deforestation refer to the actions of agents or individuals. Second, the immediate causes of deforestation include the agents' own characteristics and exogenous decision parameters, such as institutions, infrastructure, markets and technology on which agents base their decisions on choice variables. Finally, the underlying causes of deforestation include broader economic, political, cultural, demographic and technological forces which determine the agents' characteristics and decision parameters. As Figure 1 depicts, institutions play a vital role in the deforestation process. Hence, to understand the impact of policy instruments on sources of deforestation, knowledge of institutions created by the policies is essential. Thus, it is necessary to review the literature on institutions in the context of forests and common resources management.

2.2 Review of Studies on Institutions

Institutions mold human behavior related to resource utilization. North (1991) referred to institutions as humanly devised formal rules and informal constraints that organize social, economic and political interactions. Jaeger (2005) defined institutions as humanly devised mechanisms or tools that constrain, guide, or encourage certain kinds of actions to influence the incentives and choices of individuals.

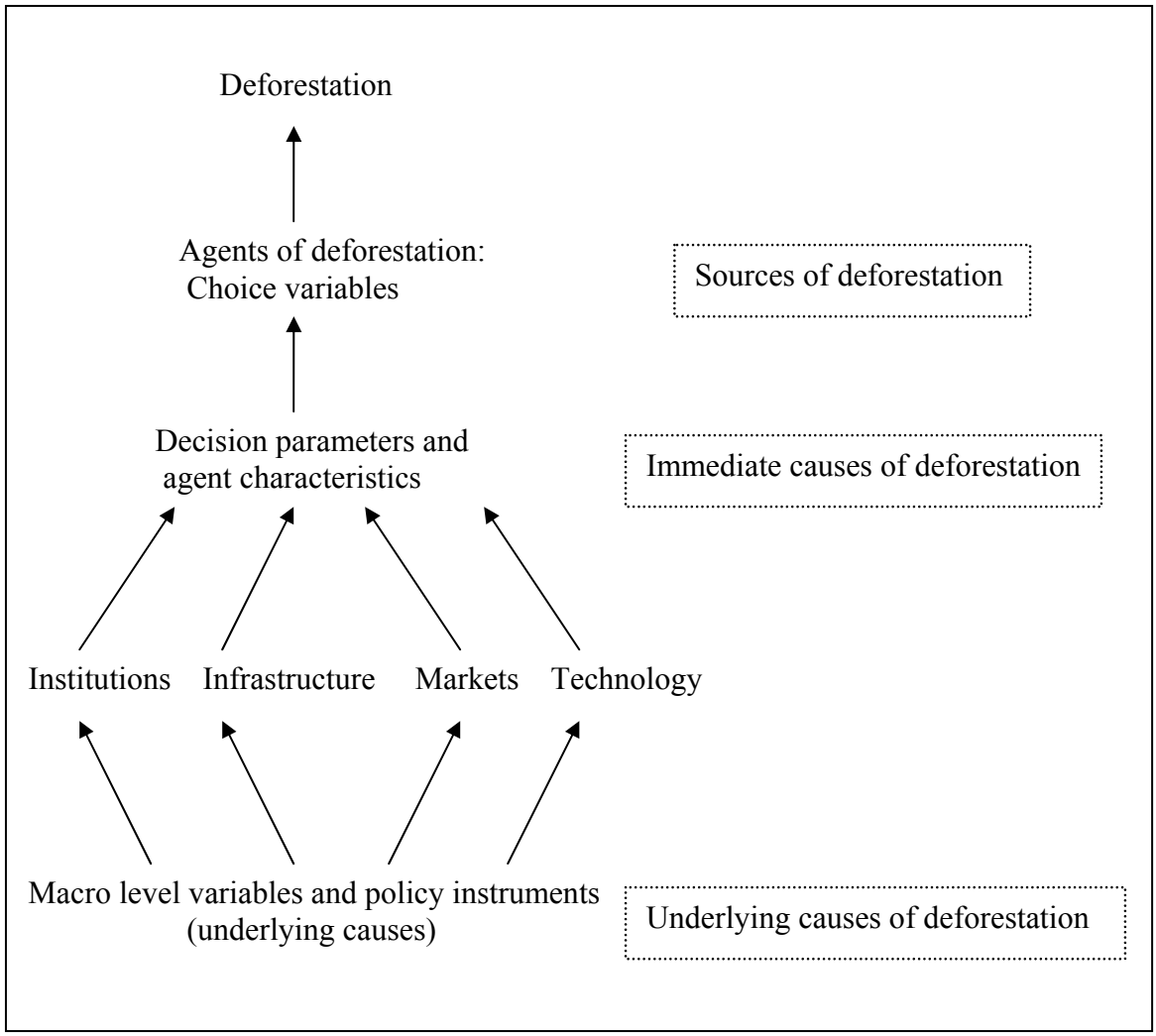

Figure 1. A Framework on Types of Variables Affecting Deforestation

Source: Adapted from Kaimowitz, D. and A. Angelsen (1998) Economic models of tropical deforestation: A review, Centre for International Forestry Research. Indonesia.

On the basis of property rights, resource regimes are classified as open access, common property, private property and state-owned. While private and state ownership are characterized by the presence of access and conservation rules, open access is characterized by the absence of both rules. Common property resources (CPRs) are

known as regulated common property when there are both access and conservation rules and as unregulated common property when there are only access rules. Though the state ownership has both access and conservation rules, failure to enforce them effectively transformed the state-owned resources into open access resources in many cases (Heltberg, 2001). Open access and common property resources together form the commons.

The literature on commons is vast. Initial studies on commons were skeptical of the incentives for efficient use of common resources as they believed that commons cannot maximize the long-term economic rent, one of the important goals for management of natural resources (Hardin, 1968). Consequently, solutions such as command and control management (Hardin, 1968) or privatization of the commons (Demsetz, 1964) were proposed. However, recent literature on common resources has pointed out that Hardin's tragedy of the commons is a result of the failure of institutions that control access and conservative uses of resources rather than the inherent failure of common property itself. The literature also advocated for decentralized collective management of CPRs and pointed out that local user groups can devise appropriate institutions to manage common pool resources sustainably over generations (Ostrom, 1990; Bromley, 1992; Baland and Platteau, 1996). Recognizing the importance of community based resource management, at present governments in more than 50 countries are undertaking initiatives to devolve some of their power to the community to use and manage natural resources (Agrawal, 2001), a practice which often results in social capital creation.

As a viable alternative to managing natural resources, creating this social capital that includes trust between individuals and groups, the evolution of norms, rules and sanctions and the development of processes of reciprocity, exchange and connectedness (Pretty, 1998) mainly depends on the nature of the participatory institutions. New participatory institutions play a role in transforming and developing social capital, thereby restructuring the relationships within society and between society and non-human nature (Martin, 2001). However, introducing new institutions into complex and dynamic locations with different social, economic, legal, political, cultural and environmental characteristics and relations results in mixed outcomes and the causal reasons for these different outcomes are yet to be understood clearly. Hence it is important to identify the factors that facilitate the development and sustainability of local organizations that manage the commons.

The factors that are conducive for the sustainable governance of commons can be grouped under four categories (Agrawal, 2001). They are (i) characteristics of resources, (ii) nature of groups that depend on resources, (iii) particulars of institutional regimes through which resources are managed and (iv) the nature of the relationship between a group and external forces and authorities such as markets, states and technology.

Theoretical literature on commons indicates that communities can successfully manage the common resources that are small, stable and that possess well-defined boundaries

along with possibilities of storage of benefits from the resources and a moderate level of human dependency (Agrawal, 2001; Dolsak and Ostrom, 2003).

Groups that are homogenous and small with clearly defined boundaries and that are characterized by successful experience in managing institutions, appropriate leadership—young, familiar with changing external environments and connected to the local traditional elite — and a high level of interdependence among group members are successful in managing the commons (Agrawal, 2001; Dolsak and Ostrom, 2003). In terms of homogeneity, communities that are homogeneous along ethnicity, caste, religion, race, education and wealth lines can limit conflicts and manage the commons better than the heterogeneous ones (Baland and Platteau, 1996; Bandiera, 2005).

The impact of group size on collective action is ambiguous. While Bardhan (2000) found a significant negative correlation between group size and collective action in his study on maintenance of irrigation systems in India, Heltberg (2001) reported a positive relationship between group size and the efficiency of institutions in his study on the impact of local institutions on the management of forest resources. Due to their proximal living, smaller groups benefit from institutional features such as monitoring and enforcement, revision of rules and conflict resolution that come easier in a more intimate setting; and this, in turn, improves co-operation. In contrast, large groups might have economies of scale. Similarly, the age of communities or institutions should be positively related with cooperative outcomes due to lower transaction costs that decrease with

experience from finding cooperative solutions (Agrawal and Goyal, 2001; Bluffstone, 2002).

Studies on commons indicate that successful communities are characterized by the presence of well-defined, simple, locally devised access and management rules, a forum for conflict resolution and revising existing rules to adapt to external changes, the ability to monitor resource extraction and to punish deviators, low cost adjudication and accountability of monitors and other officials to users (Wade, 1988; Ostrom, 1990; Baland and Platteau, 1996; Bluffstone, 2002). Moreover, successful communities deliver punishments that are context-specific and are subject to negotiation with the offender (Ostrom *et al.*, 1994). For example, sanctions such as cultural isolation are effective to assure sustainable management of common resources (Fernandez, 2006).

Moreover, the collective action for resource management will be highly successful when the potential gains from co-operation are higher than the potential losses from over-use and resource degradation (Wade, 1998). This leads to the idea that the higher the net benefit of organizing collective action, the larger will be the gains from co-operation (Heltberg, 2002).

Agrawal (2001) proposed a functional relationship between durable institutions and other variables. It has a positive relationship with strong enforcement, population pressures and

predictable benefit flows and a negative relationship with migration levels and market pressures. The relationship with technology level remains undetermined.

The impact of external intervention on traditional management systems may be either positive or negative depending on the nature of intervention (Heltberg, 2002). For example, when colonial and independent governments nationalized forest resources, the existing CPR management systems collapsed since the state undermined the local authority structures governing the resources (Ostrom, 1990; Ostrom *et al.*, 1994). In contrast, a study by Chopra and Gulati, (1998) indicates a positive intervention by non-governmental organizations (NGOs) where better maintenance of common land and water resources is achieved through larger labor contributions from the villagers and by providing substantial levels of external aid and support to compensate local users for conservation activities.

In India, devolving management rights to the community came through the Joint Forest Management Program (JFMP) in 1990. As of March 31, 2001 there were 44, 943 official JFM groups known as Village Forest Councils whose role is to protect over 11.63 million hectares of government-owned forest (15.5 % of the recorded forest area of the country) (Kumar, 2002).

Under the JFMP, a partnership between the FD and fringe forest user groups was developed on the basis of mutual trust and jointly defined roles and responsibilities with

regard to forest protection and development. The FD provided people the rights to harvest resources from the forest. In return, the VFC helped the FD to protect forests against grazing, illicit felling and overexploitation and to reduce management costs. To sum up, in the JFMP the user (local communities) and the owner (government) manage the resource and share the cost equally.

The degree of success of the JFMP is site-specific. In a study from 524 rural villages in five states in India to ascertain the determinants and impact of community forestry participation on household participation, Bandyopadhyay and Shyamsundar (2004) found that community forestry is benefiting participants in the short to medium term. They found that participation increases the ability of households to consume more fuelwood (260 kgs per household) than non-participants, indicating a positive relation between fuelwood consumption and participation. However, there is no significant effect on the village as a whole due to the presence of the village-level forest institution. They also found that proximity to forests, leadership and fuelwood dependence are significant factors in explaining village participation in community forestry. This study indicated a positive correlation between scarcity and participation that leads to the inference that community forestry can be extended from degraded to less degraded forests.

In another study, Edmonds (2002) evaluated the impact of government-initiated community forestry programs on the extraction of wood for fuel using data collected from 1200 households in 100 communities from the Arun Valley of Nepal. He reported

that a 14 % reduction in wood extraction from natural forests can be attributed to the creation of forest user groups in the short-term.

In contrast, a study by Heltberg (2001) that analyzed the determinants and impact of local institutions on CPRs in 37 villages of Rajasthan, India reported that though the active village resource management institutions through JFM promoted private biomass production and reduced dependency on commons, the impact is not enough to protect the commons from continued degradation. A positive relation with population size and negative relation with prior institutional experience on collective action was found; there was no positive impact of local institutions to protect forests and commons. This result might be due to insufficient incentives for the local people. In addition, the study stressed the importance of long-term official commitment and encouragement of collective action through enhanced co-operation between villagers and FD officials. The study concluded that scarcity of resources, as measured by people per unit of resource, did not encourage formation of management institutions.

The grassroots level institution created in villages under the EDP is the VFC. It has a microfinancial concept built into it that serves as its major driving force. Hence, literature relevant to microfinance is presented in the following section.

2.3 Review of Studies on Microfinance

Microfinance refers to loans and services such as savings, training and organizational help provided by micro credit institutions and programs (Khandker, 1998). These micro credit programs and institutions with site-specific, flexible and simple rules and regulations provide smaller loans to the poor at affordable rates with the intention of making them productively self employed. The major objective of microfinance programs is poverty alleviation in addition to consumption smoothing, empowerment of women and reduction in reliance on money lenders. The idea behind microcredit programs is that group lending may help in better targeting and results in higher loan repayment through self-selection, peer pressure, peer monitoring and creation of social collateral (Khandker, 1998).

The impact of micro finance programs can be assessed at individual, household, enterprise, village and institution levels. At the household level, microfinance programs had a positive impact on household income, net worth, asset accumulation and schooling in addition to reducing poverty. Khandker (1998), in his seminal work on assessing the impact of three microfinancial institutions in Bangladesh, found that microcredit had a positive impact on average household income (30 to 33 %), consumption expenditure (7%), net worth (0.09 to 0.14 %), schooling (1.9 to 2.4 %) and poverty reduction (3 to 5% per annum). Adding to this, Zohir *et al. (*2001) showed a positive impact on household expenditures, schooling and poverty reduction in their study on Bangladesh. However, in

a study on Peru, Dunn and Arbuckle (2001) reported an increase only in food consumption expenditure and not in household appliances and education. Nevertheless, they found a positive impact of microfinance on per capita income (more than $ 266) and income diversification.

The increase in self-employment that comes from microfinance programs increases household income (Khandker, 1998, Zohir *et al.* 2001), leading towards a reduction in poverty. However, conclusions reached about poverty impact depend upon the definition of poverty used (Mosley and Rock, 2004). Moreover, Halder (1998), found an inverse relationship between length of membership and poverty.

In the same way, at the individual level microfinance helps in improving the empowerment of women by increasing their participation in financial decisions, mobility and self esteem (Khandker, 1998; Zohir *et al.* 2001; Khalily, 2004). However, Dunn and Arbuckle's (2001) study reported that even though women had control over financial decisions, there is no positive impact on personal savings, self esteem and respect.

The outcome parameters considered at the enterprise level were net revenue, fixed assets and employment generation (Khalily, 2004). Dunn and Arbuckle (2001) found a positive impact on annual average revenue ($1000), accumulation of fixed assets ($500) and employment generation (9 more employment days per month). At the village level, an

increase in employment and the wage rate was also found (Khandker, 1998; Zohir *et al.* 2001).

Likewise, outreach, cost efficiency and sustainability were considered as outcome parameters at the institutional level (Khandker, 1998; Khalily, 2004). Microfinance programs have a higher transaction cost of providing financial services due to smaller loan size. But, if the social benefits generated by them are considered, they are more cost-effective and financially profitable than public sector agricultural development banks (Khandker, 1998; Khalily, 2004). Similarly, an increase in loan size and expansion in outreach will reduce transaction costs (Yaron, 1992). Moreover, the presence of effective and well institutionalized procedures for ensuring administration and management succession to avoid dependency on the leadership of a particular person will ensure the viability of an institution (Khandker, 1998).

In addition, the co-operation and trust created through regular group meetings and interactions within microfinance institutions' groups can develop a bond and trust within the group (Zohir and Matin, 2004). This helps in sharing valuable social and market information, storage and transport facilities and effects reliance on the group during the time of crisis (Mosley and Rock, 2004).

Literature on microfinance indicates that effective microfinance institutions had a higher positive impact on asset growth, consumption smoothing and occupational mobility and a

negative impact on moneylender reliance. Institutions that provide training and advice services, emergency services, savings services and pledged savings accounts services resulted in higher annual growth (5 - 6 %) in assets to their villagers (Kaboski and Townsend 2005). Moreover, a higher positive impact on households is often correlated with institutions that seem to succeed in membership, savings mobilization and lending (Kaboski and Townsend 2005). Furthermore, the extent of transparency of loan transactions, morale and commitment of program staff, their accountability and the staff incentive structure also play a vital role in loan recovery rates of the microfinance institutions (Khandker, 1998).

The wider impact of microfinance based on AIGAs can be observed in agriculture, trading and transport areas (Zohir and Matin, 2004). A greater access to credit increases the use of agricultural inputs resulting in higher agricultural production. Consequently, there will be more transactions in non-labor input markets and in the agricultural output market that lead to an increase in employment and income in both the trade and service sectors. Similarly, using loans for trading results in an increase in the number of traders and in the availability of quality products for consumers at competitive prices. At the same time, existing ineffective intermediaries are supplanted with new marketing linkages and temporary immigration is decreased due to stable employment. Likewise, in transportation, the loans served as an investment in buying bicycles, rickshaw and motor bikes. This results in increased mobility, reduction of transportation costs and creation of demand for new kinds of goods and services.

2.4 Review of Studies on Fuelwood Collection and Consumption

One of the earliest studies that provided an empirical analysis on households' forest labor supply decisions was carried out by Kumar and Hotchkiss (1988). Using data from 120 Nepalese households they found that deforestation and time allocated to fuel wood collection had a positive relation. They concluded that an increase in time devoted to forest collection led to a decrease in time allocated to agricultural work, resulting in reduced agricultural output affecting food consumption and health.

Kidane (1991) used a household utility maximization model to estimate the demand for energy in rural and urban Ethiopia. By applying a simultaneous equation system to the village-level cross sectional data, he found that the demand for fuelwood was responsive to its own price and the price of other modern energy sources, implying that price can be used as a policy tool. They also found that the households with more wealth had a higher demand for fuel resources, relative to those with low income.

Amacher *et al.* (1992) developed a separable household model to study the adoption of improved stoves in Nepal by using data collected from 99 households in two districts in 1986. The probit model estimates showed that households that had higher income, greater exogenous incomes and education adopted more stoves. With the same data, Amacher, *et al.,* (1993) estimated the demand for fuelwood and fuel substitutes, as well as the demand elasticities for fuelwood, combustible agricultural residues and improved stoves, each by

household income type. The Tobit estimates pointed out that all price and income demand elasticities and substitution elasticities between residues and fuel wood were less than one. While the low income group used residues, the high income group used improved stoves to substitute fuelwood. The results of the study indicated that improved stoves reduced fuel consumption by 8 and 10 % in the two districts separately and 29 % when the districts are combined. An increase in income among poor households may lead to a reduction in deforestation due to the inferior nature of fuelwood consumption. The study concluded that as household incomes increase, agricultural households may grow more of their own fuelwood and non-agricultural households will substitute fuels and fuel technologies.

In another study, Amacher *et al.* (1996) formulated and estimated a non-separable household utility maximization model to study the behavior related to fuelwood purchase and collection among rural households in Nepal using data collected from 286 households in1988. By applying log-log production function and 2SLS (and switching regression), they found a positive relationship between livestock ownership, family size, distance to road and fuelwood collection per household. In addition, they reported a negative relationship for land ownership (wealth) and improved stove ownership with fuel wood consumption. Furthermore, the study showed that the decision to purchase or collect fuelwood depends on household labor opportunities, with people who were wealthy and who owned improved stoves being more able to divert their labor to other non-fuelwood activities. Moreover, the study reported that an increase in fuelwood price

decreased consumption and purchase of the households that collect and purchase, forcing them to collect their total consumption of fuel wood. They concluded that though both purchase and collection households as well as only collection households were responsive, households that only collect fuelwood were more responsive to changes in the marginal products of their labor rather than to changes in the market.

Cooke (1998) estimated the demand for fuelwood, leaf fodder and cut grass and allocation of time to collect these items using data from the Nepal Energy and Nutrition Survey of 118 households in Nepal in 1982-83 by applying the household production model. He found that these items had significant negative own price elasticities in the inelastic range. A higher shadow price for fuelwood, fodder and livestock ownership led to an increase in the time allocation for collecting fuelwood and fodder that mostly came from women. He concluded that scarcity led to a reduction in consumption of the goods and spending more time in their collection.

In another study, Mekonnen (1999) designed a non-separable agricultural household model to study the biomass fuel collection and consumption behavior of 419 rural households in Ethiopia in 1996. Using the method of instrumental variables to take care of endogenity of shadow prices for fuel and wages in estimating the demand functions, (as he used the cost of time spent to collect a unit of fuel as a measure of shadow prices) he found negative own price elasticities indicating the advantages of forest policies that can reduce fuel collection time and make more time available for other activities. In addition, he reported negative and significant or insignificant cross price elasticities,

suggesting that fuelwood and dung were either complements or independent, indicating the absence of substitutability. Furthermore, he pointed out that households with more labor income, number of cattle and number of trees on the farm consumed more woody biomass and dung. From that, he concluded that fuel choice and mix were significantly influenced by scarcity, cooking habits and culture and recommended for policies focusing on education and improved stoves adoption to reduce the demand for fuelwood.

Edwards and Langpap (2005) analyzed the ENCOVI (Living Standards Measurement Survey) 2000 data from 7276 households to examine the effects of credit access on firewood consumption in Guatemala by applying a household model. The results indicated that improved access to credit helped the household to cover the start-up costs and increased their ability to purchase a gas stove, resulting in reduced fuelwood consumption. However, through simulations, they found that these effects are small (0.6% of base per annum of rural consumption) and concluded that subsidizing stoves as a policy measure might reduce fuelwood consumption. In addition, they found a negative and significant own price elasticities and positive cross price elasticities of kerosene indicating the substitutability of kerosene and fuelwood.

The study by Heltberg, *et al*. (2000) used a non-separable household model to understand the linkages among household fuel collection, forest scarcity and substitution of fuels from the commons and private sources. They applied the maximum entropy approach to data collected from 180 households through stratified random sampling from four villages located within 2.5 km of the reserve. The results indicated that while the time

allocated for fuel collection from forests was positively related with family size, it was negatively related to farm size, the number of trees on farm, improved stove ownership and presence of active village management institutions. In addition, the study noted that collection time and, in turn, scarcity had a negative impact on consumption of fuelwood from forests and a positive impact on private fuel consumption. The study concluded that producing more trees on private lands along with involving people in managing forests by strengthening the existing institutions and promoting new institutions will slow deforestation.

Kohlin and Parks (2001) formulated a household model with four different types of fuelwood collection possibilities and estimated the potential decrease in collection from the natural forest due to plantation establishments. Using the data collected from 742 households from 22 villages in the vicinity of the Dhani Reserve Forest in Orissa, they found that the establishment of plantations had reduced the pressure on the natural forest by 13 %. In addition, they observed that decreased collection in natural forests depends on the plantation location, the effect being non-linear with an inverted U-shape that peaks when planted forests are located around three kilometers from the natural forest, indicating the necessity of establishing buffer zones with trees around PAs. The study concluded that at this location the household collection decision was most sensitive to changes in relative shadow wages.

In 2003, Linde- Rahr applied a Random Utility Model to analyze the choice of fuelwood supply sources, using data on 300 Vietnamese households. By calculating the demand and production elasticities for fuelwood from four sources they concluded that a policy intervention that aims at substituting fuel from plantations may reduce deforestation.

Another study by Kohlin and Amacher (2005) estimated the welfare effects of Orissa's social forestry project in India in terms of the value of time savings afforded by plantations. They used a household model and relied on marginal products in defining the value of a unit of time spent collecting as the prices are not easily observed for each household. Along with remote sensing data, they collected data from 741 interviews using a questionnaire designed to gather information regarding collection in community forest and natural forest sites, as well as supplementary household data from villages within the distance of 5 km from Dhani Reserve forest that has a well defined natural forest and numerous community forest plantations. They predicted that average time savings due to the presence of community forests were in the range of about 250 hours per household per year.

The study by Pattanayak *et al*. (2004) examined the importance of fuelwood in the rural household economy using the household production framework by including fuelwood collection time (trips) as input in the utility function for the household. Using data from 494 households in 47 *desas* (village clusters) in the buffer zone of Rueteng park in Indonesia, they found that the opportunity cost of collection, availability of fuel

alternatives and wealth were the primary determinants of fuelwood collection. In addition, they observed that households that had a low level of dependency on forest fuelwood had more wealth, more trees on their farms and better wage opportunities. Likewise, households in *desa*s with more schools and closer to paved roads showed a low level of forest dependency as they were more able to collect alternative fuels and /or had higher travel costs. The study concluded that park management activities such as frequent visits to improve the interaction with communities and involving them in maintenance and increasing the environmental awareness and assisting households to plant trees on farms and acquire kerosene stoves can reduce collection of fuelwood from forests.

Hazari, (2003) applied a Cobb-Douglas utility function to examine the relationship among property rights, basic needs and degradation of commons in Gurgaon district, India. They found that degradation of commons occurred both at low and high price of basic needs and concluded that properly defined property rights and provision of basic goods in kind will better solve the problem of degradation of commons rather than just the price mechanism of basic needs.

Bluffstone *et al.*, (2002) studied the local economic and ecological impact of effective local management institutions by integrating the household modeling literature with that of determinants of effective common property management through inclusion of institutional and management variables into a formal household model. Using data from 378 households of 32 communities that had different institutional characteristics,

ecological conditions, geographic and market features in the Bolivian Andes, they found that households situated in areas that had clear management and institutional rules experienced labor savings of 16 hours per week (50 %) more to do home work and spent 14 hours (50 %) less in grazing activities than households where rules were unclear. They also reported a shift from using common forest to on-farm trees for fodder in the households where the rules are clear. Furthermore, the households' borrowing capacity had a negative effect on labor allocated to fuelwood collection. In addition, the study indicated that households that burned fuels traditionally spent six hours per week more on domestic labor than households using improved stoves. As the authors did not have good measures for forest quality to evaluate explicitly the effects of differing forest management systems on forest quality directly, they concluded that effective institutions with clear and better management rules (explicit limits on collections, including penalties, democratic control and perceived fairness in reality) might have favorable effects on the forest quality by relying on common property and other literatures.

Mac Donald *et al.,* (2001) embedded the travel cost approach in the household production model to examine fuelwood collection behavior to assess the tradeoffs implicit in the choice of a fuelwood collection site, which in turn helps to assess the impact of changes in the quality and quantity of fuelwood collection sites. Using household data from Zimbabwe, they considered calories as a measure of the opportunity cost of collecting and found that using alternative fuels or using carts, which represent a labor saving capital good to collect fuelwood and conserving strategies resulted in fewer trips to

collect fuelwood. In addition, they found that closing sites for protected forests increased the cost for the local population through an increase in caloric expenditures by 10 % of their daily intake (165 to 200 calories per trip). They concluded that providing compensation through deliveries of staple commodities (or cash equivalents) to increase caloric consumption in the short term and afforestation programs in the long term may be effective to improve firewood availability. This research suggested the nature of the costs that would be borne by the local population if stocks of carbon in the form of forested areas were set aside for protection.

Godoy *et al.,* (1997) conducted a survey with 101 Tawahka Amerindian households in the Honduran rainforest to examine the effects of household variables on clearing forests for agriculture on deforestation. They found an inverted U relation between income or age and deforestation and a negative relation of household residence duration and size, education, off-farm income, credit, wealth and crop yields with clearance of forest lands for agriculture. The authors concluded that while increases in income and age motivate the people to clear more forests, beyond a threshold both variables had a negative impact as people could go for non-farm occupations inside and outside the forests, agricultural intensification and migration.

In another study, Pendleton and Howe (2002) developed a two-period household model to investigate the key development parameters' role in the smallholder's decision to clear forest for agriculture. Using data collected from 209 households in Tsimane they found

that market integration increases the prices of agricultural output and decreases the prices of agricultural inputs, leading towards rapid clearance of forests for agriculture. They concluded that access to cheap credit could directly increase deforestation by permitting the farmer to cover foregone wages while clearing forest as farmers were more interested to adopt agriculture in the next season.

The relationship between household labor allocation for fuelwood collection and off-farm work was first examined by Bluffstone (1995). Using parameter values of a typical Nepali hill village, in his simulations exercises he compared the time paths of forest stocks, deforestation and household labor supply and concluded that presence of off-farm labor opportunities had a negative effect on deforestation as it increases the opportunity cost of fuel collection time from open access forests.

The study by Adhikari (2002) used a household production model to examine the household dependency on local community managed commons (forests) in Nepal. By applying a log-log two stage least squares equation to data collected from 309 households, he found that household's size, land and livestock holdings exerted a positive pressure, while gender, ethnicity and education of household head exerted negative influence on household labor allocation for extraction from forests. He concluded that increasing homogeneity among user households and adopting management regimes oriented toward non-timber forest products might increase the income of the poorer households from community managed local commons.

More recently, Fisher *et al*. (2005) formulated and estimated a labor allocation model using household production approach in which households divide their labor among farming, forest employment and non-forest employment. They used data from 99 low-income households from three villages in Malawi and applied a system estimation approach to examine the determinants of activity choice affecting forest use among them. The authors found that forest and non-forest employment were substitutes for one another and as returns in the non-forest sector rise, households allocated a greater share of their labor to non-forest employment and a lower share to forests. The constrained maximum likelihood estimates showed that education of the household head, wealth and favorable returns from non-forest employment have reduced forest dependency. From that, they proposed that if a positive correlation between reduced forest reliance and reduced demand for forest products is expected then that might lead to formulation of policies that are complementary with poverty alleviation and forest conservation.

2.5 Uniqueness of the Present Study

The studies reviewed in earlier sections mostly employed a household production framework to (i) estimate econometrically the demand and supply of fuelwood (Amacher *et al.,* 1993; 1996; Cooke 1998; Mekonnen, 1999; Heltberg , *et al*., 2000; Linde- Rahr, 2003; Pattanayak *et al.,* 2004; Edwards and Langpap, 2005; Kohlin and Amacher, 2005), (ii) analyze the adoption of stoves (Amacher, *et al.,* 1992; 1993; Edwards and Langpap,

2005), (iii) fuelwood substitution (Kidane,1991; Mekonnen, 1999) and (iv) household labor allocation for forest and non-forest activities (Bluffstone 1995; Amacher *et al.,* 1996; Heltberg *et al*., 2000; Adhikari, 2005; Fisher *et al.*, 2005) at the micro level. However, these studies ignored the influence of existing and new institutions at the local level. On the other hand, the studies that concentrated on the impact of institutions on forest management at the macro level were concerned with forest conservation through JFM rather than on forest preservation (Bluffstone *et al.,* 2001; Edmonds, 2002; Bandyopadhyay and Shyamsundar, 2004). Though Heltberg (2002) in his study analyzed the determinants and impact of local institutions in Sariska Tiger Reserve, Rajasthan, India, where forest preservation is the main objective, the analysis was focused only on forest conservation rather than on forest preservation. In addition, the impact of institutions on economic development of villagers was not addressed. Moreover, the institutions he analyzed had no microfinance concept built in them. Likewise, most of the microfinance studies (Khandker, 1998; Dunn and Arbuckle, 2001; Zohir *et al.,* 2001; Khalily, 2004; Mosley and Rock, 2004) examined only the economic development of the people by improving their access to credit neglecting the ecological effect of microfinance on natural resources/forests. This leads to the conclusion that no study had attempted a combination of these three issues.

In the present study, the impact of institutions on both the economic development of villagers and the ecological development of forests that have to be preserved to maintain biodiversity has been analyzed in the presence of microfinance tools. Moreover, this

study uses the knowledge derived from each of the above reviewed studies specific to institutions, microfinance and forest resources utilization and combines them to develop the theory, methodology and econometric tools that are to be used in this study. Thus, this study uniquely combines the analysis of institutions, economic development, microfinance and forests preservation towards better management of commons/forests along with poverty alleviation.

3. ECONOMIC THEORY

Economics is the study of the allocation of scarce resources among competing uses. Economic theories and models help understand rational individuals', firms' and governments' allocation decisions. Most assume that an agent maximizes either utility or profits or welfare or a combination of these. These theories equipped with this optimization assumption, can be easily solved using a variety of mathematical techniques and, in turn, provide a strong semblance to real-world situations due to their empirical validity. Accordingly, economic models can be applied to understand systematically the impacts of policy interventions on deforestation as they simplify the complex multidimensional processes and explain the importance of only a few of many variables and causal relations involved in a research problem (Lambin, 1997). In this chapter, a brief discussion on models of deforestation issues is provided in section 3.1. Next, a detailed description on the household production function (HPF) approach is presented in section 3.2. The application of the HPF model to the present study is described in section 3.3, followed by the relevant empirical model in section 3.4.

3.1 Deforestation Models

Economic models related to deforestation issues can be studied at the national or regional or household level. National studies consider the general equilibrium of an economy, whereas regional models are either spatial or non-spatial and often use either regression

or simulation techniques. Lastly, household or firm-level models are either analytical or empirical. The major objective of these models is to analyze the influence of deforestation policy.

National studies and regional studies are useful when they take into account regional diversity, distinguish between sub sectors of agriculture and modify conventional perfect competition assumptions. However, they do not provide insight into the behavior of an individual person. Among other things, the lack of quality data limits the value of regional and national level studies, thus making the household level research studies more productive than those on the regional, national or global scale (Kaimowitz and Angelsen, 1998). At the household level, empirical models use real-world data and statistical methods to quantify the relationships between relevant variables. Empirical models on households also succeed in conveying alternatives that can improve policy formulation. In contrast, analytical models explain the theoretical framework with formal mathematical equations without using empirical data (Lambin, 1994). Moreover, the majority of household models use the theory of consumer behavior as a basis in explaining the issues related to deforestation.

3.2 Household Production Function Approach

The main objective of the EDP is to divert individuals from deforestation activities to alternative income generating activities. This economic problem can be modeled by using

the household production function (HPF) approach of Michael and Becker (1973), which is a modification of the traditional theory of consumer behavior[5]. In the traditional approach, the household's preferences are expressed in terms of quantities of goods and non-labor time. However, in the HPF approach they are expressed as in terms of activities or household products that are produced with the aid of these goods and time endowments. Thus, in a HPF model the household buys market goods and combines them with its time spent pursuing activities to produce commodities that comprise the arguments in its utility function (Offutt, 2002). The household, depending on the nature of its taste for these commodities, allocates its inputs between these commodities, which may be viewed as complements or substitutes (Clain and Zech, 1999).

The uniqueness of the simpler HPF models is that while consumption decisions are influenced by production decisions, the production decisions are not necessarily influenced by consumption decisions. Thus, under a HPF, the consumer will first make decisions to minimize the cost of production and then make decisions to maximize his or her utility. Moreover, in the household production literature it is assumed that households are price takers for all inputs and outputs including labor and that a market exists for all the goods produced. Further, it is assumed that commodities are homogeneous, implying that hired labor and household labor are perfect substitutes. The additional assumptions

[5]The theory of consumer behavior is concerned with the decision making behavior of the consumer, mainly focusing on his or her utility maximizing behavior. The fundamental postulate of consumption theory is that the consumer—an individual or a household—is a utility maximizing agent whose decisions are directed towards the maximization of his or her total utility, given his or her resources and market conditions.

of the HPF model are that there are no economies of scale, production factors will have diminishing marginal returns, objective functions are quasi concave and twice differentiable, for which interior solutions exist.

In a HPF model the household maximizes an objective (utility) function subject to income, time and production technology constraints. The two common mathematical techniques of optimization used in solving HPF models to derive the first-order conditions for a maximum are the Lagrange Multiplier method for equality constraints and Kuhn Tucker programming for inequality constraints.

From the first order conditions we can infer that, in order for the household to maximize its utility and the profitability of its production activities, it must first set the ratio of marginal utilities for each pair of consumption goods equal to the ratio of the market price of the goods. Second, it has to remain within its budget constraint and operate on its production frontier. Third, it has to allocate purchased and non-purchased factors efficiently amongst potential uses. Finally, the household has to produce the optimal combination of goods.

3.3 Application of the Household Production Function Model to this Study

The theoretical model of the present study uses the notion of the HPF where a household as a consumer maximizes utility by combining capital and time in the production of a set

of commodities that directly yield utility. The produced commodities appear as direct arguments in the household or consumer's utility function. Thus, in this formulation households are considered both as producing units and utility maximizers.

Formally, let the household's utility function be

$$U = U(Z_F, Z_A, Z_L, X; H) \quad (1)$$

where utility U is derived from both the services from and the quantity of the commodity derived from forests (Z_F), AIGA (Z_A), leisure (Z_L) and a purchased composite non-fuel, non-AIGA commodity (X). H refers to a vector of household characteristics that influences preferences. The above utility function is assumed to be ordinal, continuous, monotonically increasing (non-satiation) ($\partial U/\partial Z_i > 0$), quasiconcave (non-increasing marginal rate of substitution (MRS)), twice differentiable and it satisfies the completeness, reflexivity and transitivity properties. Another assumption specific to this model is that the provision of additional capital from the VFC has a positive effect on Z_A by increasing the marginal productivity of labor in Z_A (MP_{T_A}) as in (A.1).

$$\frac{\partial Z_A}{\partial K_A} > 0 \quad (A.1)$$

Moreover, the household is assumed to maximize its utility subject to production technology, time and income constraints.

As a producer, the household allocates time to produce the commodities Z_F, Z_A by combining time and capital and allocates time to Z_L as specified in equations (2), (3) and

(4), respectively. These production functions are assumed to be increasing functions of purchased inputs as well as non-purchased inputs, to exhibit decreasing marginal productivity and to be homogeneous of degree one and concave in nature.

The fuelwood collected from forests is given by

$$Z_F = z_F(T_F; G, H, R) \tag{2}$$

which is a function of T_F (time allocated for fuelwood collection). In addition to time, a household may allocates a small amount of capital to buy implements, such as a sickle, to collect fuelwood from forests. These implements have a life period of several years and are used in a variety of other domestic, farm and off-farm uses. Hence, it is assumed that the amount spent on capital to collect fuelwood from forests is negligible. G refers to a vector of variables that represent the environment in which production takes place and includes the level of technology or the state of production. H is a vector of household characteristics that influence preferences and R refers to resource availability.

Likewise, the production function for AIGA (Z_A) is given by

$$Z_A = z_A(T_A, K_A; G, H,) \tag{3}$$

which is a function of T_A (time allocated for AIGA), K_A (capital available from the VFC), G and H. Similarly, the production function for leisure (Z_L) is given by

$$Z_L = z_L(T_L; G, H) \tag{4}$$

which is a function of a vector for T_L (time allocated for leisure).

The constraint on the household's available time is given by

$$T = T_M + \sum_{i=1}^{n} T_i$$
$$\sum T_i = T_F + T_A + T_L \tag{5}$$

where T_M is the household's time spent in the labor market, T_F is time involved in producing Z_F, T_A is time involved in producing Z_A and T_L is time spent on leisure. The time constraint can be rewritten as

$$T_M = T - \sum_{i=1}^{n} T_i \tag{6}$$

where the vector T denotes the total time available.

The income constraint will be

$$I = P_X X = V + wT_M + K_A \tag{7}$$

where P_X refers to the price of a purchased composite non-fuel, non-AIGA commodity X. V is the household's non-wage income, w is the wage rate and K_A is the loan obtained from the VFC. Thus substituting for T_M in (7) its equivalent in (6) gives the single constraint

$$P_X X + \sum T_i w = V + wT + K_A \tag{8}$$

Thus, the time and money income constraints can be collapsed into a single resource constraint on the household's full income S.

$$S = wT + V + K_A = \sum wT_i + P_X X \tag{9}$$

The utility function (1) is maximized subject to the constraints of the production functions and full income (9). The Lagrangian may be expressed as

$$L = u(Z_F, Z_A, Z_L, X; H) + \lambda\left[S - \left(\sum_i wT_i + P_X X\right)\right]$$

$$L = u(Z_F(T_F), Z_A(T_A, K_A), Z_L(T_L), X; H) + \lambda\left[S - \left\{\sum_i w(T_L + T_F + T_A) + P_X X\right\}\right] \qquad (10)$$

The first order conditions are

$$\frac{\partial L}{\partial T_F} = \frac{\partial U}{\partial Z_F}\frac{\partial Z_F}{\partial T_F} - \lambda w = 0 \qquad (10.1)$$

$$\frac{\partial L}{\partial T_A} = \frac{\partial U}{\partial Z_A}\frac{\partial Z_A}{\partial T_A} - \lambda w = 0 \qquad (10.2)$$

$$\frac{\partial L}{\partial T_L} = \frac{\partial U}{\partial Z_L}\frac{\partial Z_L}{\partial T_L} - \lambda w = 0 \qquad (10.3)$$

$$\frac{\partial L}{\partial T_L} = \frac{\partial L}{\partial T_F} = \frac{\partial L}{\partial T_A} = \lambda w \qquad (10.4)$$

where λ w is the marginal opportunity cost of time. Solving for λ in (10.1) and substituting it in (10.2) results in

$$\frac{\partial U}{\partial Z_F}\frac{\partial Z_F}{\partial T_F} = \frac{\partial U}{\partial Z_A}\frac{\partial Z_A}{\partial T_A}$$
$$MU_F MP_{T_F} = MU_F MP_{T_A} \qquad (11)$$

where MP_{T_F} and MP_{T_A} represent the marginal products of time when it is spend in forest based activities and AIGA, respectively. Similarly, MU_F and MU_A refer to the marginal utility obtained from forest based activities and AIGA, respectively. Equation (11) implies that, at equilibrium, the factor time will be allocated among commodities to equalize the utility value of marginal product on the production of different commodities.

According to equation (3) it is apparent that capital is essential to pursue AIGA. Initially, the individual has no or less capital to pursue AIGA. However, after joining the VFC, the individual has access to capital K_A to pursue AIGA. Moreover, according to (A.1), an increase in capital from the VFC results in a higher marginal product of labor in Z_A (MP_{T_A}). Hence, when the individual gets capital from the VFC to pursue AIGA there will be an increase in MP_{T_A} that results in a higher value of the right hand side of equation (11). To bring down this value to equality, a shift in labor from the left hand side of equation (11) representing fuelwood collection activity to AIGA is expected for equation (11) to hold. Hence, it is implied that provision of K_A would increase the labor allocation for AIGA (T_A) and decrease the labor allocation for fuelwood collection (T_F), indicating a positive effect on Z_A (AIGA) and negative effect on Z_F (fuelwood collection activity).

A similar interpretation can be drawn to know the impact of K_A on leisure as in equation (12). As explained above, an increase in capital from the VFC makes us to expect movement of more labor from leisure to AIGA, implying that provision of K_A might have a negative effect on Z_L (leisure).

$$\frac{\partial U}{\partial Z_A}\frac{\partial Z_A}{\partial T_A} = \frac{\partial U}{\partial Z_L}\frac{\partial Z_L}{\partial T_L}$$
$$MU_A MP_{T_A} = MU_L MP_{T_L} \qquad (12)$$

3.4 Empirical Model

The empirical model of this study draws on the solution to the HPF model illustrated in the previous section. More specifically, the empirical equivalent of the trade-off between time allocated to AIGA and fuelwood collection or leisure can be captured in the following specification of reduced form labor supply equations. For AIGA, T_A can be written as

$$T_A = f_{T_A}(w, V, H, G) \quad (13)$$

where H refers to household characteristics such as age, gender, education and household composition and V is non-wage income. Likewise, the reduced form labor supply equation for fuelwood collection (T_F), is given by

$$T_F = f_{T_F}(w, V, H, G) \quad (14)$$

The empirical specification of (13) is

$$y_i = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + ... + \beta_k X_k + \varepsilon \quad (15)$$

where y_i is the dependent variable that denotes households' time allocated for AIGA, while $X_1, X_2 \ldots X_k$ refer to the explanatory variables, k refers to the number of independent variables to be estimated, $\beta_{1,}\ \beta_{2,\ldots,}\ \beta_k$ represent the parameter to be estimated, β_0 is the intercept and ε refers to the error term.

Similarly, the empirical specification corresponding to equation 14 can also be expressed as identical to equation 15 if the value of the dependent variable is observed for all

sample households. However, it is likely that some households may not access forest-based resources. Hence, the reduced form labor supply equation for fuelwood collection can be estimated through a censored regression or Tobit model given by

$$y_i^* = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + ... + \beta_k X_k + \varepsilon_i \tag{16}$$

$$y_i = \begin{cases} y_i^* = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + ... + \beta_k X_k + \varepsilon_i & if\ y_i^* > 0 \\ 0 & if\ y_i^* \le 0 \end{cases} \tag{17}$$

$$\varepsilon_i \sim IN(0\ \sigma^2)$$

where the dependent variable y_i denotes the hours allocated by the household for fuelwood collection and is observed only if $y_i^* > 0$ and not observed if $y_i^* \le 0$.

By impacting on households, the EDP also has economic and ecological impacts at the village-level, which can be considered as an aggregation of individual household behavior. However, aggregation of individual behavior to the village-level requires two assumptions (Mäler, 1985): identical utility functions and production functions for all households; homothetic utility functions and production functions. The second assumption implies that the budget shares are not affected by changes in the wealth or income of a household. The first assumption then implies that the budget share in aggregate is not changed by the income redistribution.

Under these assumptions, the village-level impacts can be captured by an estimable equation of the form:

$$y_{it} = (\beta_0 + \alpha_t) + \sum_{k=1}^{K} X_{itk}\beta_k + \varepsilon_{it} \qquad i = 1,...,N; \quad t = 1,...,T \tag{18}$$

where *t* denotes the time period and *i* denotes the specific village. The dependent variable y_{it} refers to the percentage of households developed to the total number of households in village *i* at time period *t*. While K refers to the number of independent variables given by $X_1, X_2,\ldots,X_K$, which refer to the attributes of the village and VFC. Likewise, ε_{it} denotes the error term, β_0 refers to the intercept and α_t captures the time effect. Equation (18) is the empirical equivalent to (13). Similarly, the empirical specification corresponding to (14) at the village-level is

$$y_{it} = (\beta_0 + \alpha_t) + \sum_{k=1}^{K} X_{itk}\beta_k + \varepsilon_{it} \qquad i = 1,...,N; \quad t = 1,...,T \tag{19}$$

where the dependent variable y_{it} refers to the percentage of fuelwood collecting households to the total number of households in village *i* at time period *t*.

In addition to its impact on labor allocation for AIGA and fuelwood collection, the EDP can influence the fuel consumption pattern of households in the study area. The three primary fuels used in the study area were wood, kerosene and liquid petroleum gas (LPG). The households' choice of primary fuel among these three fuel sources is estimated through the Probit model. The Probit regression equation corresponding to

wood as the primary fuel is

$$y_i^* = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + ... + \beta_k X_k + \varepsilon_i \quad (20)$$

where y_i^* is the desire of the household to use wood as a primary fuel, a latent variable that is not observed. Instead, a dummy variable y_i that denotes the household's usage decision is observed

$$y_i = \begin{cases} 1 & if\ y_i^* > 0 \\ 0 & otherwise \end{cases}$$

From this, the household's probability of choosing wood as a primary fuel source may be then written as

$$Pr(y_i = 1) = \Phi\ (\beta_0 + \beta_1 X_1 + \beta_2 X_2 + ... + \beta_k X_k + \varepsilon_i) \quad (21)$$

where the dependent variable y_i denotes the household's probability of choosing wood as a primary fuel. While X_1, $X_2 \ldots X_k$ refer to the explanatory variables related to household and community attributes, ε_i refers to the error term that has the standard normal distribution and Φ denotes the cumulative distribution function[6].

Similarly, the household's probability of choosing kerosene as the primary fuel source is given by

$$Pr(y_i = 1) = \Phi\ (\beta_0 + \beta_1 X_1 + \beta_2 X_2 + ... + \beta_k X_k + \varepsilon_i) \quad (22)$$

where y_i denotes the probability of choosing kerosene as the primary fuel.

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[6] Φ is obtained from formula $\Phi(x) = \int_{-\infty}^{x} \frac{1}{\sqrt{2\pi}} \exp\left(\frac{-t^2}{2}\right) dt$

Likewise, the household's probability of choosing LPG as the primary fuel source is:

$$Pr(y_i = 1) = \Phi\ (\beta_0 + \beta_1 X_1 + \beta_2 X_2 + ... + \beta_k X_k + \varepsilon_i) \quad (23)$$

where y_i denotes probability of choosing LPG as the primary fuel.

4. STUDY AREA AND DATA COLLECTION

The principal objective of the study is to empirically assess the EDP's impact on households and communities with the help of the model described in the previous chapter. To fulfill this objective, both primary and secondary data were collected from the project area. To facilitate understanding of the nature of the data, first a detailed description of the project area is presented in section 4.1 followed by an explanation of the EDP in section 4.2. Finally, information on data collection method is provided in section 4.3.

4.1 Study Area

The EDP was the first of its kind implemented to preserve biodiversity in the Kalakad–Mundanthurai Tiger Reserve (KMTR). The KMTR is located in south India in the Southwestern Ghats region at 8°25'–8°53'N latitude and 77°10'–77°35'E longitude (Figure 2). Established in 1988 in an area of 895 km^2, (of which 537 km^2 is in the core zone), it is recognized as one of the 18 global 'hot spots' of biodiversity and one of the five centers of plant diversity and endemism in India (Myers, 1990). In addition, the KMTR has ten distinct forest types beginning at 40 m mean sea level (msl) and reaching up to 1800 m msl, making it unique in its tropical forest conglomeration with rich floral and faunal diversity, both in terms of species richness and endemism (Melkani, 2001). Moreover, it harbors no less than 2000 plant species including around 150 localized

endemic plant species and serves as a habitat for a rich and wide variety of wildlife, including tigers and other carnivores, primates, ungulates, small mammals, birds, reptiles, amphibians and many other life forms (Ali 1998; Melkani, 2001).

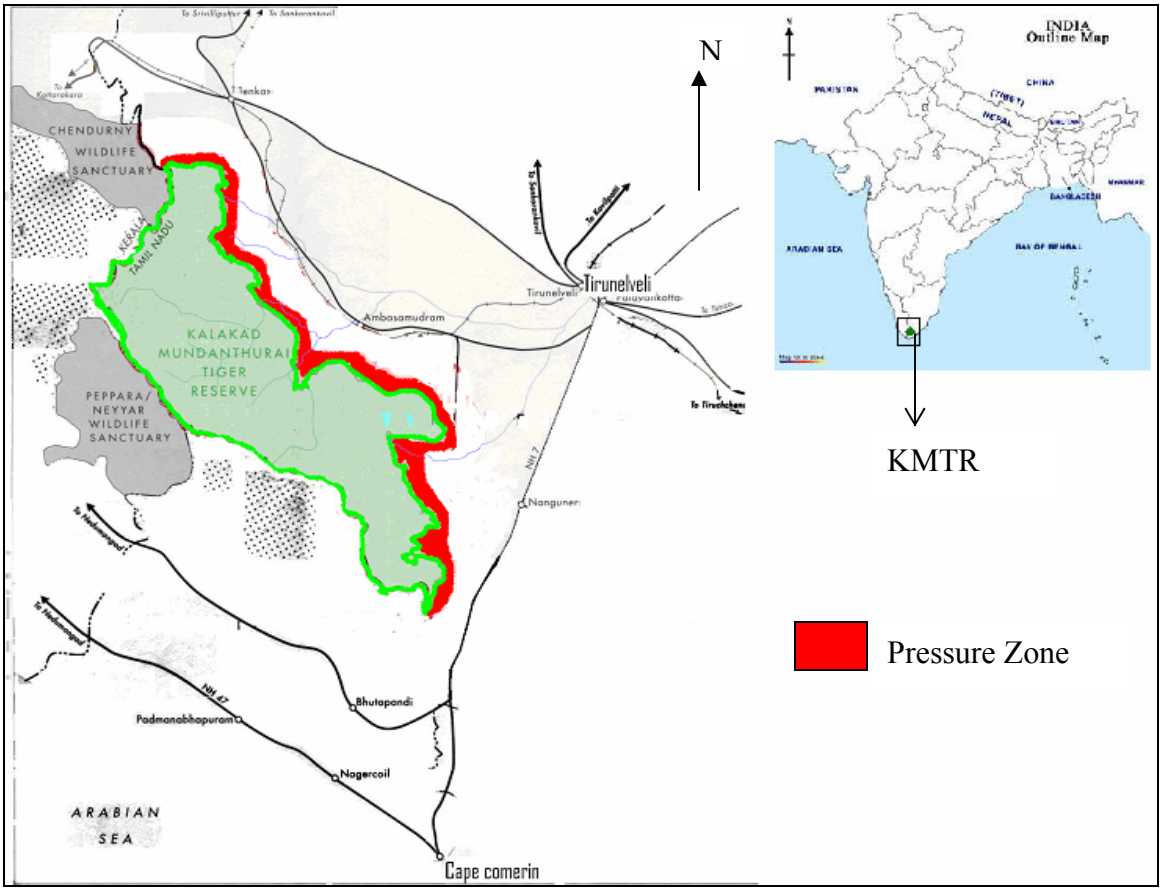

Figure 2. Map of the Kalakad Mundanthurai Tiger Reserve

4.1.1 Pressures on the Kalakad Mundanthurai Tiger Reserve

While the KMTR is bordered by forests having protected status in the north, south and west, it is open in the east for over 110 km. Along the eastern border, there are around 150 villages within 5 km distance from the periphery of the reserve. Human and cattle population from these villages exerted moderate to marginally high pressure on the reserve through grazing, cutting and removing fuelwood for a long period of time (Melkani, 2001). On the other hand, villages also experienced problems of crop damage from KMTR wildlife due to their close proximity to the reserve (Ali, 1998; Melkani, 2001). Though grazing and firewood removal is legally prohibited, the forest department found it difficult to enforce these laws in the vast area of the reserve due to inadequate monitoring capacity. Moreover, the management objective of the state at the KMTR is preservation rather than conservation of forests. Hence, though the state recognized the importance of involving people in participatory management of forests and practicing joint forest management (JFM) elsewhere, it could not adopt JFM at the KMTR as the core concept of resource sharing in such policies is prohibited there. Besides, there was a conflict between maintaining biodiversity and human utilization of the forest resulting in a hostile relationship between forest officials and the villagers.

4.2 The Ecodevelopment Project

Considering the conflicts explained above, the state began looking for new ways of participatory management at the KMTR and came up with a new method known as the ecodevelopment approach, a kind of JFM without resource sharing. This resulted in the introduction and implementation of the EDP in the KMTR as a pilot project to involve people in forest preservation during 1995-99 with an outlay of 91 million INR ($ 0.25 million) funded by the World Bank[7]. Since the EDP generated a lot of valuable experience and information on causes, concerns and outcomes of local people's involvement in preserving biodiversity, the project was extended for another two years with an outlay of 118.24 million INR ($ 0.33 million) (Annamalai, 2004). A detailed explanation of the components of the EDP follows.[8]

4.2.1 Objectives of the Ecodevelopment Project

The overall objective of the EDP was to simultaneously achieve ecological and economic development of the reserve and the fringe villages, respectively. This was to be accomplished through specific objectives such as (i) establishing committed grassroots-level organizations concerned with preservation in the eco-development villages through education, motivation and involvement of local people in these villages, (ii) reducing resource dependency on the reserve by providing alternative livelihoods to the forest

[7] Exchange rate (1996) used throughout this chapter is 1$ = INR 35.4.
[8] A brief introduction to the idea of the EDP including definitions is presented in section 2.1.

dependents and enhancing their skills through training, workshops and field visits, (iii) increasing the availability of biomass resources (firewood, fodder, small timber and fruit trees) by producing them in and around the villages, (iv) motivating people to substitute commercial energy resources for fuelwood and to adopt efficient methods of energy use, (v) creating awareness among the villagers about the value of the reserve, (vi) providing opportunities for local people to participate in PA's management activities and (vii) increasing collaboration of local people in preservation efforts.

4.2.2 Formation of the Village Forest Committee

The project's eco-development activities were concentrated in the villages within five km of the reserve's eastern border (Melkani, 2001). The objectives of the EDP were achieved by establishing a village-level institution called the Village Forest Committee (VFC) in each village. The process of forming VFCs passed through several stages. First, to develop credibility and better rapport with the local people, the Forest Department (FD) undertook a preliminary activity that was essential and specific to the village, such as providing a drinking water facility, repairing a village road, desilting a water channel or improving community structure at the cost of INR 50,000 ($ 1412). After establishing rapport, awareness was created among the villagers about the value of the reserve as a catchment of the Tamirabarani, the only perennial river of the state. The need for conserving the river was conveyed using different media such as folk arts, audio-visual presentations, posters and brochures. After developing an initial relationship with the

people and creating awareness, the eco-development planning and implementation team, consisting of project staff and local non-governmental organization (NGO) representatives, visited the village and met with villagers to establish the VFC.

4.2.3 Structure of the Village Forest Committee

The VFC was comprised of a "General Body" and an "Executive Committee" elected by the General Body for discharging assigned functions. All households were eligible to be a part of the VFC and one male and one female could be enrolled as members by paying one rupee per month as a membership fee[9]. After joining, all members together elected an executive committee of six to seven members, of whom at least 50 % were required to be females. The executive committee also had a forest guard and a representative from a local NGO as members and a forester as a member secretary without voting rights. While the General Body met at least once in three months with at least 50 % of households' participation, the executive committee met at least once a month or whenever needed. The executive committee elected a VFC chairperson who was eligible to hold the position for two years and for no more than two terms. The election of executive committee members was held annually, and members up for reelection had no term limits.

[9] However, households — not interested in abiding by the rules of the VFC; demanding loans immediately after their enrollment; incapable of pursuing AIGA; and having strong political background — were restricted from joining the VFC. In addition, some higher income households with no forest dependency showed no interest in joining the VFC.

After forming the VFC, the FD committed to provide an amount to be specified in the village's microplan as assistance to the village. In reciprocity, the members of the VFC, individually and collectively, provided assistance to the forest officers to pursue forestry development works as mentioned in the microplan in addition to ensuring protection against fuelwood collection, grazing, fires and thefts of forest produce. Furthermore, members had to increase awareness on the importance of forests among other villagers. In addition, they identified beneficiaries in accordance with the approved microplan.

4.2.4 Functioning of the Village Forest Committee

After reaching an agreement with the VFC, the forest officials and NGO representative along with the VFC prepared a microplan relevant to their village in the local language to be approved by the Field Director and Conservator of Forests. The microplan contained the details on community asset building, individual income generation activities and the serial order in which the members would be given a loan, as well as information on biomass production, alternate energy and energy conservation devices and human resources development. To facilitate better targeting, the households were labeled as Red, Yellow or Green based on their level of forest dependency. The Red group depended on forests for their daily livelihood and for fuel consumption. The Yellow group depended on forests only for their fuel consumption, and the Green group indirectly depended on forests by purchasing fuelwood from the Red group. De facto the Red, Yellow and Green

groups represented poor, middle and rich economic status, respectively[10]. The FD allocated the microplan amount for each village usually at the rate of INR 1600 ($ 45) per household enrolled in the VFC. The VFC was advised to spend the amount in the ratio of 25:25:50 for biomass creation, alternate energy saving devices and alternate income generating activities, respectively. In most cases, it was observed that while the Red group received assistance for AIGA, the Yellow and Green groups received assistance for improved energy devices and biomass creation, respectively.

Members were granted their loan as specified in the microplan at a nominal interest rate of 12 %. To receive a loan they had to provide evidence to the VFC of their capability to contribute 25 % of the principal amount. The principal amount and the borrower's contribution would then go towards financing the AIGA. The borrowers' contribution would be either in the form of cash or in-kind transfers, with the latter being the most common. Loans were repaid in monthly installments, with the number of installments decided by the VFC. From its initiation through today, the VFC has maintained a bank account jointly operated by the Forester and the chairman of the VFC. Funds from the VFC account could be withdrawn only with a two-thirds majority vote of members'

[10] During the initial stages of the project period, the project staff used forest dependency as the main criteria for this classification. In due course, the forest dependency had reduced due to the EDP, and at present, these categories are used by the project staff to indicate the socio economic status of the households. This status was determined by a group of villagers along with representatives of NGOs and project staff based on multiple criteria in a participatory rural appraisal exercise. Households' socio economic attributes such as nature of profession, income from off-farm activities, nature of house residence, and amount of land owned and number of livestock and other assets were used to determine the economic status of the households, a technique commonly used in rural areas of developing countries (Richards et al., 1999; Adhikari, 2005).

approval, ensuring transparency. The VFC was registered under the Tamil Nadu Societies Act of 1975.

To sum up, the tripartite relationship among the FD, NGOs and forest fringe dwellers rendered the EDP as a kind of JFM without direct benefit sharing from the forests that aims to empower the un-empowered and disempowered forest fringe dwellers and enable them to be involved in forest preservation projects.

4.3 Data Collection

As explained in section 4.2, the EDP was implemented in 129 villages within the five km distance from the eastern border of the KMTR[11]. In addition to a personal visit to the project area, several discussions were held with the forest officials, representatives of the NGOs and villagers to understand the EDP's impact. These discussions revealed that by diverting the forest fringe dwellers from forest based to alternate income generating activities, the EDP had influenced households' income status and fuel consumption patterns, which in turn had an impact on reducing forest dependency and improving the economic status of the villages. Hence, to understand the impact of the EDP, data related to both villages and households were collected by using two separate questionnaires over a two month period from November through December 2004. The data was collected in

[11] Only VFCs formed during the first phase of the project were considered for the analysis as they were present for a considerable amount of years both during and after the completion of the project, which is ideal for the study's objective.

person and the objectives of the study were explained to both VFCs and households to ensure their full co-operation in disclosing the information.

Taking into consideration the time constraint, 20 local enumerators were trained to collect data. These enumerators are from NGOs and are familiar with the project area as they have been associated with the EDP for a long time period. They were instrumental in refining both types of questionnaires along with forest officials and key members from the VFCs. Training was provided to these enumerators before the survey and regular on-field and off-field meetings were held to clarify the questions that emerged.

The village level data was collected from VFC records for 1996, 2001 and 2004 which represent the start of the project period, the end of the project period and the time after the project period, respectively. The data was collected for only 128 VFCs as it was not possible to access the records of one VFC due to legal reasons. Information related to demographic characteristics, literacy rate, infrastructure facilities, rural industries, distance to market and forest, fuelwood collecting households, socio-economic status of households, involvement of members in VFCs' activities and performance of VFCs in terms of beneficiaries, loan recovery rate and capital rotation were collected from VFCs' records. Information not found in VFCs' records, such as forest pathways, was collected from local VFC members and forest officials.

To understand the impact of the EDP at the household level, 400 sample households were chosen through the stratified random sampling technique. This sampling technique provides precise, reliable and highly detailed results (Kothari 2005) and has been widely adopted in household level fuelwood studies (Heltberg 2001; Pattanayak, Sills et al. 2004; Adhikari 2005; Edwards and Langpap 2005). First, the villages were stratified into five groups based on the proportion of Green (higher income) VFC households to total VFC households. The idea behind choosing this variable to stratify the data was that it showed more variation among villages in addition to being a key variable for the success of the EDP to reduce forest dependency. The villages were arranged in ascending order based on this forest dependency ratio and the cumulative number of households was calculated, which was later divided into five equal groups each comprising around 3900 households. A total of 40 villages were randomly selected by choosing 8 villages from each group by the random number technique. From these 40 villages, 10 households from each village were randomly chosen, making the sample size 400 households, or approximately 2 % of total VFC households. Out of 400 household questionnaires, 18 were excluded from the final analysis since they were incomplete.

The household level survey collected information on a wide range of topics, including demographic characteristics, education, assets, income, expenditures, labor allocation, fuel consumption and perceptions on VFC and forests. Most of the information was collected for the previous month as recall- based information, a technique mostly followed in other economic studies on fuelwood (Kohlin and Amacher, 2005). To

minimize the potential for accuracy problems of recall based data in the questionnaire, questions were ordered so as to assist the respondents' memory. Furthermore, cross checks were built into the questionnaire to validate the information provided by the respondents. A detailed description of both village level and household level data is provided in the next chapter.

5. DATA DESCRIPTION

This chapter provides a detailed description of the data collected for this study. First, the nature and performance of VFCs from 1996 to 2004 is explained in section 5.1. Next, the households' characteristics and behavior is described in section 5.2.

5.1 Description of Village–level Data

This section starts with a detailed description of the nature of villages. Following that, the characteristics and performance of the VFCs in terms of capital allocation, beneficiaries supported, improvement in the economic status of households, reduction in forest dependency and involvement of members in VFCs' activities are explained.

5.1.1 Socio-demographic Profile of the Study Area

The socio-demographic profile of the study area is presented in Table 1. Out of 25,007 households in the villages, around 59 %, 31 % and 10 % belonged to the Lower Income, Middle Income and Higher Income Groups, respectively in 2004. The proportion of VFC households to total households in the villages was 77.7 % for the whole sample area and it was 78 %, 81.3 % and 65 % for the Lower, Middle and Higher Income Groups, respectively in 2004. There was a 20.6 % increase in the total VFC households from 1996 to 2004. This increase was observed in all three groups from 1996-2001. However, from

2001-2004, the increase was only observed in the Middle and Higher Income Groups; there was a decrease in VFC households in the Lower Income Group in this period. There may be a correlation between this reduction and movement of households from the Lower Income Group to the Middle Income Group and from the Middle Income group to the Higher Income Group[12].

Table 1. Socio-demographic Profile of the Study Area

Serial No.	Group	Village Forest Committee(VFC) Households			Total Households	% of VFC Households to total Households
		1996	2001	2004		
1	Lower Income Group	11420 (70.9)	11852 (64.6)	11484 (59.1)	14723 (58.9)	78.0
2	Middle Income Group	3603 (22.4)	5112 (27.9)	6296 (32.4)	7742 (31.0)	81.3
3	Higher Income Group	1107 (6.9)	1382 (7.5)	1652 (8.5)	2542 (10.2)	65.0
	Total	16111 (100)	18346 (100)	19432 (100)	25007 (100)	77.7

(Figures in parentheses indicate percentage to total)

Table 2 shows the age-wise distribution of VFCs. About 64 % of VFCs were more than seven years old, indicating their lengthy presence both during and after the completion of

[12] This trend is explained in detail in Table 10.

the project, which is ideal for the study's objective[13]. About 11 % of VFCs were less than four years old and 20.3 % of VFCs were between 4 and 7 years old.

Table 2. Age-wise Distribution of the Village Forest Committees

Serial No	Years	Number of VFCs	Percentage to total VFCs
1	4	14	10.9
2	4.1 T0 5	6	4.7
3	6.1 to 7	26	20.3
4	7.1 to 8	51	39.8
5	Above 8	31	24.2
	Total	128	100.00

To facilitate better understanding of the nature and performance of VFCs, the VFCs were classified into three groups based on the recovery percentage of loans, which may be a proxy for performance quality. The classifications comprise: Group I (above 90 %), Group II (80-90 %) and Group III (less than 80 %). The percentage ranges were chosen to provide a considerable variation in VFCs under each category.

5.1.2 Group-wise Socio-demographic Profile of the Study Area

The average age of the VFCs was 7.1 years and was the lowest (6.8 years) in Group III, suggesting a correlation between the age of the VFC and recovery rate (Table 3). Meanwhile, the average village size was 195 households and was the lowest in Group I

[13] As this was a pilot project, the project staff experimented this project initially in a few villages and gradually extended the scope to several villages, resulting in VFCs of different ages.

(172), followed by Group II (197) and Group III (232). Similarly, the average VFC size was 152 households and was the lowest in Group I (137) followed by Group II (155) and Group III (172). In contrast, the number of VFC households to total households was the highest in Group I (79.7 %), followed by Group II (78.7 %) and Group III (73.9 %) , suggesting a positive correlation between the number of VFC households and total households.

Table 3. Group-wise Socio-demographic Profile

Serial No.	Group	Number of Villages	VFC's Age	Average Village Size	Average VFC Size
1	Group I	52	7.03	172	137
2	Group II	45	7.41	197	155
3	Group III	31	6.79	232	172
	Total	128	7.11	195	152

5.1.3 Capital Allocation among the Village Forest Committees

The average amount of capital provided to VFCs was 0.24 million INR ($ 6780 (1996)) (Table 4). There was no major difference among the groups in allocating their money to AIGA, energy conservation activity and biomass regeneration activity. In brief, all three groups allocated about 65 % of their capital to AIGA, 18 to 20 % for providing energy conservation devices and about 15 % on biomass regeneration. However, Group I increased their capital by 409.7 % from 1996-2004 while Group II and Group III increased their capital only by 250 % and 165.7 %, respectively during the same time

period. This increase came mainly through increases in the circulation of capital allocated to AIGA by providing loans to the members at 12 % annual interest. Group I provided AIGA loans to 144.8 % of members, indicating that members have received loans more than once. In Group II and Group III 112 % and 78 % of members received loans (Table 5). As for AIGA, the amount of female beneficiaries was the highest in Group I (63.4 %), followed by Group II and Group III, suggesting a positive correlation between granting loans to female beneficiaries and recovery rate.

Table 4. Capital Allocation among the Village Forest Committees

Serial No.	Group	Allocation of Capital (%)			Average Capital Amount (in million INR)			Growth Percentage	
		ECA*	BRA*	AIGA*	1996	2001	2004	2001	2004
1	Group I	18.6	16.2	65.2	0.23	0.71	1.19	204.7	409.7
2	Group II	17.7	14.6	67.8	0.26	0.58	0.90	125.1	250.1
3	Group III	20.2	14.9	64.9	0.24	0.41	0.63	72.4	165.7
	Total	18.7	15.3	66	0.24	0.59	0.95	143.9	292.8

* ECA, BRA and AIGA denote energy conservation activity, biomass regeneration activity and alternate income generating activity, respectively.

Table 5. List of Beneficiaries

(in percentage)

Serial No.	Group	ECA	BRA	AIGA	Female Beneficiaries
1	Group I	31.1	60.7	144.8	63.4
2	Group II	32.7	58.2	112.0	57.6
3	Group III	15.2	56.0	80.0	56.6
	Total	27.8	58.7	117.6	59.7

5.1.4 Members' Involvement in the Village Forest Committees

Table 6 provides the members' participation in VFCs' activities. Regular participation percentage was the highest in Group I (89.3 %) while non-participation percentage was the highest in Group III (16.9 %). Likewise, the percentage of VFCs that had irregular and non-participation was highest in Group III and was lowest in Group I suggesting a positive correlation between the active involvement of members in VFCs' activities and higher loan recovery rate.

Table 6. Members' Involvement in the Village Forest Committees

(in percentage)

Serial No.	Group	Regular	Irregular	Non-participation
1	Group I	89.3 (100)	8.3 (88.5)	4.9 (69.2)
2	Group II	73.7 (100)	16.4 (97.8)	11.1 (93.3)
3	Group III	59.9 (100)	23.3 (100)	16.8 (100)

(Figures in parentheses indicate percentage of villages exhibiting that activity)

5.1.5 Grazing Incidences

Table 7 illustrates the grazing incidences in the study area. There was a 91 % decrease in grazing incidences for the whole area from 1996 to 2004 and these incidences were found in 60 % of the villages. Group I had the highest percentage of decrease in grazing incidences and the lowest percentage of villages having these incidences.

Table 7. Grazing Incidences

Serial No.	Group	Total Incidences			Average Incidences per Village			Participating Villages (%)		
		1996	2001	2004	1996	2001	2004	1996	2001	2004
1	Group I	8123	1500	504	166	47	24	94.2	61.5	40.4
2	Group II	8372	1817	887	190	44	31	97.8	91.1	64.4
3	Group III	5418	1494	583	175	51	22	100	96.8	87.1
	Total	21913	4811	1974	177	47	26	96.9	80.5	60.2

5.1.6 Households Collecting Fuelwood from Forests

From 1996 to 2004 the number of fuelwood collecting households decreased by 87.6 % (Table 8). On average there were 4 fuelwood collecting households per village. However, the fuelwood collecting households were present only in 82.8 % of villages. Likewise, the proportion of fuelwood collecting households to total households for the whole sample was 1.57 %. Group I showed the highest decrease in the percentage of fuelwood collecting households and also had the lowest number of fuelwood collecting households. From Table 5, it is observed that Group I provided loans to relatively larger number of beneficiaries to pursue AIGA. This suggests a negative correlation between fuelwood collection from forests and granting loans to pursue AIGA.

Table 8. Households Collecting Fuelwood from Forests

Serial No.	Group	Total Fuelwood Collecting Households (FCH)			% of FCH to total Households in 2004	Average FCH per Village			Participating Villages (%)		
		1996	2001	2004		1996	2001	2004	1996	2001	2004
1	Group I	1237	410	96	1.1	24	8	3	100	98.1	63.5
2	Group II	1117	437	152	1.7	25	10	4	100	100	93.3
3	Group III	817	386	145	2.0	26	12	5	100	100	100
	Total	3171	1233	393	1.6	25	10	4	100	99.2	82.8

5.1.7 Forest Pathways

The details on forest pathways of the study area, an indirect proxy for forest dependency, are presented in Table 9. There was a 67.6 % decrease in the total number of pathways for the whole area from 1996 to 2004. The average number of forest pathways present in a village was 2. However, forest pathways were seen only in 85.2 % of villages. The average number of forest pathways as well as the percentage of villages having forest pathways was the lowest in Group I, suggesting a negative correlation between fuelwood collection from forests and granting loans to pursue AIGA.

Table 9. Forest Pathways

Serial No.	Group	Total Pathways			Average Pathways per Village			Participating Villages (%)		
		1996	2001	2004	1996	2001	2004	1996	2001	2004
1	Group I	315	142	71	6	3	1	100	98.1	67.3
2	Group II	228	121	81	6	3	2	100	100	95.6
3	Group III	182	98	83	7	4	3	100	100	100
	Total	725	361	235	6	3	2	100	99.2	85.2

5.1.8 Economic Development

Table 10 provides the details on economic development of households from one group to another from 1996-2004. There was an increase in the number of households developed from one group to another in both 1996-2001 and 2002-2004 time periods. However, the increase in 1996-2001 is higher than in 2002-2004, which might be due to the greater length of time covered in the first period. To sum up, 27.8 % of Lower Income Group households or 13 % of total households developed to Middle Income Group levels from 1996-2004. In terms of loan repayment classifications, the percentage of development was highest in Group I (15.6 %), followed by Group II (13 %) and Group III (9.5 %). Similarly, 12.9 % of Middle Income Group, or 2.2 % of total households, developed to Higher Income Group levels from 1996-2004. Again, the percentage of development was the highest in Group I and the lowest in Group II. This suggests a correlation between the loan recovery rate of the VFCs and economic development of the households.

Table 10. Economic Development of the Households

Serial No.	Group	1996 to 2001		2002 to 2004		Total Households Developed		% of Households Developed to Total Households	
		LI* to MI*	MI to HI	LI to MI	MI to HI*	LI to MI	MI to HI	LI to MI	MI to HI
1	Group I	734	161	658	162	1392	323	15.6	3.6
2	Group II	657	73	497	69	1154	142	13	1.6
3	Group III	376	41	306	39	682	80	9.5	1.1
	Total	1767	275	1461	270	3228	545	13	2.2
		(15.5)	(7.6)	(12.3)	(5.3)	(27.8)	(12.9)		

* LI, MI and HI denote lower income, middle income and higher income, respectively.
**Figures in parentheses indicate percentage change to the total number of households in the starting period

5.2 Description of Household-level data

Analogous to the idea of classifying VFCs into separate groups for a better understanding of regression results, the sample households were also separated into three groups: Lower Income, Middle Income and Higher Income Groups[14]. The number of respondents in the Lower, Middle and Higher Income Groups was 214 (56 %), 141 (36.9 %) and 27 (7.1 %), respectively.

5.2.1 Socio-demographic Information of the Households

Table 11 shows the socio-demographic profile of the sample respondents. The average age of the family's head was 44.03 years and was 43.33 for the Lower Income Group, 44.78 for the Middle Income Group and 45.70 for the Higher Income Group. Males served as head of the family for 63.08 % of the whole sample and for 64.01 %, 61.70 % and 62.96 % of the Lower, Middle and Higher Income Groups, respectively[15]. The average family size for the whole sample was 4.1. The dependency ratio was higher in the Lower Income Group (0.97) than in the other groups, indicating a higher share of dependents in the Lower Income Group. This factor might contribute to their poor income status.

[14] The same approach is followed by the project implementation authorities to adopt specific strategies for different segments of the society.
[15] This is near the aim of providing equal opportunities to females (50 %) in the project. A detailed explanation is provided in Table 5.

Table 11. Demographic Profile of the Households

Serial No.	Description	Lower Income Group	Middle Income Group	Higher Income Group	Total
1	Number of Respondents	214	141	27	382
2	Average Age(years)	43.33	44.78	45.70	44.0
3	Average Family Size	4	4.3	4.6	4.1
4	Average Dependency Ratio*	0.97	0.80	0.88	0.9
5	Male Head	137	87	17	241.0
		(64)	(61.7)	(63)	(63.1)

Figures in parenthesis indicate % of households having male heads.
* Dependents divided by laborers

The literacy status of the respondents is presented in Table 12. Of the total respondents 67 % were literate. About 30.1 % had primary education and only 6 % had education above high school. Moreover, literacy increased with the increase in income level.

Table 12. Education of the Households

Serial No.	Description	Number of Households				Percentage of Households			
		Lower Income Group	Middle Income Group	Higher Income Group	Total	Lower Income Group	Middle Income Group	Higher Income Group	Total
	Literate								
1	Primary	66	44	5	115	30.8	31.2	18.5	30.1
2	Middle	31	27	9	67	14.5	19.2	33.3	17.5
3	High	20	27	4	51	9.4	19.2	14.8	13.4
4	Higher	8	8	3	19	3.7	5.7	11.1	5.0
5	Degree	0	1	3	4	0.0	0.7	11.1	1.1
	Total	125	107	24	256	48.4	75.9	88.9	67.0
	Illiterate	89	34	3	126	41.6	24.1	11.1	33.0
	Total	214	141	27	382	100	100	100	100

Table 13 illustrates that the average total income of the sample was INR 4744 ($ 105 (2004))[16]. Average total income was the highest in the Higher Income Group (INR 8786), followed by the Middle (INR 6026) and Lower Income (INR 3389) Groups. Likewise, the average land holding size was 2.1 acres for the whole sample and was the highest for the Higher Income Group (4.1 acres), followed by the Middle (2 acres) and Lower Income (1.00 acre) Groups. Moreover, 70.4 % of the Higher Income Group respondents owned land, while only 54.6 % of the Middle Income Group respondents owned land. Similarly, the average number of livestock owned for the whole sample was 3, with 4 for both the Higher and Middle Income Groups and 3 for the Lower Income Group. The amount of respondents holding any livestock was slightly higher in the Middle Income Group (39.7 %) than in the Higher Income Group (37 %). It could be observed from the table that mobile livestock may be a major asset for members of the Middle Income Group, while fixed land may be a major asset for the Higher Income Group members.

Table 13. Assets of the Households

Serial No.	Description	Lower Income Group	Middle Income Group	Higher Income Group	Total
1	Average Total Income (INR /month)	3389	6026	8786	4744
2	Average Land (acres)	1.0	2.0	4.1	2.1
		(13.6)	(54.6)	(70.4)	(32.7)
3	Average Livestock*	3	4	4	4
		(20.6)	(39.7)	(37.1)	(28.8)

* Rounded to the nearest integer.
(Figures in parentheses indicate percentage of households owning that asset)

[16] Exchange rate (2004) for household data is 1$ = INR 45.3.

5.2.2 Fuel Consumption Pattern

The details on households' fuel consumption are presented in appendix 4. The key observations made from these appendices are explained below.

The sample households exhibited seven types of fuel consumption patterns involving wood, kerosene and LPG. The percentage of households using both wood and kerosene in combination (67 %) was the highest followed by the wood, kerosene and LPG combination (14 %) in the sample area. The data suggest a positive correlation between households' income and the latter combination and a negative correlation in case of former combination. Moreover, among these seven types of fuel consumption patterns involving fuelwood, kerosene and LPG, the percentage of households using wood or kerosene as the primary fuel source for cooking was the highest in the Lower Income Group, suggesting a negative correlation between income and usage of these fuels. In contrast, the percentage of households using LPG as the primary fuel source for cooking was the lowest in the Lower Income Group (7.5 %) followed by the Middle Income Group and Higher Income Group, suggesting a positive correlation between income and usage of LPG.

Moreover, seven patterns of fuelwood collection from different sources were observed in the study area. The proportion of the households collecting fuelwood from the common lands alone (52.9 %) was the highest, followed by collection from owned land alone

(13.6 %) and from the market alone (9.7 %). The percentage of households collecting fuelwood from common lands was the highest in the Lower Income Group (73.4 %) followed by the Middle and the Higher Income Groups, suggesting a negative correlation between households' income and fuelwood collection from common lands. In contrast, the percentage of households collecting fuelwood from owned land and purchasing fuelwood from the market was the highest in the Higher Income Group followed by the Middle and Lower Income Groups, suggesting a positive correlation between income and fuelwood collection from owned land and purchase. This, in turn, suggests that land ownership and affordability may be correlated with income. In addition, there may be a positive relationship between the households' income and opportunity cost of fuelwood collection from common lands.

Around 10 % of the respondents in the study area used non-wood fuels. Only 8.1 % of the households used a single fuel. The percentage of households using multiple fuels was the highest in Higher Income Group (96.3 %) followed by the Middle and the Lower Income Groups, suggesting a positive relationship with income and multiple fuels' usage. However, there was not much variation in the percentage of households using wood or kerosene in a combination with other fuels, among these three groups. In contrast, the percentage of households using LPG in a combination with other fuels was the highest in the Higher Income Group (81.5 %) followed by the Middle and Lower Income Groups, suggesting a positive correlation between income and usage of LPG in combination with other fuels.

The average monthly consumption of fuelwood, kerosene and LPG for the whole sample was 90.1 Kgs, 5.7 liters and 13.4 Kgs, respectively. While around 90 % of the households consumed fuelwood and kerosene, over one quarter of the sample households consumed LPG. Moreover, there may be a positive correlation between the income and quantity of fuels consumed. While the Higher Income Group consumed the highest amount of LPG (15.5 Kgs), the Middle Income Group consumed the highest amount of kerosene (6.1 liters) and fuelwood from owned land (74.4 kgs) and market (79.9 kgs).

Likewise, the average monthly fuel expenses for all sample households was INR 169.06 ($ 4) and it exhibited a positive relationship with income. In the case of the Higher Income Group, there may be a correlation between the fuel expenses and LPG consumption. Alternatively, in the Lower Income Group there may be a correlation between the fuel expenses and collection of fuelwood from the common lands, a practice without explicit cost. In fact, 3.3 % of the Lower and 0.7 % of the Middle Income Groups' households incurred no fuel expenses as they collected all their fuelwood from the common lands. Accordingly, the percentage of average amount of fuel expenses to total income (3.6) showed a positive relationship with income and was the highest for the Higher Income Group (4.2).

In brief, three key observations can be made on the fuel consumption pattern of the study area. First, there may be a negative correlation between households' income and dependency on common lands for fuelwood. Second, there may be a positive correlation

between income and LPG usage. Finally, the usage of multiple fuels, which was dominant in the study area, may be positively correlated with income.

5.2.3 Households' Labor Allocation for Alternate Income Generating Activities and Fuelwood Collection

The average number of hours allocated for AIGA in a month was 180 for the whole sample and it was highest in the Middle Income Group (183.4), followed by the Lower (178.1) and Higher Income (177) Groups (Table 14). However, the Higher Income Group (INR 2520.4) had the highest average monthly returns from AIGA, followed by the Middle and Lower Income Groups while monthly returns for the whole sample averaged INR 2088.9 ($ 46). However, the share of income from AIGA to total income was the lowest in the Higher Income Group (38.6 %) when compared to the Middle (44.4 %) and Lower Income (58.7 %) Groups. This suggests a negative correlation between the hours allocated for AIGA and income diversification opportunities.

The average number of hours allocated for fuelwood collection from the common lands in a month for the whole sample was 8.14[17]. Though the Middle Income Group (8.3) allocated slightly more hours than the Lower Income Group (8.2), it had a lower amount of participants (47.5 %) than the Lower Income Group (82.2 %). The Higher Income Group had the lowest both in terms of number of hours allocated for fuelwood collection

[17] It is to be noted here that no respondents were willing to accept that they were collecting fuelwood from the forest since it is illegal. In addition, they feared that doing so would affect their prospects of getting further loans from the VFC. Hence as an alternative, the details related to fuelwood collection from the common lands which would serve as a proxy to identify the respondent characteristics and other features that would influence the collection of fuelwood from the forests is reported here.

and participants. The average imputed value based on the prevailing market rate of the fuelwood collected for the whole sample was INR 210 and was highest for the Middle Income group, followed by the Lower and the Higher Income Groups. However, the proportion of this fuelwood value to total income was the highest in the Lower Income Group (6.6), followed by the Middle and Higher Income Groups, suggesting a negative correlation with income. This also suggests a correlation between the rational behavior of the Lower Income Group and fuelwood collection from common lands that has no explicit cost.

Table 14. Households' Labor allocation for Alternate Income Generating Activities and Fuelwood Collection

Serial No.	Description	Lower Income Group	Middle Income Group	Higher Income Group	Total
1	Average number of hours allocated for AIGA per month	178.1	183.4	177	180
2	Returns from AIGA (INR / month)	1903.5	2287.2	2520.4	2088.9
3	% of AIGA returns to total income	58.7	44.4	38.6	52
4	Average number of hours allocated for fuelwood collection per month	8.2	8.3	1.5	8.1
5	Percentage of Participants	82.2	47.5	7.4	64.1
6	Imputed value for the wood collected (INR / month)	207	221.8	40	209.7
7	% of imputed value to total income	6.6	4.6	1.3	6.0

5.2.4 Accumulation of Households' Assets after Joining the Village Forest Committee

Upward movement of households from one economic group to another may take several years. In that case, the accumulation of consumer durables and mobile assets can provide an idea of how the economic status of a household changes in the short run. The percentage of households owning any of these assets was the highest in the Higher Income Group and lowest in the Lower Income Group (Table 15). After joining the VFC, households' television purchase was the highest in the Middle Income Group (50.4). Likewise, radio (17.8) and bicycle (25.7) purchases were the highest in the Lower Income Group and motor bikes purchases were the highest in the Higher Income Group (29.6).

Table 15. Accumulation of Households' Assets after Joining the Village Forest Committee

(in Percentage of Households)

Serial No.	Description	Lower Income Group	Middle Income Group	Higher Income Group	Total
1	Consumer Durables				
	Television	47.2	88.0	100	66.0
		(35.5)	(50.4)	(44.4)	(41.6)
	Radio	46.3	60.9	100	55.2
		(17.8)	(10.6)	(11.1)	(14.7)
3	Bi- cycle	62.2	82.3	100	72.3
		(25.7)	(21.3)	(3.7)	(22.5)
4	Motor Bike	4.2	19.9	51.9	13.4
		(4.2)	(17.7)	(29.6)	(11)

*Figures in parentheses indicate the percentage of households that purchased the assets after joining the VFC

6. RESUTLS AND DISCUSSION

This chapter provides and discusses the results of the study. First, the regression results on VFCs' economic and ecological impacts are presented in section 6.1. Then, the regression results on households' labor allocation for AIGA and fuelwood collection are reported in section 6.2. Finally, the results of probit analysis to identify the determinants of households' primary fuel choice are discussed in section 6.3.

6.1 Village-level Impact of the Ecodevelopment Project

At the village level, the EDP's impact was measured in terms of improvement in the economic status of households, reduction in fuelwood collecting households and reduction in forest pathways. The regression results for households developed are presented first, followed by the regression results for fuelwood collecting households and for forest pathways.

6.1.1 Regression Results for Households Developed

The first hypothesis is on the village level impact of VFCs, especially on the income status of the households during and after the project period. Accordingly, variation in the income status of households among villages can be explained by the VFC's and village's attributes. This hypothesis can be tested by estimating the model:

$$Households\ developed(Y_1) = f\left\{\begin{array}{l}\beta_0 + \beta_1\ VFC's\ age\ +\ \beta_2\ VFC\ families\ +\ \beta_3\ VFC's\ capital \\ +\ \beta_4\ Non\text{-}participation\ +\ \beta_5\ Village's\ households\ +\ \beta_6\ Literacy \\ +\ \beta_7\ Distance\ to\ market\ +\ \beta_8\ Distance\ to\ forest \\ +\ \beta_9\ Non\text{-}farm\ opportunities\ +\ \beta_{10}\ End\ of\ the\ project\ period \\ +\ \beta_{11}\ After\ the\ project\ period\ +\ \varepsilon\end{array}\right\}$$

(6.1)

The dependent variable (Y_1) denotes the proportion of the number of households that moved up from lower income status to higher income status to the total number of households in the village, expressed as a percentage. The independent variables are the attributes of the VFC and Village. Note that equation (6.1) corresponds to equation (18) in chapter 3.

The presence of both time-series and cross-section observations in the data set motivated the use of panel data models which will relatively improve the precision and efficiency of the obtained estimates (Gujarati, 2003). Among the various panel data models available, two specification tests were conducted to choose the final specification that best fit the data. First, through an incremental F test, the null hypothesis of poolability of the data was rejected in favor of either fixed effect or random effect. Second, by using the Hausman (1978) specification test, the null hypothesis, which states that there is no correlation between the random effects and the regressors in the model, was rejected. The latter implies that a fixed effect model was to be used instead of a random effect model. The data had neither severe multicollinearity nor autocorrelation as confirmed by Durbin–Watson test. However, White test and Breush – Pagan Lagrange multiplier tests

showed the presence of heteroscadasticity, which was corrected with White's modified heteroscadasticity consistent covariance matrix estimator in the reported results in Tables 16, 17 and 18.

Table 16 shows the regression results of equation (18). Ten out of 12 coefficients were significant with the expected sign. Only two of 12 coefficients (literacy rate and distance to forest) showed unexpected sign but neither was significant. The adjusted R-square is 83 %.

The coefficient of the variable *VFC's age* showed that an increase in the age by one month would increase the proportion of households developed to total number of households by 0.12 %. This is consistent with the findings of Halder's (1998) study and indicates the importance of the durability of the VFC in the continuous economic development of households. Likewise, if the percentage of VFC households to total households is increased by one, then the proportion of households developed to total households would increase by 0.08 %, indicating the importance of the VFC in the economic development of the households. A similar result that emphasizes the importance of an increase in membership of microfinance institutions to improve the economic status of households is reported by Kaboski and Townsend (2005). Joining the VFC would provide easy access to capital which would be unavailable otherwise, to pursue AIGA resulting in higher household income. This result is also consistent with

those reported by the microfinance studies of Khandker (1998) and Zohir, Mahamud et al. (2001).

Table 16. Regression Results for Households Developed

(in % to total households)

Serial No.	Independent Variables	Parameter Value
1	Constant	-2.94**
2	VFC's Age	0.12***
3	Percentage of VFC Households to Total Households	0.08***
4	Increase in VFC's Capital (INR)	0.26***
5	Non-participation (%)	-0.12***
6	Total Households of the Village	-0.007***
7	Literacy Rate (%)	-0.01
8	Distance to Market (Km)	-0.10*
9	Distance to Forest (Km)	-0.06
10	Presence of Non-farm Opportunities	1.13***
11	At the end of the Project Period (1996-2001)	1.56**
12	After the Project Period (2002-2004)	3.28***
	R-Square	0.84
	Adjusted R-square	0.83

*, ** and *** denote the 10 %, 5 % and 1 % levels of significance, respectively.

Similarly, an increase in the VFCs' initial capital had a positive effect on the proportion of developed households in a village. If the VFCs are able to increase their initial capital by one lakh INR, then there will be a 0.26 % increase in the proportion of households

developed to total households. It could be inferred from Table 4 that VFCs with better loan recovery rates had increased their capital by providing loans to a larger number of beneficiaries for AIGA. Better loan recovery rates may be due to appropriate leadership of VFC and the morale and commitment of VFCs' members as well as of Project staff (Khandker, 1998; Dolšak and Ostrom, 2003).

As expected, the variable *non-participation* in VFC's regular activities had a negative relationship with the percentage of households developed. A unitary increase in the percentage of non-participation of households would reduce the proportion of households developed to total households by 0.12 %. This might be due to the fact that regular group meetings and interactions with group members can develop a bond and trust within the group that in turn increases peer pressure and peer monitoring, which result in higher recovery rates. In addition, it would help in sharing valuable social and market information and other AIGA related details to increase households' income (Mosley and Rock, 2004).

Consistent with the theoretical literature on the commons (Agrawal, 2001; Dolšak and Ostrom, 2003), the size of the village had a negative relationship with the percentage of households developed. An increase in the total number of households of the village by one household would reduce the proportion of households developed to total households by 0.007 %. Smaller groups might have advantages in monitoring, enforcement and conflict resolution.

As expected, the distance to a major market from the village showed a negative relationship with the economic development of households. A kilometer increase in the distance would reduce the proportion of households developed to total households by 0.10 %. This might be due to the fact that as the distance increases it would be difficult to find markets to buy and sell products for and from households' AIGA activities. In contrast, the presence of non-farm opportunities such as small rural industries in the villages promoted the economic development of households. Availability of one more rural industry will increase the proportion of households developed to total households by 1.13 %.

The effect of the project's duration on the percentage of households developed during as well as after the project period was calculated separately. Both time periods showed a positive relationship with the percentage of households developed, indicating the influence of the VFCs in promoting the economic status of the households. However, a higher rate of improvement was observed after the project period (3.28) than at the end of the project period (1.56). This might be due to the fact that certain households might need more time and successive loans to move up to higher income status. In addition, it appears that the project was sustainable in improving the economic status of the people even after the project period.

6.1.2 Regression Results for Fuelwood Collecting Households

The second hypothesis at the village level is the EDP's impact via VFCs, on the number of fuelwood collecting households during and after the project period. Accordingly, variation in the number of fuelwood collecting households among villages can be explained by the VFC's and village's attributes. This hypothesis can be tested by estimating the model:

$$\begin{matrix} Fuelwood \\ collecting \\ Households(Y_2) \end{matrix} = f\left\{\begin{matrix} \beta_0 + \beta_1\ VFC's\ age\ +\ \beta_2\ VFC\ families\ +\ \beta_3\ VFC's\ capital \\ +\ \beta_4\ Non-participation\ +\ \beta_5\ Village's\ households\ +\ \beta_6\ Literacy \\ +\ \beta_7\ Distance\ to\ market\ +\ \beta_8\ Distance\ to\ forest \\ +\ \beta_9\ Non\text{-}\ farm\ opportunities\ +\ \beta_{10}\ End\ of\ the\ project\ period \\ +\ \beta_{11}\ After\ the\ project\ period\ +\ \varepsilon \end{matrix}\right\} \quad (6.2)$$

The dependent variable (Y_2) denotes the proportion of households in the total number of households, expressed as a percentage that collects fuelwood from forests. The independent variables are the attributes of the VFC and Village as in equation (6.1). Table 17 reports the regression results of estimating equation (19). The results showed that eight out of 12 coefficients were significant with anticipated signs. The adjusted R-square is 57 %.

As expected, the age of the VFC had a negative relationship with the proportion of fuelwood collecting households, indicating that an increase in the age by one month

would reduce this proportion by 0.11 %. As noted earlier, the presence of growing co-operation and trust among members as well as an increase in peer pressure and monitoring in older VFCs may have reduced forest dependency.

Table 17. Regression Results for Fuelwood Collecting Households

(in % to total households)

Serial No.	Independent Variables	Parameter Value
1	Constant	42.88***
2	VFC's Age	-0.11***
3	Percentage of VFC Households to Total Households	-0.17***
4	Increase in VFC's Capital (INR)	0.04
5	Non-participation (%)	0.06
6	Total Households of the Village	-0.03***
7	Literacy Rate (%)	-0.02
8	Distance to Market (Km)	0.35**
9	Distance to Forest (Km)	-1.18***
10	Presence of Non-farm Opportunities	-0.11
11	At the end of the Project Period (1996-2001)	-9.97***
12	After the Project Period (2002-2004)	-10.28***
	R-Square	0.58
	Adjusted R-square	0.57

*, ** and *** denote the 10 %, 5 % and 1 % levels of significance, respectively.

Likewise, if the proportion of VFC households to total households is increased by one percent then the percentage of fuelwood collecting households would decrease by 0.17%, indicating the importance of VFCs in reducing forest dependency. Joining the VFC might have strengthened members' commitment to pursue AIGA instead of fuelwood collection from forests. In addition, fear of ineligibility for future loans and sanctions such as cultural isolation might contribute to reduced forest dependency of villages' households.

As expected, the increase in village size is negatively related to forest dependency. If the village size increases by one family then the proportion of fuelwood collecting households to total households would decrease by 0.03 %. This might be due to the fact that the additional family may have the option of pursuing different types of livelihood activities based on its income status.

Consistent with other studies (Adhikari, 2002; Köhlin and Amacher, 2005), the distance to forest had a negative relationship with forest dependency. A one kilometer increase in the distance from the village to forest would reduce the proportion of fuelwood collecting households in total by 1.18 %. This might be due to the fact that the opportunity cost of the time of the household increases with the distance to the forest. In contrast, the distance to market from the village had a positive relationship with forest dependency, which was consistent with studies by Pendleton and Howe (2002) and Amacher, et al. (1996). If the distance increases by one kilometer then the proportion of fuelwood collecting households to total households would increase by 0.35 %. An increase in

distance to the market might have a negative effect on households' interaction with other areas for their economic activities. This, in turn, would force the households to confine their livelihood activities to areas around the village, resulting in increased forest dependency.

The effect of the project's duration on forest dependency was calculated separately both for during and after the project period. Both time periods showed a negative relationship with the percentage of fuelwood collecting households, indicating the influence of the VFCs in reducing forest dependency. However, a slightly higher rate of improvement was observed after the project period (10.28) than at the end of the project period (9.97). Again, this indicates that the project was sustainable in reducing forest dependency even after the project period.

6.1.3 Regression Results for Forest Pathways

In addition to the above regression equation, the impact of the EDP on reducing forest dependency was estimated by using the number of forest pathways, an indirect proxy for forest dependency, as the dependent variable. It was hypothesized that the EDP, by creating VFCs, reduced the dependency on forests by reducing the number of forest pathways in the village, during and after the project period. Accordingly, variation in the number of forest pathways among villages can be explained by the VFCs and village's attributes. This hypothesis can be tested by estimating the model:

$$Forest\ Pathways(Y_3) = f\left\{\begin{array}{l}\beta_0 + \beta_1\ VFC's\ age\ +\ \beta_2\ VFC\ families\ +\ \beta_3\ VFC's\ capital \\ +\ \beta_4\ Non\text{-}participation\ +\ \beta_5\ Village's\ households\ +\ \beta_6\ Literacy \\ +\ \beta_7\ Distance\ to\ market\ +\ \beta_8\ Distance\ to\ forest \\ +\ \beta_9\ Non\text{-}farm\ opportunities\ +\ \beta_{10}\ End\ of\ the\ project\ period \\ +\ \beta_{11}\ After\ the\ project\ period\ +\ \varepsilon\end{array}\right\}$$

(6.3)

The dependent variable (Y_3) denotes the number of forest pathways that people use to bring the collected fuelwood from forests. The independent variables are the attributes of the VFC and Village. Table 18 reports the regression results of the reduction in forest pathways. Six out of 12 coefficients were significant with anticipated signs. The adjusted R-square is 60 %.

As with our earlier findings, the age of the VFC was found to be negatively related to the number of forest pathways. Likewise, the increase in the VFCs' initial capital showed a negative relationship with the forest pathways, indicating that households might have become involved in non-forest activities for their livelihood. In contrast, an increase in the total number of households in the village showed a positive relationship with the forest pathways. This might be due to the fact that bigger villages had a larger number of pathways before the project period, which may still exist but remain unused.

The effect of the project's duration on forest dependency was calculated separately both for during and after the project period. Both time periods showed a negative relationship with the number of forest pathways, indicating the influence of the VFCs in reducing

forest dependency. However, a higher rate of reduction was observed after the project period than at the end of the project period, similar to the earlier finding that the project was sustainable in reducing forest dependency even after the project period.

Table 18. Regression Results for Forest Pathways

(in Number)

Serial No.	Independent Variables	Parameter Value
1	Constant	546.51***
2	VFC's Age	-0.80*
3	Percentage of VFC Households to Total Households	-0.42
4	Increase in VFC's Capital (INR)	-5.71**
5	Non-participation (%)	0.62
6	Total Households of the Village	0.54***
7	Literacy Rate (%)	-0.37
8	Distance to Market (Km)	1.82
9	Distance to Forest (Km)	-7.23
10	Presence of Non-farm Opportunities	-20.76
11	At the end of the Project Period (1996-2001)	-228.26***
12	After the Project Period (2002-2004)	-279.41***
	R-Square	0.61
	Adjusted R-square	0.60

*, ** and *** denote the 10 %, 5 % and 1 % levels of significance, respectively.

6.2 Household-level Impact of the Ecodevelopment Project

At the household level, the impact of the EDP on labor allocation for AIGA and fuelwood collection activities was estimated. First, the regression results for households' labor allocation for AIGA are presented. Following that, the regression results for households' labor allocation for fuelwood collection are provided.

6.2.1 Regression Results for Labor Allocation for Alternate Income Generating Activities

The first hypothesis to be tested at the household level was that the allocation of labor for AIGA depends on the returns from AIGA and other household attributes. Accordingly, variation in allocation of labor for AIGA among households can be explained by the socio-economic characteristics of the household. This hypothesis can be tested by estimating the model:

$$AIGA\ Hours(Y_4) = f\left\{\begin{array}{l}\beta_0 + \beta_1\ Male\ head\ + \beta_2\ Education\ + \beta_3\ Age\ above\ 50 \\ + \beta_4\ Family\ size\ + \beta_5\ Adults\ + \beta_6\ Land\ owned \\ + \beta_7\ \text{Re}turns\ from\ AIGA\ + \beta_8\ Percentage\ of\ AIGA\ returns \\ + \beta_9\ Middle\ Income\ Group\ + \beta_{10}\ Higher\ Income\ Group + \varepsilon\end{array}\right\} \quad (6.4)$$

where Y_4 is the dependent variable that measures the number of hours allocated for AIGA per month and the independent variables are household attributes. The equation (6.4) corresponds to equation (15) in chapter 3.The data was corrected for heteroscadasticity by using White's modified heteroscadasticity consistent covariance

matrix estimator. Table 19 presents the regression results of labor allocation for AIGA. Six out of 11 coefficients were significant with anticipated signs. The adjusted R-square is 69 %.

The gender of the family's head showed a positive relationship with labor allocation for AIGA. If the AIGA is pursued by a male then there will be a 22.44 hours increase in labor allocated for AIGA. This may be due to the fact that AIGA pursued by males such as trade, were mostly outdoor based and more time demanding, while AIGA pursued by females such as livestock rearing were indoor based and less time demanding[18].

Likewise, the size of the family showed a positive relationship with labor allocation for AIGA. If the family size increases by one individual there would be a 3.08 hours increase in labor allocation for AIGA. This finding might be due to the fact that with bigger family size comes more labor availability as well as greater income needs.

As expected, the returns[19] from AIGA were positively related to labor allocation for AIGA. The returns were calculated for a month after subtracting all the input costs except labor. An increase in the returns from AIGA by one INR would increase hours allocated for AIGA by 0.04. Likewise, the percentage of AIGA returns to total income had a

[18] Livestock rearing is a type of AIGA, where one or two hybrid cows are reared in the households' backyard. Households' preference for hybrid cows over traditional cows is due to their higher milk yield. However, to get this higher milk yield, the hybrid cows have to be fed with nutritional feeds, such as rice bran, oil cake, etc. Hence, households prefer stall feeding over open grazing in the common lands.

[19] Returns from AIGA per hour is not used since different households adopted different AIGA that are unique in nature and vary in returns and monthly demand.

positive relationship with hours allocated for AIGA. A unitary increase in the percentage of AIGA returns to total income would increase the hours allocated to AIGA by 0.41.

Table 19. Regression Results for Households' Labor Allocation for Alternate Income Generating Activities

(Hours/month)

Serial No.	Independent Variables	Parameter Value
1	Constant	47.78***
2	Head (Male = 1, Female = 0)	22.44***
3	Education	0.67
4	Household's Head's Age Above 50	-4.06
5	Family Size	3.08*
6	Adults	0.16
7	Land Owned (acres)	-1.52
8	Returns from AIGA (Indian Rupees(INR))	0.04***
9	Percentage of AIGA Returns to Total Earnings	0.41***
10	Middle Income Group	-4.87
11	Higher Income Group	-18.39*
	R-Square	0.70
	Adjusted R-square	0.69

*, ** and *** denote the 10 %, 5 % and 1 % levels of significance, respectively.

Moreover, the income status of the household had a negative effect on hours allocated for AIGA as expected. The Higher Income Group spends 18.39 hours lesser than the Lower Income group for AIGA per month. This might be due to the fact that the Higher Income

group had several sources of income whereas AIGA was the main source of income for the Lower Income Group (Table 14).

6.2.2 Regression Results for Labor Allocation for Fuelwood Collection

The second hypothesis to be tested at the household level was that the allocation of labor for fuelwood collection depends on the returns from fuelwood collection and other household and community attributes. Accordingly, variation in allocation of labor for fuelwood collection among households can be explained by the socio-economic characteristics of the household. This hypothesis can be tested by estimating the model:

$$\begin{matrix} Fuelwood \\ collection = \\ Hours(Y_5) \end{matrix} f \left\{ \begin{matrix} \beta_0 + \beta_1\ Male\ head\ + \beta_2\ Education\ + \beta_3\ Age\ above\ 50 \\ + \beta_4\ Family\ size\ + \beta_5\ Adults\ + \beta_6\ Land\ owned \\ + \beta_7\ LPG\ used\ + \beta_8\ Wood\ purchased\ + \beta_7\ Kerosene\ purchased \\ + \beta_9\ Middle\ Income\ Group\ + \beta_{10}\ Higher\ Income\ Group + \varepsilon \end{matrix} \right\} \quad (6.5)$$

where Y_5 is the dependent variable that measures the number of hours allocated for fuelwood collection per month and the independent variables are related to household attributes. The equation (6.5) corresponds to equation (16) in chapter 3. In the sample, as 137 households did not collect fuelwood from the common lands, a Tobit model was employed to estimate the relationship. The Lagrange multiplier test showed the presence of heteroscadasticity, which was corrected by the Harvey's (1976) exponential form of variance due to its flexibility and versatility (Greene, 2003). Table 20 shows the Tobit

estimates of labor allocation for fuelwood collection which is the empirical counterpart of (16). Six out of 13 coefficients were significant with anticipated signs.

The gender of the family's head showed a positive relationship with labor allocation for fuelwood collection. In the sample area, fuelwood is mostly collected by females, a phenomenon common in developing countries (Amacher, Hyde et al. 1993). Households with male heads derive their main source of the income from males. This would have resulted in more availability of female labor that was used for fuelwood collection from common lands.

Consistent with the findings of Kohlin and Parks (2001), a binary variable for age of household head, which was included in the analysis to assess the labor allocation change over the life cycle, indicated that households headed by an individual over 50 years spend less time collecting fuelwood than do those with a head less than 50 years. This indicates that fuelwood collection is a tedious activity with older heads of household finding it more difficult to collect fuelwood from the common lands.

As expected, the usage of LPG showed a negative effect on labor allocation for fuelwood collection, indicating that LPG and fuelwood are substitutes. Similarly, fuelwood purchased from the market had a negative effect on labor allocation for fuelwood collection. In the study area it was observed that while the Higher Income Group substituted LPG for fuelwood, the Middle and Lower Income Groups supplemented their

fuelwood demand with fuelwood from the market and kerosene[20]. This is consistent with the results reported by Amacher, Hyde et.al (1993) and Israel (2002).

Table 20. Regression Results for Households' Labor Allocation for Fuelwood Collection

(Hours/ Month)

Serial No.	Independent Variables	Parameter Value
1	Constant	-2.41***
2	Head (Male = 1, Female = 0)	1.58***
3	Education	-0.08
4	Household's Head's Age Above 50	-1.51**
5	Family Size	0.3
6	Adults	0.03
7	Land Owned (acres)	0.02
8	LPG Used (Kgs)	-0.17***
9	Wood Purchased (Kgs)	-0.05***
10	Kerosene Purchased (liters)	0.009
11	Common land per Household (acres)	0.74
12	Middle Income Group	-0.64
13	Higher Income Group	-7.14***
	Log likelihood	-679.02

*, ** and *** denote the 10 %, 5 % and 1 % levels of significance, respectively.

In accordance with the theory, the market value of wood collected per hour was positively related with labor allocation for fuelwood collection. In contrast and as

[20] Households purchased kerosene from public distribution system (PDS) at subsidized price as well as from the market at regular price. Most of the households purchased kerosene through PDS. Since there is not much variation in both the quantity and price of the kerosene purchased through PDS, kerosene purchased from the market alone was considered in the analysis.

expected, the income status of the household showed a negative effect on labor allocation for fuelwood collection from the common lands, which was consistent with the findings of Kohlin and Amacher's (2005) study. While both the Middle and Higher Income Groups showed negative relationships with fuelwood collection from the common lands, the effect was significant in the Higher Income Group alone. As income increases, the capability of owning land to collect fuelwood and to purchase wood from the market or fuelwood substitutes such as LPG and kerosene is expected to increase.

6.3 Regression Results for Household's Primary Fuel Preference

In addition to labor allocation for AIGA and fuelwood collection, the EDP also influenced the fuel consumption pattern of the households in the study area. There were seven types of fuel consumption patterns involving wood, kerosene and LPG among the sample households[21]. Identifying households' primary fuel among these three fuels and factors associated with their choice would be important from a policy perspective. To capture this effect, it was hypothesized that the probability of choosing LPG is positively related to income status and other household attributes. Accordingly, variation in the probability of choosing LPG as the primary fuel can be explained by the socio-economic status of the household. Moreover, the availability of wood and kerosene also influence the choice of LPG as a household's primary fuel. Hence, three separate probit regression

[21] A detailed explanation is provided in section 5.2.2.

equations pertaining to wood, kerosene and LPG as primary fuel sources were used to test this hypothesis.

The relationship between the probability of choosing a primary fuel and all relevant independent variables can be explained by estimating the model:

$$Prob(Y_j = 1) = f\left\{\begin{array}{l}\beta_0 + \beta_1\ Male\ head\ + \beta_2\ Education\ + \beta_3\ \ Family\ size \\ + \beta_4\ Dependency\ ratio\ + \beta_5\ Fuelwood\ collecting\ hours \\ + \beta_6\ AIGA\ hours\ + \beta_7\ Kerosene\ \ purchased \\ \ + \beta_8\ Per\ capita\ \ fuel\ \ \text{exp}enses\ + \beta_7\ Land\ owned \\ + \beta_9\ Middle\ Income\ Group\ + \beta_{10}\ Higher\ Income\ Group + \varepsilon\end{array}\right\}$$

$$j = 6, 7, 8$$

(6.6)

where Y_6, Y_7 and Y_8 represent the dependent variables that denote the probability of choosing wood, kerosene and LPG as the primary fuel, respectively. Accordingly the equation (6.6) corresponds to equation (21), (22) and (23) in chapter 3. The independent variables are related to household attributes. Table 21 reports the probit estimates after correcting for heteroscadasticity. 10 out of 12 coefficients showed expected signs.

Households with male heads showed a negative relationship with the probability of choosing kerosene as their primary fuel. Households having males as their heads derive their main source of the income from males. This reduces the compulsory participation of females in the labor market. Consequently, more female labor is available, which might go for collection of fuelwood from common lands. This would results in increased usage

of fuelwood, which in turn would have a negative effect on kerosene as the two are substitutes.

Table 21. Probit estimates for Households' Primary Fuel Preference

Serial No.	Independent Variables	WOOD	KEROSENE	LPG
1	Constant	6.35*	0.38	-6.32***
2	Head (Male = 1, Female = 0)	2.67	-0.57***	-0.44
3	Education	-0.28	0.02	0.06
4	Family Size	-0.75	-0.19**	0.69***
5	Dependency Ratio¥ (dependents divided by laborers)	-0.40	0.38**	-0.72
6	Fuelwood Collection Hours	0.6*	-0.16***	-0.06
7	AIGA Hours	-0.01	0.00	-0.001
8	Kerosene from Market (Yes = 1)	-2.57**	1.50***	-2.77***
9	Per Capita Fuel Expenses (Indian Rupees)	-0.19*	-0.008***	0.07***
10	Land Owned	2.22*	-0.24**	0.02
11	Middle Income Group	-0.41	-0.45**	0.2
12	Higher Income Group	-8.82	-0.92*	1.82**
	Log likelihood	-117.24	-130.02	-55.02
	Likelihood Ratio	290.45	123.92	314

*, ** and *** denote the 10 %, 5 % and 1 % levels of significance, respectively.
¥ Dependents are young children and elderly

Smaller households have the highest probability of using kerosene as their primary fuel due to the relative labor scarcity of these households that translates into a higher opportunity cost of fuelwood collection. However, household size showed a positive effect on the probability of choosing LPG as the primary fuel, contradicting the results of Heltberg's (2005) study. Larger households are more likely to use LPG as their primary fuel since a larger family size creates more labor availability and more income that would lead to an increased ability to afford LPG.

In contrast, households with higher dependency ratio values are more likely to use kerosene as their main fuel due to the fact that dependents were neither able to collect fuelwood nor contribute to household income so as to afford LPG. The effect of dependency ratio on the probability of choosing either wood or LPG as the primary fuel was insignificant.

Households allocating more time to collect fuelwood from the common lands have the highest probability of choosing wood as their primary fuel. It could be observed from Appendix 4 that the Lower Income Group mostly collected fuelwood from the common lands as they were less likely to be able to afford wood from the market or other substitute fuels. Accordingly, households allocating more time to collect fuelwood from common lands are less likely to choose kerosene as their primary fuel.

As expected, households that are able to afford kerosene from the market are more likely to choose kerosene as their primary fuel. Households that are able to purchase kerosene from the market preferred kerosene to wood and are at the same time unable to afford LPG. Accordingly, these households are less likely to choose either wood or LPG as their primary fuel.

Consistent with Israel's (2002) study, a negative relationship was observed between per capita fuel expenses and the households' probability of choosing wood as their primary fuel. Accordingly, households with low per capita expenses have high probability of using wood as their primary fuel. It can be observed from Appendix 4 that the Lower Income Group had the lowest per capita fuel expenses as they collected most of their wood from the common lands, where no market cost need be paid[22]. Likewise, those households with relatively higher per capita fuel expenses than the Lower Income Group and relatively smaller than the Higher Income Group had the highest probability of using kerosene as their primary fuel since they were not able to afford LPG. The most expensive fuel source of the households in the study area was LPG, indicating a positive relationship between per capita fuel expenses and LPG use. Accordingly, households with more per capita fuel expenses are more likely to choose LPG as their primary fuel.

As expected, the size of land owned had a positive relationship with wood use. Households owning land are more likely to use wood as their primary fuel since they can

[22] A detailed explanation is provided in section 5.2.2.

easily collect it from their own land for free. Accordingly households owning land are less likely to choose kerosene as their primary fuel.

Consistent with other studies (Israel, 2002; Heltberg, 2005), households' income showed a positive effect on choosing LPG as the primary fuel. Accordingly, the income of the household had a negative effect on the use of kerosene as the primary fuel. It could be observed from Appendix 4 that the Higher Income Group had the highest probability of using LPG. The Higher Income Group's preference for LPG may be due to its affordability and to reduced health risks due to indoor pollution[23].

[23] A detailed explanation is provided in section 5.2.2.

7. SUMMARY AND CONCLUSIONS

The main objective of this research was to assess the sustainability of the ecodevelopment project (EDP) in preserving the Kalakad Mundanthurai Tiger Reserve (KMTR) and improving the economic status of the surrounding villages. To fulfill this objective, data collected from 128 villages and 382 households were analyzed. A brief summary of the results on the EDP's impact on villages and households is presented in section 7.1. The conclusions arising from these results are explained in section 7.2. Finally, the limitations of this study and recommendations for future research are provided in section 7.3.

7.1 Summary of Results

The results of the study are summarized in three sections. First, the EDP's impact on villages' economic status and forest dependency is presented in section 7.1.1. Next, the EDP's impact on households' labor allocation is summarized in section 7.1.2, followed by that of the EDP's impact on households' primary fuel choice in section 7.1.3.

7.1.1 Ecodevelopment Project's Impact on Villages' Economic Development and Forest Dependency

In the sample, the average size of the village and VFC was 195 and 152 households, respectively (Appendix 5). There was a 20.6 % increase in the total VFC households

from 1996 to 2004 with a growth rate of 13.9 % and 5.9 % during 1996-2001 and 2002-2004, respectively. Recall that the EDP ended in 2001.

The average amount of capital provided to VFCs was 0.24 million Indian rupees (INR) ($ 6780 (1996)), which increased to 0.59 and 0.95 million INR at the end and after the project period, respectively. This increase came mainly through increases in the circulation of capital allocated to AIGA by providing loans to the members at 12 % annual interest. At the end of 2004, on average 117.6 % of members received loans for AIGA, indicating that members have received loans more than once. Out of this, 59.7 % of loans were provided to females.

From 1996 to 2004 households collecting fuelwood from forests decreased by 87.6 % with a reduction rate of 61.1 % and 68.2 % at the end and after the project period, respectively. The average number of households collecting fuelwood from forests in a village was 4 and the proportion of fuelwood collecting households to total households was 1.57 %. Likewise, there was a 67.6 % decrease in the total number of pathways for the whole area from 1996 to 2004, with a reduction rate of 50.3 % and 34.9 % at the end and after the project period, respectively. On average there were 2 forest pathways in a village.

Due to the presence of VFCs, around 15 % of total households have developed from one income group to another between 1996 and 2004 with a growth rate of around 8 % and

7% at the end and after the project period, respectively. The average number of households developed per village was 30.

In addition to emphasizing the importance of the project's duration, the panel data regression results showed that the age of the VFC, percentage of VFC households to total households, increase in the VFC's capital and presence of non-farm opportunities such as rural industries had a positive effect on the economic development of the households. In contrast, and as expected, the size of the village, distance to a major market and level of non-participation in VFC's regular activities had a negative effect on the economic development of the households.

On the other hand, the regression results for fuelwood collecting households indicated that the age of the VFC, percentage of VFC households to total households, size of the village and distance to forest had a negative effect on households collecting fuelwood from forests. As expected, the distance to market had a positive effect on fuelwood collecting households. Likewise, the regression results for forest pathways showed that the age of the VFC and increase in the VFC's capital had a negative influence while the size of the village had a positive effect on the number of the forest pathways.

7.1.2 Ecodevelopment Project's Impact on Households' Labor Allocation

The average number of hours allocated for AIGA per household per month for the whole sample was 180 and it was the highest in the Middle Income Group, followed by the Lower and Higher Income Groups. However, the share of income from AIGA to total income was the lowest in the Higher Income Group when compared to the Middle and Lower Income Groups. This might be due to the increase in income diversification within the Higher Income Group.

The average number of hours allocated for fuelwood collection from common lands per month for the whole sample was 8.14 with only around 66 % of the households involved in the activity. The Higher Income Group had the lowest both in terms of hours allocated for fuelwood collection and percentage of households involved in fuelwood collection. This implies that there is a higher opportunity cost of fuelwood collection from common lands for the Higher Income Group.

The regression results for labor allocation for AIGA showed that the family size, gender of the household's head (male), returns from AIGA and percentage of AIGA returns to total earnings had a positive influence on the labor allocation for AIGA. As expected, the income status of the household had a negative effect on hours allocated for AIGA.

On the other hand, the regression results for labor allocation for fuelwood collection indicated that the age of the household's head, amount of LPG used, amount of wood purchased and the income status of the household had a negative influence on the labor allocation for fuelwood collection. In contrast, the gender of the family head (male) had a positive influence on labor allocation for fuelwood collection.

7.1.3 Ecodevelopment Project's Impact on Households' Fuel Consumption

The sample households exhibited seven types of fuel consumption patterns involving wood, kerosene and LPG. Around 10 % of the respondents used non-wood fuels. Only 8% of the households used a single fuel. The number of households using both wood and kerosene in combination was the highest, followed by the wood, kerosene and LPG combination. Moreover, seven patterns of fuelwood collection from different sources were observed in the study area.

The empirical results showed the positive effect of household's income on choosing LPG as the primary fuel. Accordingly, the primary fuel source for the Higher Income Group was LPG, whereas it was wood for the Lower Income Group. Moreover, the quantity of fuels consumed increased with income. While the Middle Income Group supplemented this increased demand for fuel through purchasing wood and collecting it from owned lands, as well as through using kerosene, the Higher Income Group met its demand by increasing LPG consumption.

The average monthly fuel expenses for all sample households was INR 169 and it exhibited a positive relationship with income. While the highest fuel expense in the Higher Income Group came from their increased consumption of LPG, the lowest fuel expense in the Lower Income Group was due to their increased consumption of fuelwood collected from the common lands, a practice without explicit cost.

In brief, the findings of the study indicated that the dependency on common lands for fuelwood reduced with an increase in households' income. Moreover, affordability was the main constraint preventing the poor from using LPG. The Higher Income Group's preference for LPG may be due to their affordability and to reduced health risks because of indoor pollution. Finally, usage of multiple fuels was dominant in the study area and increased with income due to an increase in affordability.

7.2 Conclusions

A sustained increase in the number of VFC households, VFCs' initial capital amount and the number of households developed, and a continuous reduction in the number of fuelwood collecting households and forest pathways at the end as well as after the project period indicated the sustainability of the EDP. In addition to continued benefit flows, fulfilling other criteria for sustainability, such as survival of institutions, ability to meet recurrent costs and institutional capacity in decision making also justify the sustainability of the EDP (Brown, 1998). This helps to derive the foremost conclusion of this study:

that the proposed institutional change (formation of the VFC) involving a tripartite relationship among the FD, NGOs and forest fringe dwellers in the EDP has been successful and sustainable in reducing the forest dependency and improving the economic status of the forest fringe dwellers. More importantly, these institutions' performance after the project period is similar to and in some instances, greater than that of during the implementation period.

The main reasons for the success of the EDP were the presence of characteristic features for successful management of commons such as creating social capital, mutual dependency and concerns for other members; establishing grassroots level institutions; initializing decentralized transparent management; relying on peer monitoring and peer pressure; as well as providing a forum for conflict management and low cost adjudication. In addition, the tripartite relationship ensured equal representation of the needs of different sections of society, accountability of the elected members and the ability to generate adequate funds for sustained solvency of VFCs. Accordingly, the study provided empirical evidence of the novel idea that natural common property resources, such as forests, can be preserved by creating financial common property resources, such as village funds and appropriate site-specific participatory institutions to maintain them.

Moreover, the successful adoption of different types of AIGA in this study showed that when reasonable and economically viable alternatives are provided, households will respond to production and work incentives. This finding is an essential element for

economic development and confirms the rational behavior of households. Policies concentrating on creating backward and forward linkages for AIGAs would help in promoting a desired type of AIGA with potentials for growth. Furthermore, the study emphasizes the importance of providing loans to females to pursue AIGA for three main reasons. First, to reduce the fuelwood dependency as they are the main collectors of fuelwood. Second, when loans were provided to males to pursue AIGA, the resultant surplus female labor had a positive influence on fuelwood collection. Finally, loans granted to females showed a better recovery. Hence, providing training related to all types of AIGA pursued by females at regular intervals would be a policy option to divert females from fuelwood collection.

Furthermore, the dependency on common lands for fuelwood necessitates a comprehensive approach in common lands management to increase the fuelwood availability. In addition, the study advocates the long term commitment from the FD in the effective management of VFCs by transforming from their traditional role as technical experts and guards to a new role as extension agents in promoting VFCs and technology transfer. Moreover, the findings of the study showed that the dependency on commons for fuelwood will reduce with improvements made in the economic status of low income households.

The study specified that affordability was the major constraint in using LPG as the primary fuel choice of households. Hence, subsidizing LPG would be a policy option to

motivate the villagers in substituting away from fuelwood usage and to reduce health risks due to indoor pollution. Moreover, in rural areas usage of multiple fuels dominates and increases with income due to an increase in affordability as confirmed in this study. Hence, while formulating inter-fuel substitution policies, in addition to income status of the households, availability of different fuel sources, local cultural factors, cooking habits and local rural infrastructure facilities should be carefully considered.

Moreover, introducing a savings component may increase the capital and involvement of members in the regular activities of the VFC. In addition, the state can strengthen the VFCs by providing loans through local banks, which would in turn grant loans to villagers. Doing so would result in better financial services for rural households and it would also improve the performance of banks. For the same reason, private firms can also consider VFCs as a viable option for investment. Considering the transparent management nature of VFC, the state could use the VFC to implement other sectors' rural development projects so that the benefits reach the rural poor effectively, in addition to strengthening the power of the VFC.

Public investment made in rural infrastructure facilities such as roads, schools and markets along with VFCs would be another policy option to reduce the dependency on forests and to improve the economic status of rural households. Additionally, investments made in the non-farm sector, say, in rural industries, would also help to expand remunerative employment opportunities.

As explained earlier, the presence of characteristic features for successful management of commons in the EDP have showed an effective way of enhancing the empowerment level of women as well as the un-empowered and disempowered populations in rural areas. Hence, the state may consider these experiences to strengthen its social institutions while promoting similar programs in other sectors that aim for female empowerment and rural development. In addition, projects identical to the EDP can be applied to other JFM areas that mainly focus on forest conservation through participatory forest management. In most of these JFM programs the main emphasis hitherto was only on forest resources extraction and institutions. Adding a microfinance component to these institutions may result in efficient utilization of forest resources and improvement of the economic status of villagers simultaneously.

Most of the results of the study are as expected and consistent with literature on commons and other earlier studies on microfinance, fuelwood collection and consumption and institutions. As explained in chapter 2, this study is unique in providing empirical analysis of these three aspects combined to support participatory natural resources management, which is now considered as a win-win solution for both the environment and economic development. Thus, in addition to contributing to a growing body of empirical evidence on rational behavior of households in labor allocation and fuel consumption, this study contributes to the literature on commons by supporting a new approach for sustainable management of commons. The new approach proposes that

creating financial common property resources, such as village funds and appropriate site-specific participatory institutions to maintain them will be one of the viable options to preserve natural common property resources, such as forests.

However, the EDP may not be considered as a panacea for all preservation problems. It had a successful start in the KMTR and may be emulated in other areas that focus on preservation of natural resources after a detailed analysis on costs and benefits of the proposed project and on appropriate careful site-specific institutional changes to meet the needs of the local people are performed.

7.3 Study Limitations and Recommendations for Further Research

In this study, the sustainability of the EDP was assessed by using the data related to before, at the end, and three years after the project period. However, there is no rule of thumb on the 'number of years after the project period' that has to be considered for assessing the sustainability of any project (Brown, 1998). Moreover, the conclusions on forest development were derived based only on forest dependency that was assessed by the number of fuelwood collecting households and forest pathways. In reality, forest development depends on edaphic, topographic, climatic and biotic factors in addition to human and livestock pressures. These limitations should be considered before arriving at conclusions on forest development and the sustainability of the EDP.

Furthermore, to analyze the household level impact, only cross section data was used. Collecting data over a period of years at regular intervals and analyzing this panel data would capture seasonal differences in the household behavior on labor allocation and fuel consumption.

Moreover, as the main objective of the study was to assess the sustainability of the EDP, data collected from the villages that had VFCs and VFC households alone was used in this analysis. Along with this, data from non-VFC villages and non-VFC households would be useful to analyze the unintended positive or negative effects of the EDP on households and institutions and would provide a comprehensive notion of the impact of the EDP.

Furthermore, this study focused only on sustainability of the EDP in terms of reducing forest dependency and improving the economic status of the forest fringe dwellers. In addition to this, a detailed analysis on comprehensive costs and benefits of the EDP would be useful to draw conclusions about the validity of the EDP.

In addition to concentrating on the above areas, future research may focus on the following six areas. First, cost benefit analysis of different types of AIGAs would be useful to evaluate their backward and forward linkages and opportunities and to understand the determinants of these AIGAs. Second, research on multiple cooking fuels, improvement in stove design and impact of different fuels on indoor pollution and health

risks, taking into consideration local cultural, political and economic factors would be helpful to derive policies on energy resources. Third, a detailed analysis on the ability of the fuelwood plantations created under the EDP to meet fuelwood demand would be beneficial to improve their productivity. Fourth, measurement of concepts such as institutional change and social capital would be useful to calculate social cost benefit analysis. Fifth, incorporating geographical map data on institutions, socio-economic outcomes and on forests' quality would be beneficial to understand the comprehensive relationships among them. Finally, focusing on the influence of other local institutions, aid and extension programs along with the EDP on households' behavior would be helpful in comparing different intervention projects.

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APPENDICES

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Appendix 1: Questionnaire for Village Survey

1. Name of the village:

2. Population:

Sl. No.	Year	Population	Families			
			Red	Yellow	Green	Total
1	VFC formation year					
2	2001					
3	2004					

3. Migration in last ten years:

Serial Number	Migration	Year	Number	Remarks
1	Immigration			
2	Out migration			
3	Net total			

4. VFC families:

Serial Number	Year	Red	Yellow	Green	Total
1	VFC formation Year				
2	2001				
3	2004				

5. Families developed from one income status to other:

Sl. No.	Families Developed	1996 to 2001	2002 to 2004	Total	Remarks
1	Red to Yellow				
2	Yellow to Green				
3	Total				

6. Details on families collecting fuelwood from forests:

Serial No	Year	Number	Remarks
1	VFC formation year		
2	2001		
3	2004		

7. Literacy rate of the village:

Serial No.	Year	Literacy rate in %	Remarks
1	VFC formation year		
2	2001		
3	2004		

8. Infrastructure facilities:

i) Number of Petty shops:

ii) Number of tea stalls:

iii) Distance to the nearest town and road details:

iv) Distance to the nearest major market:

v) Distance to the nearest bus stop and number of bus stops:

vi) Number of bus trips per day:

vii) Distance to primary health center:

viii) Distance to commercial bank:

ix) Distance to co-operative trade society:

x) Distance to agricultural input depot:

xi) Distance to post office:

xii) Distance to village office:

xiii) Distance to the nearest school:

9. Non-farm sector:

Serial Number	Name	Distance	Employees from the village	Scale	Period	Year started	Remarks
1	Industrial Plant						
2	Food processing plant						
3	VFC enterprise						
4	Others						

10. Role of VFC in building infrastructure facilities in the village:

11. Occupation details of the village families (in percentage):

Sl. No.	Particulars	VFC year	2001	2004	Remarks
1	Agriculture				
2	Industry				
3	Self employment				
4	Fuelwood collection				
5	Government offices				
6	Others				

12. Wage rate:

Sl.No.	Particulars	Agri. workers	Other workers	Available days	Remarks
1	VFC formation year				
2	2001				
3	2004				

13. Details on the presence of other village institutions:

14. Details of land reform programs in this community in the past 10 years?

15. Previous experience in managing common lands:

16. Distance to and area of common lands where fuelwood is collected:

17. Distance to and area of the forest:

18. Details on forest pathways and grazing incidences:

Serial No.	Year	Number of pathways	Number of grazing incidences	Remarks
1	VFC formation year			
2	2001			
3	2004			

VFC details

1. Formation date:

2. List the reasons/ factors for starting VFC:

3. How the leader is chosen?

4. How the management committee is chosen?

5. Membership participation in percentage:

Sl. No.	Particulars	Percentage	Remarks
1	Regular		
2	Irregular		
3	Non-participation		
4	Drop out and reasons		
5	Other		

6. Beneficiaries details:

Sl. No.	Year	Members			Number of beneficiaries								
					AIGA			Biomass			Energy conservation		
		Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total
1	VFC year												
2	2001												
3	2004												
4	Total												

7. AIGA beneficiaries' details:

Sl. No.	Type of AIGA	Number of beneficiaries in the year										Remarks
		1	2	3	4	5	6	7	8	9	T	
1												
2												
3												
4												
5												

7. b) Number of beneficiaries received loans more than once:

Sl. No.	Year	I time	II time	III time	IV time	V time	VI time
1	VFC year						
2	2001						
3	2004						

8. Recovery details:

Serial Number	Year	Number of installments	Amount of loans	Cost of lending	Interest %	Repayment %
1	VFC year					
2	2001					
3	2004					

9. Capital details:

Serial Number	Year	Member savings	Total capital	Capital allocation			Remarks
				AIGA	Biomass	Energy conservation	
1	VFC year						
2	2001						
3	2004						

10. Borrower details:

Sl. No.	Year	Regular	Irregular	Struggling	Defaulters	Others	Remarks
1	VFC year						
2	2001						
3	2004						

11. Whether all members who obtained loans from VFC are Pursuing AIGA? Reasons:

12. What are the mechanisms followed by the VFC to prevent defaulters?

1. Social confinement
2. Fines
3. Others

13. How the funds are maintained?

a. By VFC itself
b. Deposited in the bank
c. Others

14. New mechanisms found in distributing funds? Give your Suggestions:

15. Type of network created through VFC:

a. Information sharing
b. Building relationship
c. VFC products marketing
d. Others

16. Special trainings provided by the VFC:

Sl. No	Activities	Number of beneficiaries	Remarks
1	Tailoring		
2	Driving		
3	Accounts management		
4	others		

17. Meetings and conflicts:

a. How often meetings are held?

b. Are there any conflicts among the VFC members during the meeting? If yes,

When?

Between whom?

Reasons:

c. How these issues are resolved?

d. Are there any unresolved issues? If yes give reasons:

18. Do you think that forest has developed after VFC formation? List the reasons:

a. No fuelwood collection

b. No grazing

c. Others

19. How VFC is helpful in improving the socio-economic development of the village?

Please rate on the following scale:

1 = completely disagree; 2 = somewhat disagree; 3 = neutral; 4 = somewhat agree;

5 = completely agree; 0= not able to rate

a) Increase in employment opportunities

b) Increase in the harmony among members

c) Increase in infrastructure facilities

d) Increase in participation in common welfare activities

e) Decrease in migration

f) Decrease in open political affiliation and consequent division among households

g) Others

20. Reasons for the success of VFC:

Please rate on the following scale:

1 = completely disagree; 2 = somewhat disagree; 3 = neutral; 4 = somewhat agree;

5 = completely agree; 0= not able to rate

a) Low interest rate

b) Easy access for loans

c) No need for collateral

d) Effective leadership

e) Transparent management

f) No political interference

g) Homogenous group based

h) Easy, amicable frequent interaction of forest department

i) Presence of NGO

j) Others

21. Performance of VFC:

Please rate on the following scale:

1 = Worse; 2 = Bad; 3 = Fair; 4 = Good; 5 = Excellent; 0= not able to rate

a) Recovery percentage

b) Average number of meetings per month

c) Voluntary savings

d) Forest / wildlife protection

e) Number of self help groups

f) Women involvement

g) Increase in the capital amount

h) Fund rotation /credit deepening

i) Awareness activities

j) Amicable interaction with forest department

k) Others

22. Suggestions for improving the performance of VFC:

23. Suggestions for the future role of VFC:

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Appendix 2: Questionnaire for Household Survey

1. General Details: **Number:**

Village Name: Range Name:

Name of the Head: Age:

2. Family Particulars:

Serial No.	Members	Gender	Age	Education	Occupation	
					Primary	Secondary
1						
2						
3						
4						
5						
6						
7						

3. Land Holdings:

Sl.No.	Particulars	Area			Value			Annual rental value	Remarks
		Wet	Gard	Dry	Wet	Gard	Dry		
1	Owned								
2	Leased in								
3	Leased out								
4	Mortgage in								
5	Mortgage out								
	Total								

4. Assets other than land:

Sl. No.	Assets	Number	Year of purchase/ construction	Value at purchase/ construction	Remarks
1	Farm machinery & implements Tractor Power tiller Tractor drawn implements Pump-set Bullock-cart Thresher Other implements				
2	Farm Buildings/Threshing floor/ Storage Godown				
3	House Type: Thatched/tiled/RCC				
4	Television				
5	Radio				
6	Two wheelers Bi-cycle Motor-cycle				
7	Others				

5. Cropping Pattern:

Sl.No.	Crops	Wet Land			Garden Land			Dry Land		
		I	II	III	I	II	III	I	II	III
1	Area									
2	Crop name									
3	Yield									
	Primary									
	Secondary									
4	Income									
	Primary									
	Secondary									
5	Expenses									
	Primary									
	Secondary									
6	Self consumption									
	Primary									
	Secondary									
7	Sold in the market									
	Primary									
	Secondary									
8	Profit									
	Primary									
	Secondary									
9	Remarks									

6. Livestock Details:

Sl. No.	Particulars	Number	Present value	Income	Dung		Feed / Grazing details
					Quantity	Value	
1	Draught animals						
2	Milch animals						
	a. Desi cow						
	b. Buffaloes						
	c. Hi-bred cow						
3	Calves and Heifers (<1 year)						
4	Sheep and goat						
5	Poultry						
6	Others						

7. Income Particulars:

7.a) Family income:

Sl. No.	Particulars	Persons employed	Working days	Income	Remarks
1	Government				
2	Private				
3	Business				
4	Agriculture				
5	Others				

7.b) Income from AIGA:

Sl. No.	Particulars	1	2	3	4	5
1	Name of the AIGA					
2	Started on					
3	Persons employed					
4	Days employed					
5	Buying place					
6	Selling place					
7	Buying price					
8	Selling price					
9	Other expenses					
10	Profit					
	Monthly					
	Annually					
11	Profit as a % of total income					
12	Reasons for pursuing					
13	Problems					
14	Remarks					

7. c) Other income:

Sl. No.	Particulars	On-farm		Off-farm		Other income		Fuelwood Collection		Remarks
		Days employed	Wage rate	Days employed	Wage rate	Days employed	Wage rate	Days employed	Wage rate	
1	Head									
2	Members									
	1									
	2									
	3									
	4									
3	Remarks									

8. Food Consumption:

Sl. No.	Particulars	Male	Female	Children	Remarks
1	Once per day				
2	Twice per day				
3	Thrice per day				

9. Other Expenses:

Sl. No.	Particulars	Monthly expenses	Annual expenses	Remarks
1	Education			
2	Health			
3	Food			
4	Fuelwood			
5	Kerosene			
6	LPG			
7	Electricity			
8	Telephone			
9	Festivals			
10	Entertainment			
11	Clothing			
12	Others:			
	1			
	2			
	3			

10. Fuel Details:

10. a) Fuelwood collection and consumption

Sl. No.	Particulars	Fuelwood					Agricultural waste	
		Forests	Commons	Market	Trees from owned land	Total	Crop waste	Rice husk
1	Quantity used							
2	Quantity collected							
3	Quantity Purchased							
4	Quantity Sold							
5	Price/Kg							
6	Collection time							
7	Times collected							
8	Collecting person							
9	Reasons for using							
10	When did you stop using? Reasons							
11	Change in consumption after joining VFC							
12	Remarks							

10.b. Have you planted trees for your future fuelwood needs? If yes, explain.

10.c. Where from dung is collected?

10. d) Other fuels:

Sl.No.	Particulars	Amount	Price	Usage	Availability	Investment	Reasons for using	Remarks
1	Kerosene							
	PDS							
	Market							
2	LPG							
3	Biogas							
4	Dung							
5	Others							

10. e) Fuel consumption details (in percentage):

Sl.No.	Fuels	Food	Light	Heating	Agriculture	Others	Remarks
1	Fuelwood						
	Forest						
	Commons						
	Purchased						
2	Agricultural Waste						
	Crop waste						
	Rice Husk						
3	Dung						
4	Kerosene						
	PDS						
	Market						
5	LPG						
6	Biogas						
7	Others						

10.f) Stoves details:

Sl. No.	Stove details	Fuel used						Present value	Usage period
		Fuelwood	Dung	Grass	Kerosene	Rice Husk	LPG		
1									
2									
3									
4									
5									

11. Did you switch over from one fuel to other after joining the VFC? If yes, Reasons:

Please rate on the following scale:

1 = completely disagree; 2 = somewhat disagree; 3 = neutral; 4 = somewhat agree;

5 = completely agree; 0 = not able to rate.

a. VFC

b. Non-availability of previous fuel

c. Easy access to the present fuel

d. Price

e. Others

12. Reasons for your forest dependency:

Sl.No.	Particulars	Place	Distance	Reasons for its availability from there	Remarks
1					
2					
3					
4					
5					

13. Do you know about monitoring and fire prevention in forests? Explain.

14. How do you know if others collect fuelwood collection from forests?

15. Are you aware of measures taken by the VFC to prevent fuelwood collection?

16. Do you know anyone collecting fuelwood from forests?

17. What are the measures taken by the VFC to control them?

18. What is your role in protecting the forests?

Please rate on the following scale:

1 = completely disagree; 2 = somewhat disagree; 3 = neutral; 4 = somewhat agree;

5 = completely agree; 0 = not able to rate.

a. Monitoring

b. Fire protection

c. Motivating others to join the VFC

d. Others

19. Alternate Income Generating Activity (AIGA) details

19.1. Name of the AIGA:

19.2. How long you are pursuing this AIGA?

For questions from 19.3 to Please rate on the following scale:
1 = completely disagree; 2 = somewhat disagree; 3 = neutral; 4 = somewhat agree;
5 = completely agree; 0 = not able to rate.

19.3. Reasons for pursuing AIGA in general:

a. VFC prevented fuelwood collection from forests
b. More income
c. Availability of loans from the VFC
d. Not interested in collecting fuelwood
e. Others

19.4. Reasons for pursuing this particular AIGA:

a. Hereditary
b. Well known
c. More profits
d. Good demand for the products from this AIGA
e. Don't know other AIGAs
f. Others

19.5. Advantages of pursuing this AIGA:

a. More income to buy fuel
b. Availability of more working days
c. Others

19.6. Whether the loans obtained from the VFC is enough to pursue this AIGA? If not, where from you borrow the extra money needed for pursuing this activity? Why?

19.7. Have you ever switched over from one AIGA to another? If yes, reasons:

19.8. Is there any increase in your household's income due to this AIGA? If yes, how much?

19.9. Have you ever received any training to pursue this AIGA? Where from?

19.10. Are you going to continue to pursue the same AIGA in future? Why?

19.11. Did you have any problems in receiving loans from the VFC?

19.12. Do you have any problems in repaying the loans?

20. VFC details

For questions from 20.1 to 20.5 please rate on the following scale:
1 = completely disagree; 2 = somewhat disagree; 3 = neutral; 4 = somewhat agree;
5 = completely agree; 0 = not able to rate.

20.1. How often you participate in the VFC meetings?

a. Regular
b. Often
c. While receiving loans alone
d. Never

20.2. Reasons for joining the VFC:

a. To protect forests
b. Peer pressure
c. Unable to collect fuelwood from forests
d. Availability of loans from the VFC
e. Others

20.3. How do you know about the VFC?

a. Peers
b. Forest department
c. N.G.O.
d. Others

20.4. Role of the VFC in improving your economic status:

a. Granting loans
b. Providing employment opportunities
c. Others

20.5. Role of the VFC in improving your social status:

a. Permanent self employment opportunity

b. Relationship with officials from various departments

c. Good exposure to other villages and markets

d. Others

21. How do you rate the performance of VFC in general?

Good ( ) Satisfactory ( ) Bad ( ) Don't know ( )

22. How do you rate the performance of the VFC in protecting forests?

Good ( ) Satisfactory ( ) Bad ( ) Don't know ( )

23. How do you rate the performance of VFC in village development?

Good ( ) Satisfactory ( ) Bad ( ) Don't know ( )

24. How do you rate the performance of the VFC in improving the socio-economic status of the people?

Good ( ) Satisfactory ( ) Bad ( ) Don't know ( )

25. How can we improve the performance of the VFC?

26. Family type: Red/Yellow/ Green

Appendix 3: Acronyms Used

AIGA – Alternate Income Generating Activity

AIGAs – Alternate Income Generating Activities

BRA – Biomass Regeneration Activity

CPRs – Common Property Resources

ECA – Energy Conservation Activity

EDP – Ecodevelopment Project

FD – Forest Department

GOI – Government of India

HPF – Household Production Function

INR – Indian Rupees

JFM – Joint Forest Management

JFMP – Joint Forest Management Program

KMTR – Kalakad Mundanthurai Tiger Reserve

LPG – Liquid Petroleum Gas

MRS – Marginal Rate of Substitution

NGO – Non-government Organization

NGOs – Non-government Organizations

PA – Protected Area

PAs – Protected Areas

VFC – Village Forest Committee

VFCs – Village Forest Committees

Appendix 4: Households' Fuel Consumption Details

Table 1. Fuel Consumption Pattern

(in Percentage of Households)

Serial No.	Fuel Source	Lower Income Group	Middle Income Group	Higher Income Group	Total
1	Wood	3.7	1.4	0.00	2.6
2	Kerosene	4.7	2.1	0.00	3.4
3	LPG	1.9	2.1	3.7	2.1
4	Kerosene + LPG	2.3	7.1	7.4	4.5
5	Wood + Kerosene	82.2	53.9	14.8	67
6	Wood + LPG	0.9	13.5	11.1	6.3
7	Wood + Kerosene + LPG	4.2	19.9	63.0	14.1
	Total	100	100	100	100

Table 2. Fuelwood Consumption Pattern

(in Percentage of Households)

Serial No.	Fuelwood Source	Lower Income Group	Middle Income Group	Higher Income Group	Total
1	Common lands	73.4	30.5	7.4	52.9
2	Common lands + Purchase	8.4	3.6	0.0	6.0
3	Purchase	5.1	14.9	18.5	9.7
4	Common lands + Owned land	1.4	12.1	0.0	5.2
5	Owned land	2.3	22.7	55.6	13.6
6	Purchase + Owned land	0.0	3.6	7.4	1.8
7	Common lands + Purchase + Owned land	0.5	1.4	0.0	0.8
	Total	91.1	88.7	88.9	90.1

Table 3. Fuelwood Sources

(in Percentage of Households)

Serial No.	Fuelwood Source	Lower Income Group	Middle Income Group	Higher Income Group	Total
1	Common lands	82.2	47.5	7.4	64.1
2	Purchase	14.0	23.4	25.9	18.3
3	Owned land	7.9	39.7	63.0	23.6

Table 4. Summary of Cooking Fuel Groups

(in Percentage of Households)

Serial No.	Fuel Source	Lower Income Group	Middle Income Group	Higher Income Group	Total
1	Non-wood users	8.9	11.4	11.1	10
2	Single fuel users	10.3	5.7	3.7	8.1
3	Multiple fuel users	89.7	94.3	96.3	91.9
	Combinations involving				
	LPG	7.5	40.4	81.5	24.9
	Kerosene	88.8	80.9	85.2	85.6
	Wood	87.4	87.3	88.9	87.4

Table 5. Primary Fuel Source

(in Percentage of Households)

Serial No.	Fuel Source	Lower Income Group	Middle Income Group	Higher Income Group	Total
1	Wood	67.3	47.5	3.7	55.5
2	LPG	7.5	38.3	85.2	24.4
3	Kerosene	25.2	14.2	11.1	20.2
	Total	100.00	100.00	100.00	100.00

Table 6. Monthly Average Fuel Consumption

Serial No.	Fuel Source	(Kg / Household / Month)				Percentage of Households Involved			
		Lower Income Group	Middle Income Group	Higher Income Group	Total	Lower Income Group	Middle Income Group	Higher Income Group	Total
1	LPG	12.2	11.2	15.5	13.4	9.4	42.6	85.2	27.0
2	Kerosene (liters)	5.6	6.1	5.0	5.7	93.5	83.0	85.2	89.0
3	Wood	86.6	101.4	59	90.1	91.1	88.6	88.9	90.1
	Wood from								
1	Common lands	81.3	87.8	15.0	82.5	82.2	47.5	7.4	64.1
2	Purchase	54	79.9	53.6	66.1	14.0	23.4	25.9	18.3
3	Owned land	55.9	74.4	59.0	68.1	7.9	39.7	63.0	23.6

Table 7. Monthly Average Fuel expenses

Serial No	Fuel source	Amount (INR / Household / Month)				Percentage of Households Involved			
		Lower Income Group	Middle Income Group	Higher Income Group	Total	Lower Income Group	Middle Income Group	Higher Income Group	Total
1	LPG	268.13	287.19	340.76	295.45	9.4	42.6	85.2	27
2	Kerosene	56.40	67.39	49.78	59.74	93.5	83	85.2	89
3	Wood purchased	147.58	216.52	130.36	178.36	14	23.4	25.9	18.3
4	Total fuel expenses	101.79	230.44	366.48	169.06	91.1	88.7	88.9	90.1
5	Per capita expenses	29.10	56.68	85.09	43.46	96.7	99.3	100	97.9
6	Imputed value for wood from common lands and owned land	221.17	259.94	145.21	229.96	96.7	99.3	100	97.9
7	Imputed Total fuel expenses	279.30	408.57	461.76	339.91	100	100	100	100
8	**Wood from**								
	Common lands	206.97	221.79	40.00	209.66	82.2	47.5	7.4	64.1
	Purchase	147.58	216.52	130.36	178.36	14.0	23.4	25.9	18.3
	Owned land	206.59	187.28	146.62	169.47	7.9	39.7	63	23.6
9	Per capita expenses imputed	75.18	98.06	104.66	85.71	100	100	100	100
10	Fuel expenses as % of income	3	3.8	4.2	3.6	96.7	99.3	100	97.9
11	Imputed fuel expenses as % of income	8.2	6.8	5.3	7.2	100	100	100	100

Appendix 5: Summary of Important Descriptive Statistics

Serial No.	Description	Average Value
	Village Statistics	
1	Village size (Number of households)	195
2	VFC* size (Number of VFC households)	152
3	Capital provided to the VFC (Million Indian Rupees)	0.24
4	Percentage of female AIGA* beneficiaries	59.7
5	Households improved in economic status per village	30
6	Households collecting fuelwood from forests per village	4
7	Forest pathways per village	2
8	Distance to forest (Kilometer)	3.0
9	Distance to market (Kilometer)	4.6
	Household Statistics	
1	Household size	4.1
2	Age of the household head (Years)	44.0
3	Literacy rate of the household head (percentage)	67.0
4	Land (Acres)	2.1
5	Livestock (Number)	4.0
6	Wood consumption (Kilograms per month)	90.1
7	Kerosene consumption (Liters per month)	5.7
8	Liquid Petroleum Gas consumption (Kilograms per month)	13.4
9	Fuel expenses (Indian Rupees per month)	169.1
10	Hours allocated for fuelwood collection from common lands per month	8.1
11	Hours allocated for AIGA per month	180.0
12	Returns from AIGA (Indian Rupees per month)	2088.9
13	Total income (Indian Rupees per month)	4744.0

*VFC and AIGA denote Village forest committee and Alternate income generating activity, respectively.