Contribution of Home Gardens to Household Income in Kerala, India

by

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ABSTRACT

Home gardens are regarded as a way to improve the livelihood and nutritional security of small scale farming households in developing countries. Viable home gardens can improve the ability of small-holders and their communities to meet interrelated concerns of food, nutrition, health and economic security. Home gardens can increase dietary diversity as well as the availability of food throughout the year. From an economic security perspective, home gardens could play two roles: marketing of the surplus home garden produce could reduce the income risks from other income generation activities, or agricultural production decisions and saving on food expenses through the consumption of home garden produce could help the households to use their earnings for other priorities such as education of children, health and paying off debts. From a social perspective, home gardens may allow women to exert greater control over the types and quality of food consumed in the household.

By using a household production model with fixed consumption levels for a number of representative households in the Wayanad district of Kerala, India, the economic impact of home gardens on six different household categories: landless households with and without home gardens; landholding households where agricultural production is relatively large in terms of its share in the total household income (between 35 – 100%), with and without home gardens (mentioned as agricultural majority households); landholding households where agricultural production is relatively small in terms of its share in the total household income (below 35%), with and without home gardens (mentioned as agricultural minority households), are examined. The impact of home gardens on male and female headed households is also assessed in the study. Whether home gardens contribute to increasing income and reducing household income variability across time is tested using simulation. The study uses data collected under the project titled 'Alleviating Poverty and Malnutrition in Agro biodiversity Hotspots in India' led by the University of Alberta and the M.S. Swaminathan Research Foundation, India, to estimate production and supply relationships. In addition, time use data from both male and female heads of the six household categories mentioned above, and historical price, production and rainfall data were collected to examine the impact of home gardens under uncertainty across time.

Optimization results indicated positive profits and consumption value from home gardens for the sample households, regardless of the category. The percentage contributions of home garden profits to the net income levels were found to be significantly higher for agricultural minority households (20% and 39%). This respective household category constituted 71% of the total sample population. The reasons for low contributions for other household categories can be attributed to the higher income levels of agricultural majority households and the landless households' lower diversity in the production from home gardens. Under uncertain scenarios, home gardens were able to contribute to the households' economic security by providing income and saving on food expenditure. Most of the home garden households, relative to households without home gardens, achieved more stable net incomes even during negative market shocks (clearly visible in the agricultural majority category). Simulations across time highlighted higher mean and lower coefficients of variation for net income for households with home gardens.

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CHAPTER 1

INTRODUCTION

Home gardens are usually identified as important social and economic units which can play a crucial role in ensuring livelihood as well as food security of rural households and can be considered as an income diversification strategy under risky circumstances. As part of a broader development/research project on ways to alleviate poverty and malnutrition, project participant households were given the opportunity to expand/establish home gardens due to their declining interest in the maintenance and cultivation of home garden crops.[1] Support in terms of training on home garden design and management, provision of seeds, plants and nets were provided to the participant households to establish/expand their home gardens. Although clearly the project home garden intervention was successful in increasing production of fruits and vegetables that households could consume, share or sell, less is known about its economic impact on these particular households. The economic impact of these home gardens is evaluated for different categories of households, through production decision making models with fixed consumption for individual households in Wayanad, to understand the differences in impacts within and across different household groups under baseline and uncertain scenarios and across time.

[1]This thesis is part of the project titled 'Alleviating Poverty and Malnutrition in Agro biodiversity Hotspots in India' (APM project funded by DFATD/IDRC) by University of Alberta and M.S. Swaminathan Research Foundation, India. The project addresses the disparity between the rich biodiversity and severe poverty in three agro-biodiversity hotspot regions in India: Wayanad (Kerala), Kollihills (Tamil Nadu) and Jaypore (Orissa). One of the objectives of the project is to enhance food and nutritional security at individual, household and community levels.

Background & Discussion

1.1.1 Characteristics of Wayanad District

In Kerala, most of the households are dependent on agriculture for their livelihoods. The agriculture sector contributes 35.7 percent of total employment (National Sample Survey 66th Round, 2009-10). Among the 14 districts in Kerala, Wayanad is known for its rich agro-biodiversity that has resulted from its contact with the Deccan Plateau and the Western Ghats. Once known as the land of paddy fields, Wayanad has now become the land of perennial plantation crops and spices. About 45.4% of the total workforce of the district is involved in agriculture (Census of India, 2011). The overuse of chemical fertilizers and pesticides has impacted soil health and in turn crop productivity. In recent years the district has witnessed hundreds of farmers' suicides owing to financial distress (Human Rights Documentation, Indian Social Institute (2012) and KSSF and Caritas India Report).

In contrast to its rich agro-biodiversity, Wayanad is considered to be one of the less developed districts in India. Although the state Kerala stands highest in the Human Development Index for India, Wayanad is characterized by low human development indicators and low economic prosperity. The deprivation index based on deprivation for four basic necessities i.e., housing quality, access to drinking water, good sanitation and electricity is much higher for Wayanad (46.3) than the state average of 29.5 (Economic Review, 2011). Table 1 shows the Human Development Indicators for Wayanad and Kerala.

Table 1.1: Human Development Indicators

		Kerala	Wayanad
Drop-out ratio	Lower Primary	*0.38*	*0.88*
	Upper Primary	*0.32*	*0.94*
	High School	*0.85*	*1.64*
Literacy rate		*90.9*	*85.5*
Index of deprivation		*29.5*	*46.3*
Life expectancy at birth		*74.6*	*73.5*
Health Index		*0.827*	*0.809*
Education Index		*0.93*	*0.866*
HDI		*0.773*	*0.753*

Source: Economic Review, 2011

These low human development indicators may be due to the higher concentration of tribal people in the district (18.52% of the total population of Wayanad and 31.24% of the state's population are tribal people, Census 2011), most of whom live in abject poverty. The five main tribal communities in Wayanad are Paniyan (44.77%), MulluKuruman (17.51%), Kurichian (17.38%), Kattunaickan (9.93%) and UraliKuruman (2.69%). They can broadly be categorized into three avocations; agricultural laborers, marginal farmers and forest dependents. The school drop-out rate is higher among the tribal children due to lack of access to schools, discrimination and the failure of the education system to inculcate the cultural requirements of the tribal population. Though they are the original inhabitants of the district, they are being marginalized by the system and the settlers, who had migrated to the district as part of the post-second World War 'grow more food' campaign which encouraged food production to curtail food shortages. The majority of tribals in the district are landless and the average land holding is 0.26 hectares as against the average holdings of the non-tribal population in the district, which is 0.58 hectares. As a result of the Kerala Land Reforms Act which fixed ceilings on land holdings, the majority of the agricultural holdings in the state are small holdings. The average agricultural land holding in

Kerala is 0.22 hectares and 96.3 percent of the farmers hold less than one hectare of land, of which 90.4 percent account for just 0.1-0.2 acres of land (9th Agricultural Census of Kerala, 2010-11). Socio-Economic and Caste Survey of India (2011) reported that 40.28% of households in rural Kerala are landless and are dependent upon wage employment for their livelihood.

Kerala households are also characterized with having a large number of migrant people due to lack of employment opportunities and low income levels in the state. Large majority of households (70.49 %) in the rural areas of Kerala earns less than Rs.5000 per month, followed by 17.15 % with an income level of Rs.5000-10,000 and 12.35 % with above Rs.10,000 (Socio-Economic and Caste Census, 2011). One out of six employed people works overseas (2.28 million as of 2011). According to the Kerala Migration Survey 2011, the total number of people who migrated to other states in India is 0.9 million. The migrated population from Wayanad accounts for 26874 people to overseas and 19390 to other states in India.

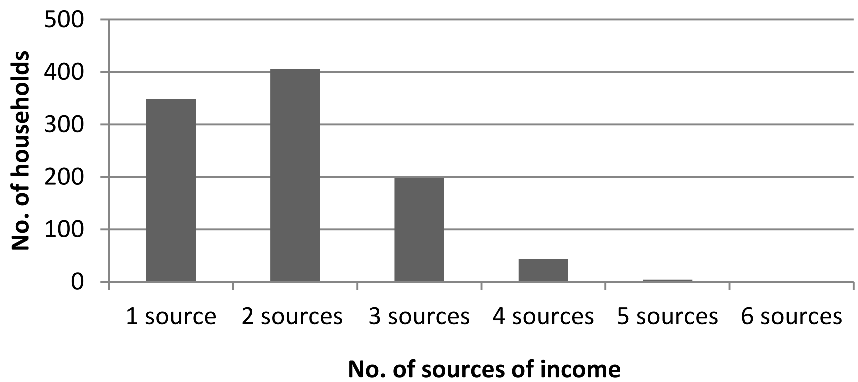
Many households in Kerala suffer from alcoholism. For such households, having a constant income support from the male household head is doubtful. Women have to shoulder the responsibility of looking after the family. A 2011 report by one of India's largest trade bodies found that Kerala accounted for 16% of national alcohol sales (The Economist, March 2013). This is very high, considering that Kerala is one of the small states in India.

Compared to other states in India, the vegetable prices in Kerala are very high since the vegetables are mainly transported from other states. More than 80 % of state's vegetables come from neighboring states like Tamil Nadu and Karnataka (The Financial Express, 2015). Escalating transportation costs, labor charges and the direct procurement of vegetables from farms by corporate giants contributes to the spiraling of prices in the market. Along with that, extreme climatic conditions like dry and windy weather in the producing states also affect the supply of vegetables which in turn lead to sharp increases in prices. Due to these issues, Kerala experienced around 25–50 % hike in prices in just a month or more than 300 percent increase within a year. The steep increase in the prices of vegetables has put constraints on household budgets. Households have to shell out around Rs.200 to buy vegetables that they require for just three days. This forces the low income groups to cut down their quantity of purchase considerably (The Hindu, 2013; The Times of India, 2014). A recent food safety study reported that the vegetables brought from Tamil Nadu found to have pesticide residues three or four times more than the permissible limit and farming is nearly controlled by pesticide-manufacturers. The switch to hybrid seeds and high cost of bio-control agents make it inevitable for the farmers to apply high doses of pesticides and fertilizers during cultivation. The high incidence of cancer in Kerala could partly be attributed to the toxic vegetables. In action with the report, Kerala Government has decided to enforce a ban on the procurement of toxic vegetables from Tamil Nadu (The Financial Express, 2015; Business Standard, 2015; The New Indian Express, 2015). Along with high vegetable prices, general cost of living is also high in the state of Kerala. Given the circumstances, even a slightly better income could help the households to improve their living status.

1.1.2 Risks Involved in Various Income Generation Activities

Having a secure income source is one of the primary concerns of any household. This necessitates households to opt for vocations that would cater to their financial needs. It was found that 66% of the households studied under the Alleviating Poverty and Malnutrition Project (APM) depended on multiple income sources for their livelihood as security in the case of failure of one source or another. Out of 1000 participant households, 406, 198 and 43 households diversify their income sources with two, three and four income generation activities respectively (figure 1.1). For example, 52.1% of the households have identified crop production as the major source of income. Other sources of income include non-farm wage earning (43.9%), farm-wage earning (38.4%), salaried employment/pension (20.4%), livestock and poultry (20.3%), migration employment (9.1%), business (5.2%), money lending (1.6%), and selling vegetables (0.6%) (Baseline survey, MSSRF - UoA Project, 2012).

Figure 1.1 Households with their number of sources of income



Source: Author's analysis

All the above mentioned activities face risks such as crop failure due to unpredictable weather patterns, falling crop prices, sickness of livestock or individuals, business failures due to lack of investment, and uncertainty of pay back for money lenders, which makes it clear that households operate in a risky environment. The risk sources for farming can be categorized into two: One, the external environment i.e., natural, economic, social, policy and political environments in which the farm system has to operate and two, the internal operational environment of the farm system which includes health, inter-personal relations, resource and ecological risk, financial risk and succession risk (McConnell and Dilllon, FAO, 1997). Among the external risk sources, the natural environment is the most important. Since agricultural production is directly dependent on nature and its uncertainties which include floods, droughts, cyclones, tsunamis, earthquakes, etc., the risks involved in agriculture are very high. Indian agriculture is often referred to as the 'gamble of monsoon' which implies the dependence on rain for cultivation. Two-thirds of the net sown area in India comes under rain fed lands (Singh & Rathore, 2010). With the changing weather patterns resulting from climate change, output and income from crop production are becoming uncertain which may lead farmers to move away from agriculture production. Resource poor small farmers usually are risk-averse and therefore use various risk management strategies which can consist of diversification, usage of risk-reducing inputs, keep reserves seed, use stable enterprises, spread sales over time, off farm employment, etc. (McConnell and Dilllon, FAO, 1997). During the agricultural crisis (2003-2007), which resulted from crop failure, rising costs of cultivation, dropping prices for farm commodities, lack of credit availability for small farmers, climate change and lack of adequate social support infrastructure, India observed a large rate of farmers' suicide (KSSF and Caritas India Report). The Wayanad district experienced the highest number of suicides in Kerala (317 out of 979, Department of Economics and Statistics, 2009).

Livestock production contributes to rural development in developing countries by providing food, income and enhancing crop production. However, those households have to face risks such as animal disease, price fluctuations for outputs and inputs, land access and land appropriation, natural factors like droughts, and diminishing fodder inputs (Jacobs and Schloeder, 2012, Steinfeld and Mack, 1995). The numbers of people employed in farm and off-farm wage earning activities are high in India. According to the NSSO (2004-05) 61st round, 86% of the total workforce in India constitutes the informal/unorganized sector. For the daily wage earners, their employment and income often depends upon the season. Farm wage earners are often struggling to survive during off-seasons. Besides, environmental factors, political instability which leads to strikes make the life of the daily wage earners miserable. In Kerala where strikes are frequent relative to other states, the earnings lost by on-farm and off-farm daily wage earners cannot be made good in the subsequent working days. For them, strikes mean no earning and no food (One India, 2013). Lack of job opportunities, economic, social and political instability, etc. have forced many people to migrate to different states and countries in order to improve their livelihood. While those with high education and skills find it easy to get good jobs, a large percentage of migrants work in irregular and high risk situations. Such workers are often exposed to unsafe and hazardous environments or even vulnerable to exploitation and abuse (UNDESA, 2012, Schenker, 2011). Considering the households who depend upon business or self-employment for their livelihood, risk and uncertainty are very high and common. The risks include financial risks, operational risk, market and environmental risks. Businesses undertaken by rural people are mostly small scale enterprises such as petty shops, production of food products, handicrafts, etc. Some of the rich households are even involved in money lending as a way to diversify their income sources. In that case, the uncertainty of paying back the money becomes a major risk. The discussion above points that all income generation activities are associated with various types of risks and diversification is one of the more common ways to deal with the situation in a subsistence economy.

1.2 Research Problem

Given the background of the study area, there exists a visible dichotomy of poverty of people and prosperity of nature (APM project, MSSRF-UoA). Ensuring a decent standard of living within available physical, resource, and time constraints is a major concern for all households. A study conducted in some developing countries in Asia, Africa, Eastern Europe and Latin

America showed that the largest share of households have diversified their sources of income through crop production, livestock production, agricultural wage employment, non-agricultural wage employment, non-agricultural self-employment, etc. since different income generating activities offer them alternative pathways out of poverty as well as allow them to manage risk in an uncertain environment (Davis et.al. 2009). The risks associated with agriculture and allied activities involve crop failures, fluctuating prices, weather patterns, health issues, socio, economic, policy and political factors, financial problems, resource unavailability, etc. Under risky circumstances, home gardens, potentially a cost effective way of producing nutritious vegetables and fruits which are suitable to the local climate and tradition, may be regarded as a way to improve livelihoods by providing an income improvement opportunity or a food buffering resource in the case of reduced incomes, reducing the risks faced by households. Home gardens satisfy the requirements of sustainability by being productive, ecologically sound, stable, economically viable, and socially acceptable (Jacob, 2014). Since home-gardening requires only a small investment in seeds and labor, even the poor should easily be able to access the benefits of it. Home gardens can also serve as a protective buffer in the households where the men spend a part, or even the whole, of their income in buying alcohol. Given the escalating vegetables prices of Wayanad and the supply of highly toxic vegetables in the market, home garden could also help households to easily manage the household food budget with access to safe food.

However, most of the households in Wayanad had become uninterested or even withdrew from home garden cultivation due to non-availability of quality seeds, pest attack, disturbances by hen and crabs, lack of space, water, knowledge and time. This led the APM project (Alleviating Poverty and Malnutrition in Agro biodiversity Hotspots in India) by University of Alberta, Canada and M.S. Swaminathan Research Foundation, India to target home gardens as one initiative to achieve food, nutritional and livelihood security at individual, household and community levels. The project supported households to expand/improve existing home gardens and new ones by providing quality seeds, plants, nets and training on structured and unstructured home garden design and management.

1.3 Research Objectives

The broad objective of this thesis is to identify the role of home gardens in stabilizing and/or raising incomes of small scale households in Kerala, India.

Specifically the research objectives are:

- To build production optimization models with fixed consumption by establishing technical coefficients from the literature and from analysis of data collected from project households for each of 6 specific household types mentioned below:
    - landless households, where land for agricultural production is zero, with and without home gardens
    - landholding households, where agricultural production is relatively large in terms of their share in the total household income (between 35 – 100%), with and without home gardens (mentioned as agricultural majority households)
    - landholding households, where agricultural production is relatively small in terms of their share in the total household income (below 35%), with and without home gardens (mentioned as agricultural minority households)
- To assess the economic contribution of home gardens for
    1) six above mentioned household categories under baseline and uncertain conditions
    2) male and female headed households

3) across time from 1990-2012 with market variability in wages, prices and costs.

- To look at whether maintaining a home garden has improved the livelihoods of households by supplementing income or food or by sharing produces.

1.4 Thesis Structure

The thesis is organized in the following manner. A review of literature on the various impacts of home gardens, methods traditionally used to measure home gardens' economic contribution, and linear programming models for farm households will be discussed in the Chapter 2. In addition, the chapter also analyzes data on the different household categories and individual sample households used to build the production-consumption decision making model. Chapter 3 will provide a conceptual framework of the structure of the household model and discuss the parameters developed for the model. Results of the analysis will be presented in Chapter 4, and discussion and limitations/recommendations for further research presented in chapter 5.

CHAPTER 2

2.1 LITERATURE REVIEW

2.1.1 Defining a Home Garden

Known as home gardens, kitchen gardens, backyard gardens, mixed garden horticulture, household or homestead farms and compound farms, these farming systems can be a cost effective way of producing nutritious vegetables and fruits which are suitable to the local climate and tradition (Puri and Nair, 2004). Home gardens are located adjacent to homes and have a close association with family activities. Home gardens can be defined as 'a small scale, supplementary food production system by and for household members' (Hoogerbrugge and Fresco 1993). Chris Landon-Lane refers to home garden as a farming system that combines physical, social and economic functions on the area of land around the family home (FAO Diversification Booklet, 2004). According to Ninez (1984), home gardens represent a crucial day-to-day survival strategy involving primary (plant) and secondary (animal) food production for household consumption in addition to generating small amounts of income in cash or kind through sale or trade of surplus production. Kumar et.al. (1994) define home gardens as operational farm units which integrate trees with field crops, livestock, poultry and/or fish, having the basic objective of ensuring sustained availability of multiple products such as food, vegetables, fruits, fodder, fuel, timber, medicines and/or ornamentals, besides generating employment and cash income.

Home gardens have been a way of life for the households in India for centuries as evident from the ancient Indian epics *Ramayana* and *Mahabharata*. The epics include a description of '*Ashok Vatika*', a form of today's home garden (Puri and Nair, 2004). In Kerala which has around 5.4

million home gardens with mostly less than 0.5 ha area (KSLUB, 1995), home gardens are identified as critical to the local subsistence economy and food security. Home gardens in Kerala are believed to be around 4000 years old. The small and marginal farmers of Kerala rely on home gardening as a strategy to stabilize their household food security and income against the risks and uncertainties of mono-cropping (Jose and Shanmugarathnam, 1993).

2.1.2 Impacts of Home Gardens

a) Contribution to Food and Nutritional Security

Several studies have proved that home garden production has significant impacts on food and nutritional security of households. Home gardens often supply large amounts of food and nutrition on relatively small extensions of land unsuited for field agriculture (Ninez, 1984). Kumar (1978) states that among the wage-earning families in Kerala who cultivate home garden plots occupying a fraction of an acre, home gardening production has been observed to have a 'buffering effect' on child nutrition and consumption during slack employment seasons with shortfalls in wage incomes and the value of home garden production was the most consistent positive predictor of child nutrition. The results of their study indicated that produce from even small plots of land, if intensively cultivated, can lead to large improvements in child nutrition.

Hellen Keller International implemented a Homestead Food Production (HFP) program in Bangladesh in order to improve health and nutritional status of children and women through household production and consumption of micro-nutrient rich foods (Iannotti et.al. 2009). The program covered 4 percent of the population of Bangladesh (240 of the 466 sub-districts), including diverse agro-ecological zones. Six out of nine evaluations by the project used a pre/post design to study the changes between the baseline and end-line points of the project. Two assessments included a control group in order to account for external factors influencing the project. The study evaluated the effects on three groups: active participants (households receiving benefits from the project for less than three years), former participants (households who had completed the program and still maintained home gardens without the project assistance) and control groups (households who received no project support). The assessments indicate that the cultivation of vegetable varieties increased by more than two-fold and in three months households produced a median amount of 135 kg and 120 kg of vegetables in the active and former groups, respectively, compared to 46 kg in the control group. The percentage of mothers and children eating dark green leafy vegetables among the NGNESP target households (National Gardening and Nutrition Education Surveillance Project- part of the HFP program) increased from approximately one-third to over three-quarters i.e., from 37% to 86% among mothers and 28% to 76% among children. Children in the households with developed garden (Home garden which offers wider range of vegetables and fruits, produced in fixed plot all year long) consumed 1.6 times more vegetables.

Similarly, the Alleviating Poverty and Malnutrition (APM) project intervention of implementing home gardens increased the consumption of vegetables among participant-households from 56.4 to 135, 48 to 90 and 26.4 to 96 (in kilo grams) in Odisha, Tamil Nadu and Kerala respectively (Abubaker et.al. 2014).

b) <u>Contribution to Income and Livelihood Security</u>

Through the consumption from home production, households may be able to reduce the money spent on food. Blaylock and Gallo (1983) states that probability of home garden production is expected to be higher when the savings from gardening are higher. They found that in the U.S.

households with home gardens saved an average of 78 cents per week ($40 per year) which is more than the 20% of the average amount spent on vegetables by non-gardening households. The home garden households in the base age group (40 - 64 years) spent less on vegetables than any other households. The results also indicated significant savings by gardening households in all seasons which reflects the storage of vegetables produced at home.

A study assessing the private value of agro-biodiversity in Hungarian home gardens by combining stated and revealed preference methods (Birol et.al. 2006) identified that home gardens generated private benefits for farmers by enhancing diet quality and providing food when costs of transaction in local markets were high. The paper indicated that high private value from home gardens was derived by those farmers located in the most economically, geographically and agro-ecologically marginalized communities. They found that households in the lowest income quartiles in Hungary consume food from own production with a value of $83 per month.

A study by Hellen Keller International in Bangladesh showed that households without home gardens primarily depend on market for their consumption of vegetables (97.5 percent), compared with only 3.2 percent for households with gardens (Iannotti et.al., 2009).

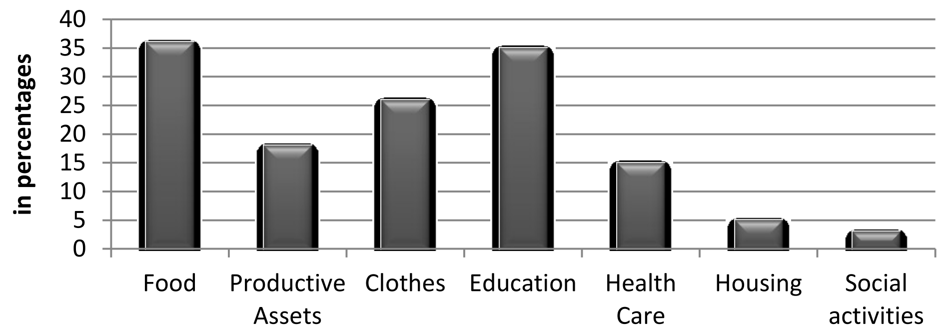
Besides saving on food expenditure, households can earn a considerable amount of income from the sales of home garden produces. The HFP project in Bangladesh showed that households have earned the cash equivalent of 14.8 percent of total average monthly income and that income value of home garden production increased from 14 percent to 25 percent of average monthly income after taking into account purchased vegetables and fruits (Iannotti et.al. 2009). Earnings from home gardens increased from 6.7 to 46.3 percent of household income which resulted in improvement in households' socioeconomic status. Former participants found to have the highest income from home garden (490 taka) followed by active participants (347 taka) and control group (200 taka).

Cleveland et.al. (1985) studied two home gardens in Tucson, U.S. to estimate net returns from gardening by average or low income households. They estimated that an average weekly investment of 2.1 to 2.9 hours will return more than the market value of the vegetables produced and can contribute to the savings of the household. The two vegetable gardens yielded an average of 1.24 and 2.31 kg/m^2 of produce and average net returns of $109 and $123 per year, $0.72 and $1.11 per hour or $8.80 and & $7.75 per dollar of water used. The study also implies that a weekly investment of two to three hours in home garden production can provide savings in regions where water availability is a crucial factor. In Indonesia, home gardens have contributed about 25 percent of household income (Landon-Lane, 2004). A study by Mohan et.al. (2006) in Kerala found that the intensity of production and profit generation is much greater in the smaller gardens (area less than 0.26 ha) with an earning of average profit of rupees $84/m^2$.

Home gardens can increase dietary diversity by supplying a wider range of food through cultivation and by saving (or even earning) household income, thereby allowing additional food to be purchased.

The earnings/savings from home gardens can also help the households to meet other needs. Iannotti et. al. (2009) stated that one-third of HFP participant-households reported spending some of the income from home garden production on food, productive assets and education. Figure 2.1 shows the patterns of spending for income generated from the sale of home garden produce among the HFP participating households. 36% of households reported using this additional income for food, 35% for education, 26% for clothes, 18% for productive assets, 15% for health care, 5% for housing and 3% for social activities.

Figure 2.1 Usage of additional income earned from the sale of HFP garden produce



Source: Iannotti et.al. (2009)

c) <u>Impacts on the Decision Making Power of women</u>

In contrast to field agriculture, home gardens are mostly managed by women in the household. After the implementation of HFP project, a higher percentage of women in the active and former participant groups, as compared to the control group, reported full decision making power on a range of issues such as type and quantity of vegetable consumption (28.5% to 77.3%), making purchases (6.7% to 41.7%), household land use (3.8% to 26.9%) and group meeting participation (2% to 32.8%) (Iannotti et.al. 2009). Women also contributed more to the household income because of home garden.

Abubaker et.al. (2014) and Huang (2014) reported that women feel a greater sense of autonomy in making decisions about food consumed within the household when they have a home garden. The study also states that the women who participated in the APM project were found to have higher levels of self-confidence than non-participants. With the improvement in the role of women in decision making, households have become more self-reliant in terms of managing income shocks and maintaining nutritional quality during crisis situations.

Talukder et.al. (2014) state a higher probability of consumption of vegetables, especially by children, when programs target women. A study by Kumar (1978) found that the child nutrition level was higher for the households where maternal labor force participation is absent, given the strong correlation between home gardening and unemployed mothers.

2.1.3 Models and Methods Used to Analyze the Economic Impacts of Home Gardens

Various studies over time have used different methods to look at the economic impact of home gardens. A simultaneous equation model was estimated by Blaylock and Gallo (1983) to quantify the effect of gardening on a household's vegetable expenditure. They defined vegetable expenditures to be a function of region and urban location of residence, race, home ownership, income, seasonality, number of guest meals served and household composition variables. Vectors of interactions were created by multiplying these variables and a unit vector by the gardening dummy variable to measure the expenditure differences between gardening and non-gardening households. The coefficients for seasonality, household composition variables with members of different age groups and unit vector interactions, were found to be significant in determining the vegetable expenditure. The potential savings on vegetable expenditure was calculated as the difference between a household's predicted vegetable expenditures when their home garden production was zero and positive. The 1977-78 USDA Nationwide Food Consumption Survey data which includes a sample of approximately 14000 households was used to estimate the model. Information on households' socio-economic characteristics and food use was collected from personal interviews with the household member/members most responsible for food planning and preparation.

Mohan et.al. (2006) used three different methodologies to assess the economic value of home gardens. Cost-benefit analysis, sensitivity analysis to assess the economic resilience of home gardens to market shifts in labor or farm prices and comparison of net values of these gardens with other available economic alternatives (selling or leasing the land) were carried out. Values of home garden produces were determined using - market prices. Shadow prices were used to value medicinal plants. Inputs for home garden were determined as monetary contribution to the annual economic cycle of garden which includes seeds, organic and chemical fertilizers, household and hired labor, maintenance and equipment costs, and transportation costs. Opportunity costs of household labor were calculated as a function of time, by multiplying time spent in the garden with the wage rate. The rate at which farmers were able to lease out the land was taken as the opportunity cost of land.

An experimental plot study was conducted by Cleveland et.al. (1985) to estimate the economic returns for two home gardens. The return was calculated using retail prices at local stores and harvested produce was valued separately for each garden. Data on inputs and outputs for home garden production were reported by gardeners rather than estimated. Expenses incurred by home garden included costs of seeds and transplants, water, soil sulfur, hauling manure, fish emulsion, straw mulch and the tools used for plantation. Other inputs consist of land and labor hours.

Although most studies use market valuation methods to estimate the economic value of home gardens, Birol et.al (2004) stated that since home garden products are not usually traded in markets, home garden farmers derive benefits primarily in non-market use values or utility and therefore, non-market valuation methods must be used to determine the value of their benefits. The preferences of the farmers determine the implicit values to home garden and its attributes (Scarpa et.al. 2003). Birol et.al (2004) used the choice experiment method to estimate the private value rural households assign to their home gardens. Building on this approach Birol et.al (2006) combined a stated preference approach (a choice experiment model) and a revealed preference approach (a discrete-choice, farm household model) to achieve more efficient and robust estimation of the private value of agrobiodiversity in home gardens. Information about the social, demographic and economic characteristics of the households, farm production characteristics, components of agrobiodiversity and household level food consumption expenditure were elicited for the farm household model.

2.1.4 Linear Programming Farm Household/ Production-Consumption Model

Taylor et.al., (2003) stated that the agricultural household model/production-consumption model best explains the economic behavior of farming system households, such as subsistence and sub-subsistence household farm, small-scale renter and share cropper farms, the net-surplus family farm and owner-operated commercial farms, which engages rural populations in the developing world. It maximizes household's expected utility from home-produced goods, purchased goods, and leisure, subject to a set of constraints which include cash-income, family time and endowments of fixed productive assets and production technologies, prices of inputs, outputs and non-produced consumption goods (Taylor et.al., 2003). The household model considers that the production and consumption decisions are linked because the deciding entity is both a producer, who chooses the allocation of inputs to crop production, and a consumer, who chooses the allocation of income from farm profit and other livelihood activities to the consumption of commodities and services. The profit includes implicit profits from goods produced and consumed by the household and consumption includes both self-produced and purchased products. The household implicitly purchases goods from itself by consuming its own output and similarly, it implicitly buys time by allocating its own time to household production activities or leisure (Singh et.al. 1986). This kind of methodological outlook considers farm households as joint production-consumption units and captures how the behavior of the household as a producer affects its behavior as a consumer and supplier of labor, and vice versa.

Bernet et.al. (2001) designed a linear-programming farm household model that involves crop or livestock production which could be used in varying economic and ecological settings in developing countries. The model was setup to understand small farmer production systems in three ecological zones in Peru, in order to identify appropriate strategies to maximize expected profitability. Given the limited amount of potential options available to describe the different domains of a potentially mixed farming system, they defined the production activities, resources, production factors, technologies and prices, which portrayed the farmer’s specific production and decision-making context. The principal production constraints defined in this model include access to land, water, labor, capital and feed. They also defined a minimum income constraint in order to reflect farmers’ propensity to favor a minimum income throughout the year. The model entails a detailed feed balance for cattle and sheep to guarantee minimum nutrient intake. For crop production, they defined food or fodder crops and the production factors required such as water, male/female labor, animal traction, tractor hours and capital. The model did not relate soil and weather data with expected yields, and all prices are exogenous.

A normative linear programming paradigm was used by Stamenkovska et.al. (2013) to develop an optimization model in order to analyze the decision-making on Macedonian family farms in three scenarios with different market and capital constraints. The model was tested on a hypothetical vegetable farm. Optimal solution was found under the assumption of maximizing expected gross margin, subject to different equality and inequality constraints that define the production margins of the farm. Their model consisted of 162 decision variables which can be broadly categorized into four groups: activities reflecting most representative vegetable crops, input related activities (use of fertilizers, manure, land and labor), activities capturing infrastructure capacity of the farm, and balance activities to assure integrity of the solutions. Constraints dealing with the production factors scarcity which include available land use and possibility for land rentals, labor availability according to the seasonal character of vegetable production, with possibility for hiring non-family labor, and available working capital for covering the annual variable cost, were defined in the model. Agronomic constraints and market and policy constraints, which affect the production structure, were also determined. Along with that, constraints like maximum available land per crop and minimum number of crop enterprises were included in the model.

In this study, production models with fixed consumption levels (to ensure consumption does not fall below original levels), which optimize household income from agricultural production, home garden and other income generating activities given the time, labor and fixed productive asset constraints, will be developed for different household categories, using a linear programming approach. These farm optimization models efficiently reflect farmer's behavior within specific production contexts and are valuable in application to mixed farming systems (Bernet et.al. 2001). Linear programming is the most often used mathematical programming method for optimization, even due to its simplified linear and normative nature, it shows quite accurately what the farmers do or how their behavior changes if the production conditions change (Hazell and Norton, 1986). This type of modelling can be used to determine the most efficient manner of organizing a farm household's operations and can offer insights into the family's production and contribution to food needs and household income and thereby increase understanding of farm level decision making (Andrews and Moore, 1976). Instead of linear programming, the study could have applied quadratic programming which allows the model to include nonlinearities of a quadratic nature into the objective function, and is better situated to simultaneously optimize production and consumption decisions. The households' total consumption levels are exogenously determined in the model developed particularly for this study to make sure the households consume at least the original given consumption quantity of each product. Whether to meet this required consumption levels through own production or market are determined within the model based on household's production capacity. A dynamic framework of integrated farm household planning developed by Loftsgard and Heady (1959) exogenously determined the optimum household consumption expenditures and included in the model as constraints. Other farm integrated models determined farm consumption as a proportion of profits which would be consumed and that which would be reinvested in the following period (Boussard, 1971). Singh (1973) in his recursive programming model specifies predetermined acreage and output to be allotted for home consumption. Studies have also treated consumption as savings in their farm household model (Dean and Benedictis, 1964). Consumption can also be determined endogenously in an integrated linear programming model. In a study conducted by Schluter and Mount, they allow the basic staples like rice, jowar and fodder to be grown for home consumption or for sale in the market. Their model specifies that minimum levels must be supplied from the farm or purchased to meet their requirements.

Although the literature on home gardens has highlighted the potential impacts of home garden on food security and household income level, what has not been considered is the contribution of home gardens to different types of households' economic security over time. Besides examining the economic impact of home gardens across time with market variability in wages, prices and costs, these farm optimization models will also be developed to determine the economic impact of home gardens to different household types based on their income generation activities, land holdings and gender of the household head, under baseline and uncertain conditions. Based on the literature, the data on the households' crop and home garden production including the cultivation pattern, types, quantities and costs of inputs used, resource availability, outputs yielded, income and expenditure of the household, and consumption pattern of home produced food will be used to design production-consumption models for each households. The data on farm prices, agricultural wages, fertilizer prices and crop production levels in Wayanad district from 1990-2012 will also be used to develop models across time.

2.2 Data and Data Analysis

2.2.1 Data Sources

The data needed to construct production-consumption optimization model for this study was collected from the surveys conducted by the 'Alleviating Poverty and Malnutrition' (APM) project in Wayanad. A baseline survey was taken from 1000 project-participant households in Wayanad district, between November 2011 and February 2012, which included information on the socio-economic and demographic characteristics, resources and activities like farm, home garden and livestock production and, information sources and services. The project undertook a more detailed survey between June 2013 – October 2013, from 501 project households and 100 control group households. The survey included wide and detailed information on home gardens such as, a list of products cultivated by the households, which consists of vegetables, tubers, greens, fruits, spices and medicinal plants, and their production, consumption and marketing.

Data on the home garden maintenance by family members, usage of organic manure and chemical fertilizers, area cultivated and sharing of land, uses of home garden produces, constraints and impacts of having a home garden are also collected from the households. Similarly, information on the households' production of staple and major crops in the farm was collected under the survey. Data was collected on the costs of production including costs of labor, land preparation and ploughing, seeds, irrigation, organic manures, chemical fertilizers and pesticides, marketing of the yield, usage of traditional and improved varieties of seeds, processing and value-addition of crops production constraints. The survey also covered information on the production, consumption, value-addition, trade and management of livestock, gender division of labor in agricultural production, self-confidence and decision making of women, wild-food gathering, nutrition and food security, access to information and services, migration and households' financial status. Along with the detailed survey, the APM project had also undertaken a food frequency survey which covered the quantity, frequency and source of food consumed by the households which comes under the categories of cereals, millets, pulses and legumes, green leafy vegetables, roots and tubers, milk and milk products, eggs, fish, meat, nuts and oil seeds, fruits, sugar and jaggery and, fats and oils. The food frequency data was used to determine the annual consumed quantities of home produced food for each household. Although the detailed survey collected the data on number of hired and family labor days employed in the agricultural production, the own labor days allocation for home garden production and management were unknown. This data was obtained from the time-use survey conducted by this study on the female and male heads of the sample households chosen to develop the model. The survey includes the data on time allocation to different activities related to daily household chores, home garden, farm cultivation, livestock maintenance, health, work, recreation, social activities and others (Appendix section a.11).

In order to develop the models across time, the historical farm prices and production levels for agricultural crops such as paddy, coffee, areca nut, rubber, plantain, ginger and elephant foot yam (production levels unavailable), market prices for major food crops cultivated in the farm (which include paddy, ginger, elephant foot yam and plantain) rural agricultural wages and rainfall statistics in the Wayanad district over the period of 1990-2012 were collected from the Department of Economics and Statistics (Kerala), Krishi Bhavan (Wayanad), Krishi Vigyan Kendra (Ambalavayal) and the Kerala Agricultural University (provided in the appendix – tables a.1, a.2, a.3, a.5, a.6). Farm and market retail price of the products cultivated in the home gardens were unavailable for this long period. However, these prices for the base year in the model (2012) were obtained from the market price survey conducted by the APM project in the project location in Wayanad, Krishi Bhavan (Wayanad) and DES (Kerala). The national level prices for most commonly used fertilizers for twenty year period (Urea and NPK) were obtained from various publications by the Department of Fertilizers in India, since the regional level prices were unavailable for this period (provided in the appendix – table a.4) .

2.2.2 Sampling and Analysis of Household Categories

501 participant households who are monitored through annual surveys and targeted project interventions under the APM project are classified into different household categories for this study. Since Wayanad is still considered as a rural area where to a greater extent industrialization has not taken over agriculture sector, majority of households depend on crop production, mostly subsistence agriculture, for their livelihood. Even the households with a small amount of land

cultivate some of the crops that do not require daily maintenance. For those households often their majority of income comes from non-farm activities such as daily wage labor, livestock production, salaried employment, and self-employed businesses. Households with no land for agricultural production too depend on these above mentioned income earning sources to sustain their livelihood. Given the income-earning situation in Wayanad, the households can be classified mainly into three categories (landless households where land for agricultural production is zero; landholding households where agricultural production is relatively large in terms of their share in the total household income (between 35 – 100%), mentioned as agricultural majority households; and landholding households where agricultural production is relatively small in terms of -their share in the total household income (below 35%), mentioned as agricultural minority households) in order to look at how the impact of home garden differs in each household category. The three categories are again classified into households with and without home gardens. This type of classification allows us to analyze the contribution of home garden to households within and across the category.

The six household categories differ in terms of their social-economic and demographic characteristics. By analyzing these characteristics, households who are representative of each of their categories in the income level, land holdings and household demographics were selected for the study. Two households were chosen from each of the home garden and no-home garden household groups to analyze the differences in impacts within and across the three major categories.

Table 2.1 captures the descriptive statistics of the six categories of households in the whole sample (501 households) and Table 2.2 captures those specific to the 12 sample households. Majority of households come under the category of agricultural minority with home garden

(285), followed by landless with home garden (83), and agricultural majority without home garden (70). Agricultural minority without home garden category consist least number of households (3). The average household size is 4 or 5 in all the categories, except for the agricultural majority without home garden. The households with highest family size are in the landless with home garden and the agricultural minority with home garden categories. Family size of the selected households in each category is almost same as the whole sample mean of the respective categories. In the whole sample and the selected 12 households, the agricultural majority with home garden category is found to have the highest annual income with an average of Rs.235247. Almost all the sample households diversify their income sources. Agricultural majority households stand highest in the average total land owned (2.51 acres) and in the average acreage allocated to home gardens (2.22 cents), and the landless category the lowest. The percentage of households with kids under the age 19 is highest in the landless with HG category (74.69%). This category has the highest number of female headed households (24.09%). Large percentage of scheduled tribe households fall under the landless categories with 59.09% in the no-home garden category and 45.78% in the home garden category.

Out of the 12 sample households, three are headed by women. This is significant since one of the main objectives of the APM project is to understand the gender dimensions of poverty and focuses on the socio-economic empowerment of women. Gender inequality in India is highly reflected in low gender ratios, wide differences in female and male literacy rates, high maternal mortality rates and low wages. The extent of poverty in India is severe among women, landless agricultural workers and small-land owners (APM Baseline report, 2013). Often the households headed by women have different outcomes in terms of productivity or entrepreneurship. In Burkino Faso, men's plots were found to have higher yields than women's plots. Even when simultaneously planted the same crop within the same household produces more yield for men because of higher labor and fertilizer use (Udry, 1996). In Uganda maize productivity was significantly lower for female headed households due to limited access to markets and lower probability of adopting fertilizer (Koru and Holden, 2008). A similar study looking at the gender differences in agricultural productivity identifies socioeconomic factors, agricultural inputs and crop choices as the reasons for lower productivity in female-owned plots and female-headed households in Nigeria and Uganda. The mean value of crop production in female-owned plots in Nigeria and Uganda accounts to ₦177.93 and USh257.88 compared to the values ₦714.72 and USh388.08 in their counterparts respectively (Peterman et.al. 2011).

Table 2.1: Characteristics of the six household categories

	Landless with HG	***Landless w/o HG***	***Ag majority with HG***	***Ag majority w/o HG***	***Ag minority with HG***	***Ag minority w/o HG***
No. of hhlds	16.57	4.39	7.58	0.60	56.89	13.97
HHLD Size						
Mean	4.98	4.27	5	2.33	4.74	4.24
Maximum	**13**	9	9	3	**13**	9
Minimum	1	1	2	1	1	2
Income						
Mean	125668.2	119042.7	**235247.3**	**67870.67**	182033.3	145777.4
Maximum	384000	416000	818739	154020	1276460	544580
Minimum	29600	20000	25000	4250	12800	3850
HHld % with children under 19	**74.69**	59.09	**73.68**	0	**72.98**	68.57
% of female headed hhlds	24.09	18.18	13.15	33.33	17.19	20
% of scheduled tribe households	45.78	**59.09**	18.42	33.33	28.07	32.86
Land area (in acres)						
Mean			**2.51**	1.89	0.93	0.94
Maximum			12.2	3.17	8.15	10
Minimum			0.1	1	0.015	0.03
HG Land area (in cents)						
Mean	1.08		**2.22**		1.7	
Maximum	7		20		15	
Minimum	0.1		0.25		0.1	

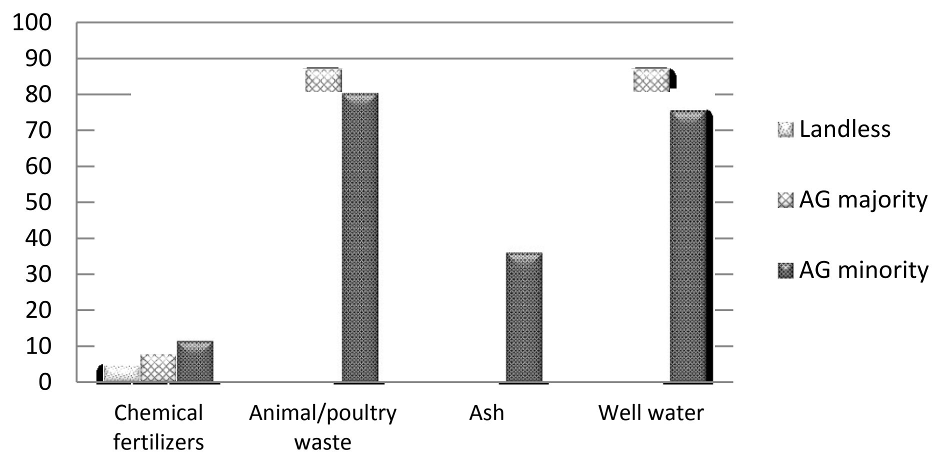
Source: Author's analysis

Table 2.2: Characteristics of the two selected sample households from each household category

HHLD Category	HHLD code	Female headed	Education of the hhld head	HHLD size	Kids under 19	Social category	Income	Contribution of AG production to total income	Total Land (in acres)	HG Land (in cents)	Sources of income
Landless with HG	293	1	Non formal	5	2	Backward caste	120000		0	0.5	Salaried emp
	256	0	Primary	4	2	Scheduled tribe	138820		0	2	Off-farm activities, migration, pension
Landless without HG	657	0	Upper primary	4	2	Backward caste	102548		0		Agricultural wages, off-farm actvities
	67	0	Illiterate	4	0	Scheduled tribe	93600		0		Off-farm activities
Ag majority with HG	281	0	Higher secondary	5	2	Backward caste	**254100**	42.86	1.55	3	Agriculture, sale of livestock products, off-farm activities
	546	0	High School	5	1	Forward caste	**261960**	59.15	**3.85**	1	Agriculture, sale of crop byproducts, off-farm activities
Ag majority without HG	137	0	High School	3	0	Backward caste	45342	**98.91**	1.4		Agriclture, off-farm activities
	300	0	High School	3	0	Backward caste	154020	**96.87**	2.5		Agriculture, sale of crop byproducts, off-farm activities
Ag minority with HG	816	0	Upper primary	3	0	Scheduled caste	172040	5.57	0.2	3	Agricultual wages, off-farm activities, salaried employment
	192	1	High School	4	0	Forward caste	169150	25.66	1.39	1	Agriculture, sale of crop byproducts, migration emp, salaried emp
Ag minority without HG	722	1	Illiterate	5	2	Backward caste	170100	2.82	0.8		Livestock production, agricultural wages, off-farm activities, agriculture pension
	264	0	Higher secondary	4	2	Forward caste	190858	31.89	1.5		Agriclture, off-farm activities

In the whole sample of landless, agricultural majority and agricultural minority with home garden categories, 72, 37 and 272 out of 83, 38 and 285 households respectively had home gardens before the introduction of the project. In the selected samples, all the six home garden households were maintaining a home garden even before the project started. However, lack of quality seeds and attack by pests, crabs and hens had caused most of the households to become uninterested in maintaining home garden. The project supported the households - to improve/expand their home gardens or even establish new gardens in some households through the supply of seeds, plants, nets, etc. Moreover, they received training on designing and managing home gardens. Households' mainly use organic manures like animal/ poultry waste and ash rather than chemical fertilizers as inputs (figure 2.2). None of the sample households apply chemical fertilizers in their home gardens. Well water is the most commonly used water source for the home garden production.

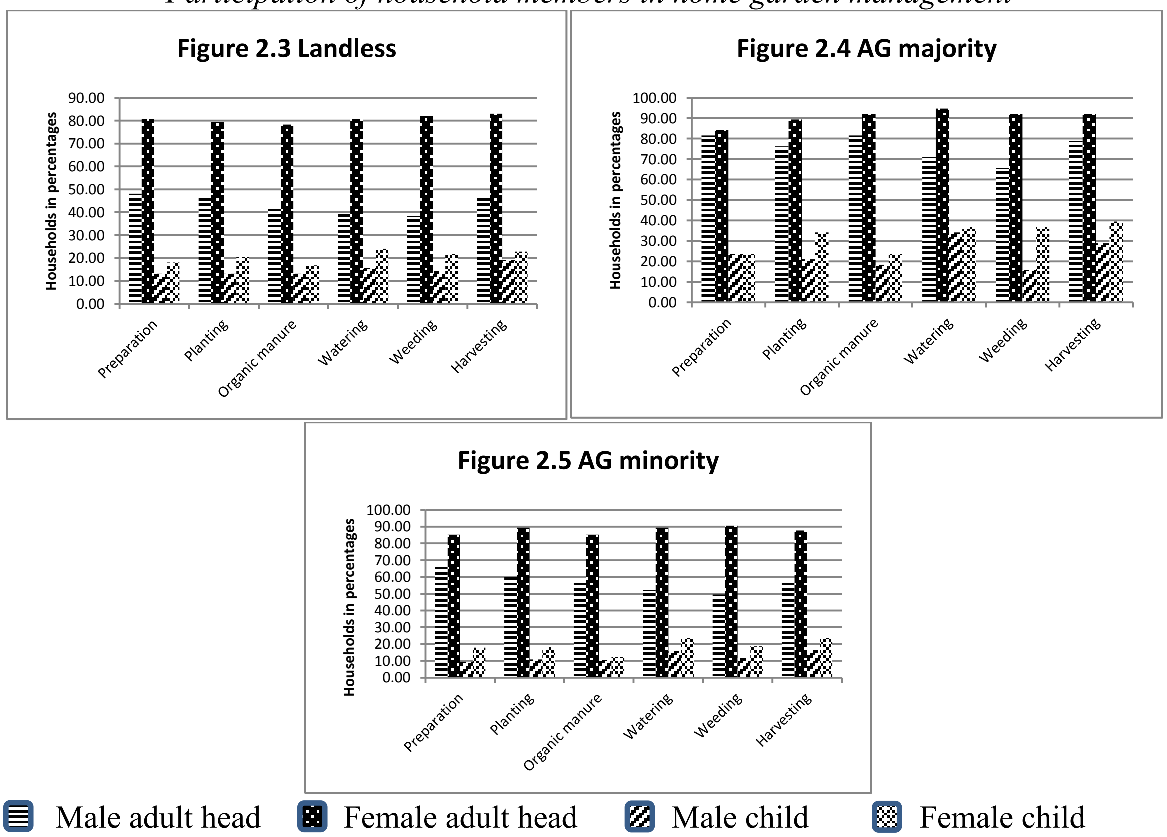
Figure 2.2 Inputs for home garden production
(whole sample)



Source: Author's analysis

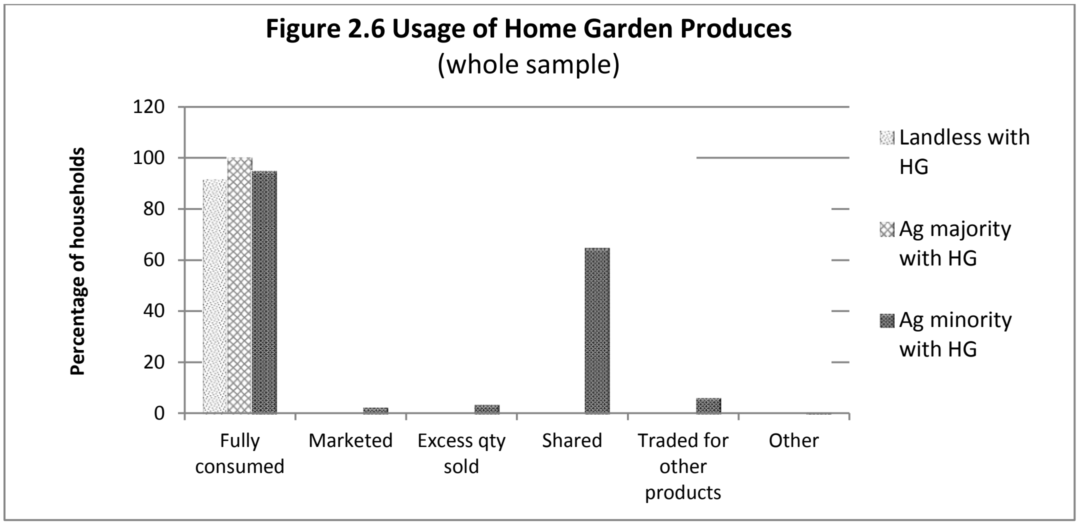
Household labor is another important input for the home garden production and management. The three graphs below (Figure 2.3, 2.4 & 2.5) illustrate participation of male adult head, female adult head, male child and female child in various home garden activities which include preparation of land, planting, applying organic manures, watering, weeding and harvesting of produces. Among the household members women spend significant amount of time in maintaining the home garden, regardless of the category, which is clearly visible from the graphs. Even among children in the household, female children are more involved in home garden activities than their male counterpart. However, the gender division is less visible in the agricultural majority category relative to the landless and the agricultural minority categories.

Participation of household members in home garden management

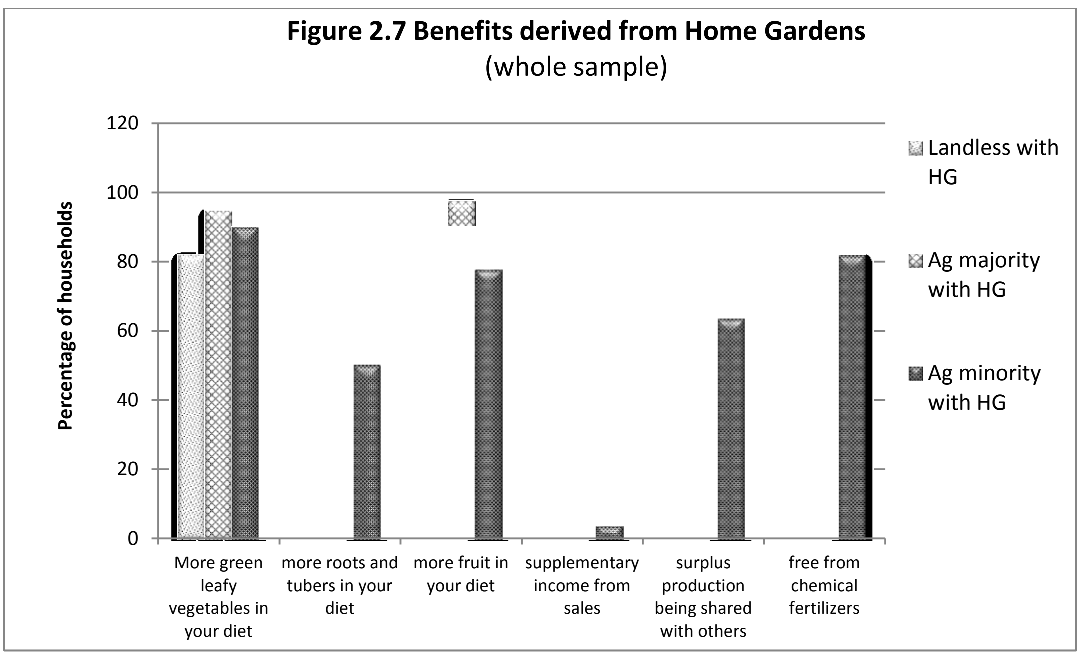


Source: Author's analysis

Produce from home gardens is mostly consumed within the households, regardless of the category (figure 2.6). A significant percentage of households share the produce with relatives, neighbors and friends. Most households do agree that home garden can avail them with more chemical free green leafy vegetables, roots, tubers and fruits in their diet (figure 2.7). However, compared to the agricultural majority and minority category, lesser percentage of households in the landless category believed that home gardens contributed to greater dietary diversity. In the agricultural majority category, around 20% of households sell the excess quantity of produce after the consumption and they believe that it contributes to supplementary income (figure 2.6 & 2.7).



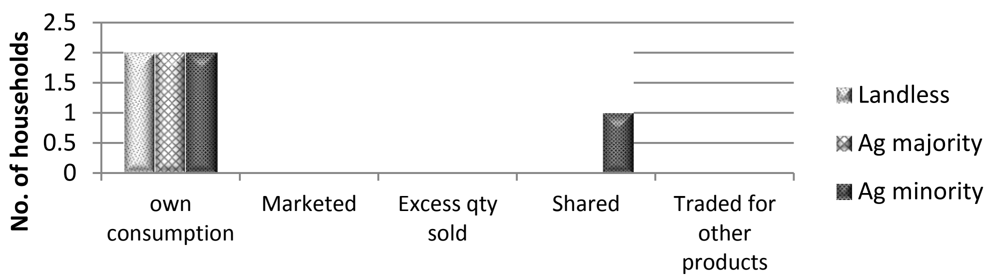
Source: Author's analysis



Source: Author's analysis

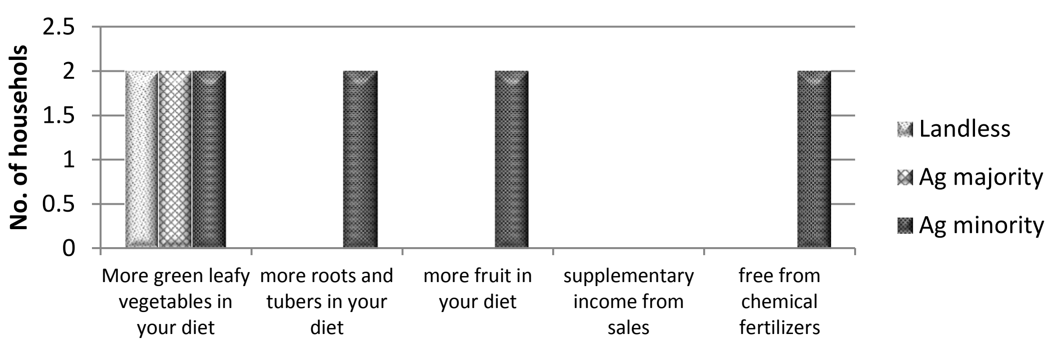
Similar to the whole sample, home garden produces in the sample households are mainly used for the home consumption irrespective of the category (figure 2.8). One out of two households from all the three categories shares their produce with relatives/friends/neighbors. Marketing of the produce is rare and just one household from the agricultural majority category sold, receiving a surplus income from sales. The sample households in the agricultural majority and minority categories believed that they received dietary diversity with more green leafy vegetables, fruits and tubers compared to that of landless who are unable to cultivate diversified products with the limited land available to them (figure 2.9). Table 2.3 shows the types and varieties of products grown in the home gardens by the sample households. It points out that the agricultural households benefit more from home gardens in terms of dietary diversity. A study which tested dietary diversity using an indicator of dietary quality found that having a home garden is significant at 10% level (p-value of 0.096) in creating healthy food diversity for Wayanad (Minhas, 2014).

Figure 2.8 Usage of home garden produces
6 sample households (two from each category)



Source: Author's analysis

Figure 2.9 Benefits derived from home gardens
6 sample households (2 from each category)



Source: Author's analysis

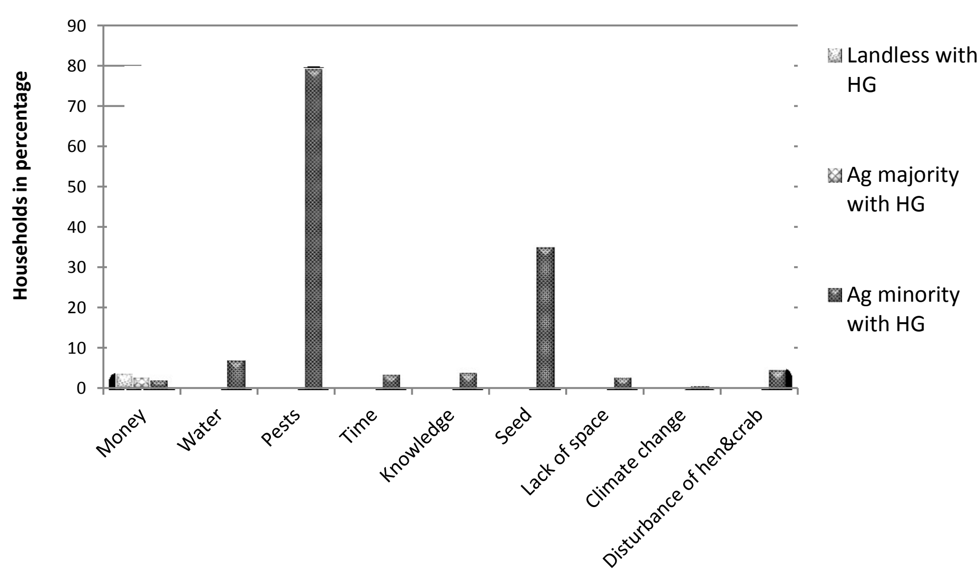
Table 2.3: Average number of products grown in the home gardens of selected households

	Vegetables	Tubers	Green leafy vegetables	Fruits	Spices	Medicinal plants
Landless	*4*	*0.5*	*1.5*	*1.5*	*1.5*	*0.5*
AG majority	*6*	*0.5*	*2.5*	*5.5*	*3*	*1.5*
AG minority	*7*	*3*	*2*	*3.5*	*3.5*	*2*

Source: Author's analysis

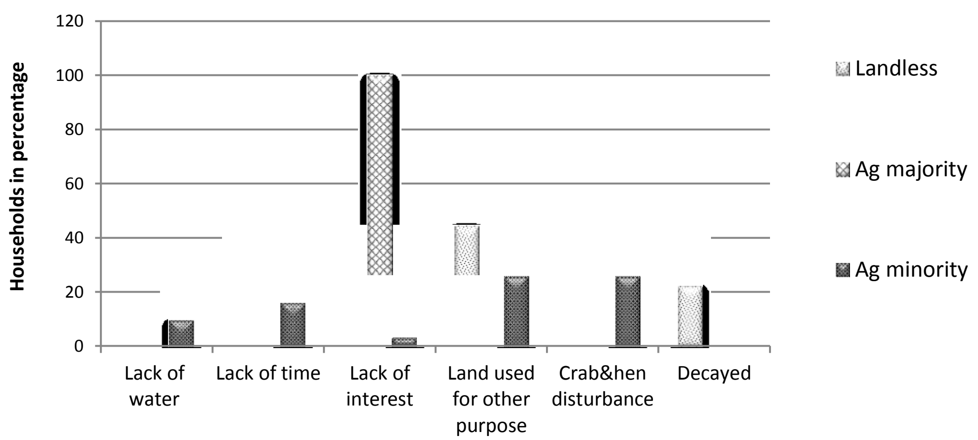
Although home gardens contribute to the households' dietary diversity and income security, they face constraints in the maintenance of home gardens mainly due to pest attack, diseases to the crops and non-availability of quality seeds, as found in our survey (figure 2.10). Landless households consider lack of space as one of the major constraints in maintaining a home garden. Lack of interest was the main factor for those agricultural majority households who quit home garden cultivation. Usage of land for other purposes and disturbance by crabs and hens caused the landless and the agricultural minority households to stop home gardens (figure 2.11).

Figure 2.10 Constraints associated with the maintenance of home gardens (whole sample)



Source: Author's analysis

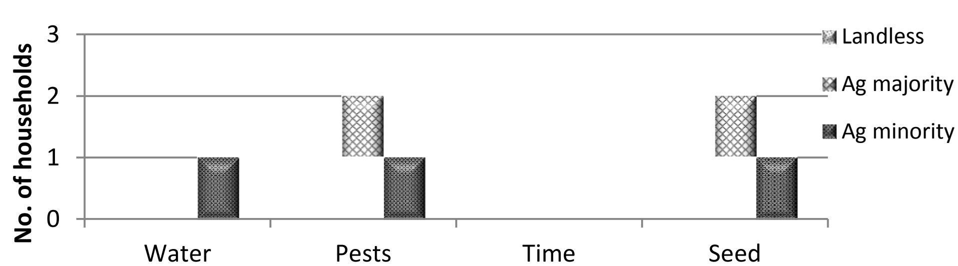
Figure 2.11 Reasons for stopping home garden (whole sample)



Source: Author's analysis

In accordance with the whole sample, figure 2.12 for the selected households shows that damage from pests and lack of seeds stand as the major constraints in all three categories. In addition, they also have to deal with problems associated with shortage of water and time. In the six no-home garden households, one household in both the agricultural majority and minority categories had home gardens before but stopped due to lack of interest and usage of land for other purposes respectively.

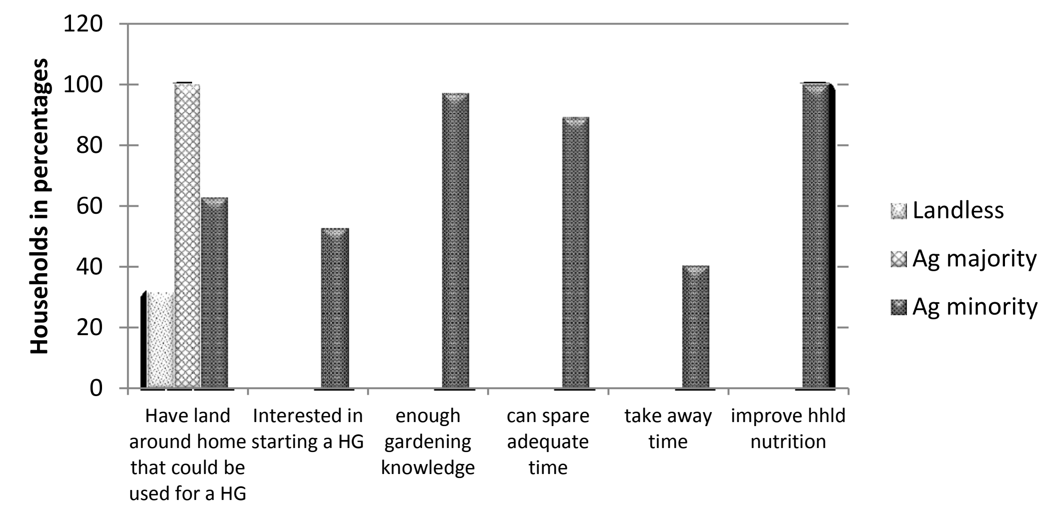
Figure 2.12 Constraints associated with the maintenance of home gardens
6 sample households (2 from each category)



Source: Author's analysis

A majority of the no home garden households in all three categories who have land around home were interested in starting one because they believe that will improve their household nutrition level. Moreover, they were worried about the trade-off of taking away a considerable amount of time from other activities (figure 2.13).

Figure 2.13 Willingness to implement home gardens (whole sample)



Source: Author's analysis

The economic impacts of home gardens for different types of households in Wayanad will be tested in this study by designing production optimization models with fixed consumption for each household using a linear programming approach. The whole sample of 501 households studied under the APM project were divided into six household categories and two households who are representative to the respective categories were chosen to build the models. Six household categories are: landless households where land for agricultural production is zero, with and without home garden, landholding households where agricultural production is relatively large in terms of their share in the total household income (between 35 – 100%), with and without home garden, and landholding households where agricultural production is relatively small in terms of their in the total household income (below 35%), with and without home gardens. The information on outputs, inputs, costs and resources for the produces cultivated in the farm and home gardens, household consumption pattern, income sources and expenditures of the household, historical prices of crops, fertilizers and labors and production will be used to develop the coefficients and the overall model.

CHAPTER 3

CONCEPTUAL FRAMEWORK

Farm households are regularly involved in decision-making about what crops to cultivate, by what methods, in which seasons, and in what quantities. Their decisions also include what quantity of food crops to sell in the market or use for their own consumption, and whether to depend either on market or on own resources for agricultural inputs like seeds, fertilizer, labor, etc. These decisions are made under the farm households' physical and financial constraints and traditionally, based on their experience, intuition, and comparison with their neighbors (Hazell and Norton, 1986). A farm optimization model can assist farmers in analyzing a set of these kinds of possible decisions under farm-specific restraints, in order to arrive at an optimum feasible solution which will provide the agricultural household with maximum return. Often these optimization models can predict quite accurately what the farmers do and this predictive possibility makes them useful for inclusion in broader agricultural sector models (Hazell and Norton, 1986). According to Beneke and Winterboer (1973), linear programming is a planning method that is helpful in decisions requiring a choice among a large number of alternatives and provides a foolproof plan with maximum possible returns (pp. 3 & 4). The number of possible alternative plans in a farm business extends to millions because of the diverse resources used and the wide range of production alternatives that are feasible on a typical farm.

3.1 General Structure of a Linear Programming Farm Optimization Model

In a farm model, the farmer tries to organize the farm activities in order to maximize net returns over variable costs, given the constraints on available resources. A typical optimization model consists of three sections: Objective function, constraints and decision variables. The equation to be maximized is called the objective function. In the following discussion of a general linear programming model set up for a farm situation, as discussed by Hazell and Norton (1986), the objective function is total gross margin (i.e., returns net of variable costs). The constraints, also called as restraints or restrictions, are placed on the resources like land and labor which will define the conditions within which the farmer seeks to maximize profits/gross margins. This farm model includes a fixed resource constraint, which implies that the total quantity of inputs used among crops must be less than or equal to the amount of resources available. Another condition specified in the model is that no activity can be carried out at a negative level i.e., produce a negative quantity of any of the crops included in the model. The quantities of inputs like land and labor are adjusted to maximize the total gross margin from the farm. These variables are the decision variables in optimization. In the case of a subsistence farm where many of the crops are included in the food needs of the household the objective function must also account for the costs of purchasing foods supplied by the farm (opportunity cost includes selling the farm produce at the market prices available).

To formulate the linear programming model mathematically, let's consider the following notations:

X_j = the level of j^{th} farm activity, e.g., the acreage of corn grown.

j = 1 to n and n is the number of possible activities.

c_j = the forecasted gross margin of a unit of the j^{th} activity (e.g., dollars per acre).

a_{ij} = the quantity of i^{th} resource (acres of land or days of labor) required to produce one unit of the j^{th} activity. Let m denote the number of resources; then i = 1 to m.

b_i = the amount of the i^{th} resource available (e.g., acres of land or days of labor).

Given the notations, the linear programming model can be written as:

$$\max Z = \sum_{j=1}^{n} c_j \, X_j$$

such that

$$\sum_{j=1}^{n} a_{ij} X_j \ \leq \ b_i$$

all $i = 1$ to m

and

$X_j \geq 0$, all $j = 1$ to n

In words, the problem is to find the optimal farm plan (defined by a set of activity levels, X_j) that has the largest possible total gross margin Z, which does not violate any of the fixed resource constraints (Eq. 2), or involve any negative activity levels (Eq. 3). This is the primal linear programming problem in a farm optimization model. The problem can be portrayed in a matrix form showing all the coefficients of the algebraic statement of the model (Table 3.1). This way of presenting a linear programming model is known as a tableau.

Table 3.1 Representation of a Linear Programming Tableau

	Columns				
Row name	X_1	X_2	**...**	X_n	**RHS**
Objective function	c_1	c_2	...	c_n	Maximize
Resource constraints:					
1	a_{11}	a_{12}	...	a_{1n}	$\leq b_1$
2	a_{21}	a_{22}	...	a_{2n}	$\leq b_2$
.	.	.	. . .	.	.
.	.	.	. . .	.	.
.	.	.	. . .	.	.
m	a_{m1}	a_{m2}	...	a_{mn}	$\leq b_m$

Source: Hazell and Norton (1986)

3.2 <u>Structure of Farm Optimization Models for Household Categories</u>

The following section of this chapter is devoted to the discussion of the formulation of farm optimization linear programming models for each of the six household categories in our study. There are a couple of specific things related to the models used in this study. First of all, each household model is based on the actual characteristics of the household being considered. There is considerable diversity in the decisions made by different households on what to grow for agricultural production and in home gardens (table 3.3 & 3.4). For the models specified the household is assumed to be maximizing their objective function with respect to the crops and products they actually grew rather than an optimal set of agricultural and home garden products based on economic circumstances. For this reason each household's results are only comparable to the particular household not across households for values of the objective function. Second the results for the agricultural majority and agricultural minority households do not include the use of household labor in activities outside the property, while those for landless households do. This was an attempt to illustrate more clearly the role of the home garden but clearly the models results underestimate the household income for those two agricultural based household types.

3.2.1 <u>Objective function</u>

The objective in the farm household models in our study is to maximize the net income of the household over costs of production and household expenditures (food). The revenue/income mainly comes from agricultural production, home gardens, livestock production, agricultural and non-agricultural wages, off-farm activities, salaried employment, migration and pensions. Costs of farm and home garden production which include costs of labor, chemical fertilizers, pesticides, organic manures, seeds, plants, nets, irrigation and land preparation and ploughing, are considered in the objective function. Expenditures for food constitute a large percentage of each household's total expenditure. Since these households are subsistence farms, food crops cultivated in the farms and home gardens are partly consumed and partly sold. Only the surplus products, after meeting the household's annual consumption requirements, are marketed. By selling, the households are able to reduce the out of pocket expenditures for food. These savings can also be considered as the value the households derive from their own consumption of home produced food. Therefore, the out of pocket food expenditure occurs only when the households' do not produce sufficient quantity to cover their consumption needs. Along with the out of pocket food expenditures, the households' spending on other activities like health, education, shelter, travel, etc., as reported by households are deducted from the revenue earned (and held fixed for the purposes of our study) .

In general, the objective function can be written as follows:

Net Income = Revenue – Costs of production – Household out of pocket expenditures

The general structure of the objective function is described for different household categories in table 3.2. The objective function for each sample household is adjusted depending on the households' specific production context i.e., number and types of crops produced both in the farm and home garden (Table 3.3) and the different income-earning sources of each household. The revenues from sources other than agricultural and home garden production, costs of home garden and all household expenditures except for food are considered exogenous in the model.

Table 3.2 General structure of objective functions for different household models

Agricultural majority and minority with home garden	*Net Income =Revenue (AG + HG + other sources) – costs(AG + HG) – expenditures(out of pocket food expenditure + other household expenditures)*
Agricultural majority and minority without home garden	*Net Income =Revenue (AG + other sources) – costs(AG) – expenditures(out of pocket food expenditure +other household expenditures)*
Landless with home garden	*Net Income =Revenue (HG + other sources) – costs(HG) – expenditures(out of pocket food expenditure +other household expenditures)*

Although the major agricultural crops cultivated by the farm households are similar, there is much more variability in the crops grown in home gardens across the sample households (Table 3.3 and 3.4). While paddy, ginger, elephant foot yam and plantain constitute the major food crops produced, cash crop production consists mainly of coffee and arecanut, which are often cultivated as mixed crops, and rubber. Since home gardens are commonly maintained to serve as a food source for the household, the types of vegetables, greens, tubers, fruits, herbs, spices and medicinal plants grown depend upon the household's dietary habits and tastes. Landless households have lower diversity and they seem to produce less lucrative crops in their home gardens compared to other farm households. The households could consume or sell the surplus quantity of these products.

Table 3.3 Agricultural production structure of sample households

	AG majority with HG		AG majority without HG		AG minority with HG		AG majority without HG	
	HH 281	HH 546	HH 300	HH 137	HH 192	HH 816	HH 722	HH 264
Paddy	✓	✓	✓		✓		✓	
Ginger	✓	✓				✓		
Elephant foot yam	✓	✓	✓		✓	✓	✓	✓
Plantain				✓				✓
Coffee	✓	✓	✓	✓	✓			
Arecanut	✓	✓	✓	✓	✓			
Rubber		✓						

Table 3.4 Home garden production structure of sample households

		AG majority with HG		***AG minority with HG***		***Landless with HG***	
		HH 281	***HH 546***	***HH 192***	***HH 816***	***HH 293***	***HH 256***
	Tomato	✓					
	Brinjal	✓			✓		
	Ladies finger	✓					✓
	Bitter gourd	✓	✓				✓
	Ash gourd	✓					
	Pumpkin	✓			✓	✓	
	Chowchow	✓					
	Drumstick	✓					
	Cowpea		✓		✓	✓	✓
	Cabbage				✓		
	Beans				✓	✓	
	Snake gourd				✓		
	Cucumber				✓		
Vegetables	***Banana stem***				✓		
	Red amaranthus	✓	✓	✓	✓	✓	✓
	Pumpkin leaves	✓					
	Curry leaves	✓			✓		
Greens	***Colocassia leaves***				✓		
	Radish	✓					
	Elephant foot yam	✓		✓	✓		
	Beetroot	✓					
	Diascorrea			✓	✓		
Tubers	***Colocassia***			✓	✓	✓	
	Banana	✓					✓
	Guava	✓	✓				✓
	Mango	✓	✓	✓	✓		
	Pineapple	✓					
	Custard apple	✓					
	Lemon	✓					
	Jackfruit		✓	✓	✓	✓	
	Suppotta		✓				
	Papaya			✓	✓	✓	
	Plantain				✓		
	Rose apple		✓		✓		
Fruits	***Coconut***	✓		✓			
	Chilli	✓		✓	✓	✓	
	Turmeric	✓		✓	✓	✓	✓
	Ginger	✓		✓	✓		
	Pepper	✓		✓			
	Myristica	✓					
Spices/Herbs	***Garcina***	✓					✓
	Tulsi	✓	✓	✓	✓		
	Aloevera	✓					
	Curcuma			✓			
Medicinal plants	***Acorus Calamus***				✓		

3.2.2 Constraints

Since the production constraints vary widely among farmers and regions, the model must be able to consider the specific production constraints of a farmer while correctly weighting his objectives (Jones et.al., 1997).

Land constraints: Fixed resource constraints are placed in order to restrain the model from using more than the resource available. The household allocates their total amount of land among a set of alternative crops. Consider the household has a fixed amount of land, A, and a_i is the amount of land allocated to crop i, where $i=1,2,...,n$, then the fixed land constraint can be written as follows:

$$a_1+a_2+....+a_n= A$$

The above condition implying the equality between the total amount of land available and the land used among the crops is applied for both the farm and the home garden acreages. Since the land used for each home garden product is very small and difficult to measure, the total land allocated to home gardens by households are divided by the number of products cultivated in the home garden in order to calculate the acreage allocation for each product. The acreages allocated under agricultural and home garden production are fixed at the original level. The model could adjust agriculture land among different agricultural crops and similarly home garden land among different home garden crops, but cannot substitute land between agriculture and home garden production.

If the crop is cultivated as a mixed crop, e.g., coffee and arecanut, a restriction indicating equal acreage allocation to each of these crops is placed in the model.

$a_c= a_a$ where, a_c is coffee acreage and a_a is areca nut acreage

Labor constraints: The household hires labor and places some of their family labor for the cultivation of agricultural crops. Households can use either hired labor or family labor or both of them depending upon the wage rates in the market. If the wage rates are lower, households tend to hire more labors. Though the households can hire as much - labor as they want for the cultivation of crops, there is a limit to the amount of family labor they can provide, since the family members are involved in various activities for their livelihood along with agricultural production. They can switch the own labor days between home garden and agricultural production and even between the crops. Therefore, a restraint imposing the condition that the family labor days allocated among agricultural and home garden production should not be more than the labor days the household can provide, is also placed in the model.

Since the landless with home garden households do not have to use their family labor for agricultural production, their total available family labor days are allocated among home garden production and agricultural wage employment. Higher farm wages might force the household to switch their own labor days from home garden production to farm wage employment.

A minimum level restraint is also placed on the number of family labor days used for home garden production.

3.2.3 Decision Variables

The major inputs for farm production such as land used under agricultural and home garden production, own labor, hired labor, total labor and fertilizer quantities per acre are adjusted in the model in order to optimize the net income of the household.

Putting it altogether, here the linear programming problem becomes how to organize the farm household business so that the net income from agriculture, home garden and other income-earning activities (based upon the household's production structure), over variable costs and expenditure would be maximized, by changing the land, labor and fertilizer inputs for production, given the land and labor constraints.

3.3 Parameters for the Farm Household Optimization Model

3.3.1 Agricultural Production

Although in reality households adjust their production structure based on the output and input prices and other market conditions, the model assumes households to produce same crops under all circumstances. Revenue is calculated for agricultural food crop as the product of marketed quantity and farm price. Since households consume a part of their own production of food crops which include crops like paddy, elephant foot yam, ginger and plantain, marketed quantity is determined as the difference between the produced quantity and own consumption.

If X_i is the units of a food crop i produced, X_{mi} is the quantity sold in the market, X_{ci} is the amount consumed by the household and P_{fi} is the farm price of the marketed commodity, total revenue from food crop production could be represented as following:

$$R_f = P_{f1} * (X_1 - X_{c1}) + P_{f2} * (X_2 - X_{c2}) + \dots\dots\dots + P_{fn} * (X_n - X_{cn})$$

$$R_f = P_{f1} * X_{m1} + P_{f2} * X_{m2} + \dots\dots\dots + P_{fn} * X_{mn}$$

Since cash crops such as coffee, arecanut and rubber are completely sold in the market, the revenue is calculated as the product of units produced and farm price where units produced is the yield received times the acreage allocated to the crop.

$$R_c = P_{f1} * X_1 + P_{f2} * X_2 + \ldots\ldots\ldots + P_{fn} * X_n$$

$$R_c = P_{f1} * Y_1 * a_1 + P_{f2} * Y_2 * a_2 + \ldots\ldots\ldots + P_{fn} * Y_n * a_n$$

where Y_i and a_i are the yield and acreage of crop *i,* and R_c is the total revenue from cash crops.

To derive the technical coefficients for the model, survey data from all of the sample households in Wayanad collected under the APM project were used. Regressions were carried out to find the technical relationships determining the yield of major agricultural crops grown in eight sample farm households. Out of a total of 501 households from whom the agricultural output-input data was collected, 202, 195, 190, 29, 102, 10 and 43 households were involved (after eliminating the households with missing yield and acreage data) in the production of paddy, coffee, arecanut, ginger, elephant foot yam, rubber and plantain, respectively. Yield, calculated as production per acre, was regressed on the area of cultivation, per acre usage of labor (sum of hired and family labor days), fertilizer and organic manure, and dummy variables for rain-fed cultivation, use of improved seed varieties and being an APM project household. The project interventions for some of these major agricultural crops include varietal selection, green manure trials and seed multiplication in paddy, introduction of paddy threshers and Integrated Pest Management systems in banana/plantain. Descriptive statistics for the dependent and independent variables for the regressions are presented in table 3.5.

The usage of fertilizers and labor are found to be the most important factors leading to the differences in yield of agricultural crops across households (Table 3.6). The application of fertilizers in arecanut, coffee and yam production are significant at 1%, 5% and 10% levels. The literature also shows that the intensive high-yield agriculture is dependent on addition of fertilizers. A doubling of global cereal production over the past 40 years was a result of the greater use of fertilizers and pesticides (Tilman et.al, 2002). A study conducted in China found a significant positive linear correlation between the annual food production and annual chemical fertilizer consumption throughout 1949-98 (Zhu et.al, 2002). The number of labor days spent on the cultivation of coffee, arecanut, rubber and yam had significant impacts on their yield. The technical relationships established for different crops by various studies also emphasize the significant relationship between their labor input and output (Battese and Coelli, 1992; Ninan, 1984; Smith and Gascon, 1979; Nandi et.al., 2011; Srinivas and Ramanathan, 2005; Fasasi, 2006; Bifarin et.al., 2010; Jamal and Pomp et.al, 1993). Regression analysis also indicated that the APM project interventions such as participatory seed production, yield enhancement trials in fertilizer (green manure trial), intercropping trials (row planting) and introduction of threshers for paddy cultivation were significant at 10% level.

Table 3.5 Descriptive statistics: agricultural regression variables

		Yield	Acreage	Organic manure per acre	Chemical fertilizer per acre	Hired labor	Family labor	Labor days per acre	Rainfed (%)	Improved seed variety (%)	Project household (%)
	Mean	*1825.88*	*0.83*	*64.92*	*78.31*	*23.34*	*9.32*	*56.10*			
	Std.Dev.	*2420.69*	*1.05*	*257.67*	*58.80*	*15.89*	*5.06*	*36.62*			
	Min	*10*	*0.05*	*0*	*0*	*0*	*0*	*0*			
Paddy	**Max**	*20000.00*	*8*	*1666.67*	*560*	*128*	*30*	*440*	*81.68*	*51.49*	*85.15*
	Mean	*2111.88*	*0.84*	*27.31*	*49.37*	*9.58*	*3.37*	*24.11*			
	Std.Dev.	*5644.75*	*1.12*	*128.72*	*142.21*	*20.24*	*3.83*	*34.30*			
	Min	*1.78*	*0.01*	*0*	*0*	*0*	*0*	*0*			
Arecanut	**Max**	*40000*	*8.25*	*1200*	*1500*	*170*	*26*	*400*	*82.63*	*45.26*	*88.95*
	Mean	*284.50*	*0.93*	*27.35*	*43.77*	*8.31*	*5.76*	*19.31*			
	Std.Dev.	*302.11*	*1.37*	*140.92*	*76.03*	*23.34*	*4.69*	*14.11*			
	Min	*0.43*	*0.04*	*0*	*0*	*0*	*0*	*0*			
Coffee	**Max**	*2960*	*12*	*1600*	*500*	*222*	*25*	*65*	*80.51*	*45.64*	*85.64*
	Mean	*3524.07*	*0.40*	*716.99*	*296.33*	*12.93*	*8.41*	*135.11*			
	Std.Dev.	*3904.10*	*0.55*	*3708.79*	*414.06*	*11.28*	*6.32*	*209.99*			
	Min	*108*	*0.01*	*0*	*6*	*0*	*0*	*5*			
Ginger	**Max**	*20000*	*2.50*	*20000*	*2000*	*38*	*30*	*1150*	*79.31*	*41.38*	*89.66*
	Mean	*2922.40*	*0.69*	*6.26*	*390.30*	*14.86*	*9.05*	*60.95*			
	Std.Dev.	*3728.41*	*0.75*	*11.69*	*378.59*	*21.05*	*6.85*	*62.88*			
	Min	*25*	*0.03*	*0*	*0*	*0*	*0*	*0*			
Plantain	**Max**	*20000*	*4*	*50*	*1600*	*100*	*25*	*380*	*81.40*	*58.14*	*86.05*
	Mean	*440.38*	*0.80*	*10.35*	*45.33*	*35.20*	*62*	*131.65*			
	Std.Dev.	*223.95*	*0.38*	*8.38*	*52.31*	*47.27*	*51.03*	*117.87*			
	Min	*200*	*0.25*	*0*	*0*	*0*	*4*	*8*			
Rubber	**Max**	*833.33*	*1.50*	*26.66*	*133.33*	*100*	*150*	*350*	*80*	*20*	*90*
	Mean	*4085.40*	*0.49*	*155.53*	*304.78*	*9.41*	*7.75*	*55.30*			
	Std.Dev.	*2514.80*	*0.59*	*559.24*	*362.95*	*7.99*	*6.65*	*38.51*			
Elephant	**Min**	*18*	*0.05*	*0*	*0*	*0*	*0*	*0*			
foot yam	**Max**	*12000*	*5.60*	*4000*	*2625*	*34*	*30*	*193*	*82.35*	*47.06*	*98.04*

Source: Author's analysis

Table 3.6 Yield responsiveness of major agricultural crops

	Paddy	Coffee	Arecanut	Ginger	Plantain	Rubber	Yam
Acreage	-250.88 (0.151)	13.00 (0.345)	-341.39 (0.365)	**-2729.75*** **(0.087)**	-826.73 (0.339)	-111.20 (0.695)	-501.22 (0.255)
Organic manure per acre	-0.38 (0.572)	0.01 (0.934)	-1.95 (0.54)	-0.80 (0.324)	**126.34**** **(0.019)**	**-23.53*** **(0.087)**	0.13 (0.78)
Fertilizer per acre	2.18 (0.492)	**0.52**** **(0.038)**	**11.18***** **(0.002)**	-3.27 (0.372)	1.57 (0.363)	0.41 (0.703)	**1.22*** **(0.081)**
Labor per acre	2.94 (0.582)	**11.70***** **(0.000)**	**-41.09***** **(0.008)**	13.36 (0.441)	-6.90 (0.55)	**2.80*** **(0.059)**	**18.46**** **(0.01)**
Rain-fed	632.78 (0.157)	10.30 (0.827)	-172.08 (0.875)	**-5299.67**** **(0.022)**	-2401.40 (0.147)	-101.07 (0.697)	-57.12 (0.931)
Improved seed varieties	95.37 (0.787)	**84.91**** **(0.022)**	-798.39 (0.339)	-1068.47 (0.554)	835.71 (0.531)	-513.90 (0.148)	-359.11 (0.448)
Project household	**844.35*** **(0.093)**	22.17 (0.678)	1323.72 (0.321)	1369.59 (0.595)	1285.44 (0.491)	-457.47 (0.174)	2174.54 (0.203)
Constant	437.52 (0.553)	-42.37 (0.568)	2217.55 (0.225)	**7765.54**** **(0.04)**	2872.07 (0.305)	**980.14*** **(0.097)**	1001.54 (0.605)
No. of observations	202	195	190	29	43	10	102

Notes: *** Significant at one percent level
** Significant at five percent level
* Significant at ten percent level

Source: Author's analysis

Given the regression analysis for different crops, a technical relationship was established between the yield, labor days and fertilizer quantity for each crop using a Cobb-Douglas production function. Including the input-output relationships in farm models can enhance the ability of a model to adjust realistically to changes in relative prices by jointly determining the level of production activity and the inputs used (Hazell and Norton, 1986).

$$Y = \alpha\, L^{\beta_1} F^{\beta_2}$$

where L is the labor days per acre, F is the fertilizer quantity per acre, α is the total factor productivity and β_1 and β_2 are the output elasticities of labor and fertilizer, respectively. Output elasticities were calculated using the coefficients derived from the regression analysis. Table 3.7 reports the elasticities for the crops cultivated by the sample households.

$$\beta_1 = b_1 \frac{\bar{L}}{\bar{Y}} \quad \text{and} \quad \beta_2 = b_2 \frac{\bar{F}}{\bar{Y}}$$

where b_1 and b_2 are the coefficients of labor and fertilizer, respectively. The elasticities were used to calibrate the Cobb Douglas relationships.

Table 3.7 Output Elasticities for labor and fertilizer

	Paddy	Coffee	Arecanut	Ginger	Elephant foot yam	Rubber	Plantain
Labor Elasticity	0.91[2]	0.79	0.40[3]	0.51	0.25	0.84	0.28[4]
Fertilizer elasticity	0.09	0.08	0.26	0.37[5]	0.09	0.04	0.21

The production costs for agricultural crops include costs for hired labor, fertilizers, pesticides, seeds, organic manure, irrigation, land preparation and fixed costs. Labor costs are determined as the product of labor days and price of labor. Only the cost of hired labor is taken into account in the objective function. Per acre fertilizer quantity applied for each crop is multiplied by the fertilizer price and the acreage allocated under that crop to determine the costs incurred for fertilizer usage.

This could be represented as

$C_f = f_q * f_p * a$ where f_q is the fertilizer quantity per acre and f_p is the price of one unit fertilizer.

---

[2] Battese and Coelli (1992) : [*ln (output)* = $\alpha + \beta_1$ *ln (land*$_{it}$*)* + β_2 *ln (irrigated land*$_{it}$*)* + β_3 *ln (family and hired labor hours*$_{it}$*)* + β_4 *ln (bullock labor hours*$_{it}$*)* + β_5 *ln (total value of input costs*$_{it}$*)* + $V_{it} - U_{it}$]

[3] Jamal and Pomp (1993)) : [*ln (output)* = $\alpha + \beta_1$ *ln (land)* + β_2 *ln (labor)* + $V_1 - U_1$]

[4] Bifarin et.al. (2010): [*ln (output)* = $\alpha + \beta_1$ *ln (family and hired labor days)* + β_2 *ln (other variable costs)* + β_3 *ln (access to credit)* + β_4 *ln (farm size)* + $v_i - u_i$]

[5] Nandi et.al. (2011): [*ln (output)* = $\alpha + \beta_1$ *ln (farm size)* + β_2 *ln (fertilizer qty)* + β_3 *ln (labor mandays)* + β_4 *ln (planting materials)* + $V_1 - U_1$]

3.3.2 Home garden production

Although the produce from home gardens is mainly used for home consumption, some households sell the excess quantity in the market which could earn them a considerable amount of income. Multiplying the marketed quantity with the farm price will provide the direct revenue generated from home garden.

$$R_{HG} = P_{f1} * X_{m1} + P_{f2} * X_{m2} + \ldots\ldots\ldots + P_{fn} * X_{mn}$$

In order to understand the technical relationships determining the home garden production, a regression analysis was carried out with variables like area under home garden cultivation, total land available, household size, number of kids in the family and dummy variables for the usage of fertilizer, animal/poultry waste, ash and well water. Number of kids in the family is included as an independent variable since mostly women and kids are involved in the maintenance of home gardens. The production might be higher for households with more family members. Descriptive statistics and regression results for some of the common crops grown in the sample households are stated in table 3.8 and 3.9. Results suggest that land allocated to home gardens and different types of organic fertilizers i.e., animal/poultry waste and ash as the major factors determining production level. Since animal manures are rich in plant nutrients such as Nitrogen, Phosphorous and Potassium, they provide organic matter that conditions the soil. The number of kids in the family also affects the production level of a few products.

Since the cultivation and management of home garden produce are usually carried out by household members, yield from home garden is dependent upon the labor hours spent on the maintenance. The household's labor allocation to home garden production and maintenance is derived from the time-use survey by converting the time use data into an annual basis. The yield-labor relationship for the home garden is established as follows:

$$Y_i = (Y_i / FL_{hg}) * FL_{hg}$$

where Y_i is the yield of a home garden produce i and FL_{hg} is the total family labor days used for home garden management.

Table 3.8 Descriptive statistics: home garden regression variables

Variable	Mean	Std.Dev.	Min	Max
Cowpea	*8.62*	*9.47*	*0.5*	*90*
Red Amaranthus	*7.57*	*10.45*	*0.15*	*150*
Mango	*30.98*	*20.28*	*0.5*	*100*
Jackfruit	*55.80*	*57.00*	*3*	*300*
Ladies finger	*4.98*	*5.56*	*0.5*	*33*
Pumpkin	*16.65*	*15.38*	*1*	*150*
Drumstick leaves	*7.82*	*7.57*	*0.5*	*50*
Chilli	*3.83*	*3.33*	*0.2*	*20*
Turmeric	*8.11*	*16.01*	*0.5*	*205*
Colocassia	*11.21*	*7.82*	*1*	*35*
Home garden area	*1.01*	*1.24*	*0.1*	*7*
Total land	*0.84*	*1.37*	*0.015*	*12.2*
household size	*4.64*	*1.90*	*1*	*13*
kids	*1.24*	*1.06*	*0*	*5*
Fertilizer (%)	*11.33*			
Animal/poultry waste (%)	*85.47*			
Ash (%)	*44.83*			
Well water (%)	*83.74*			

Source: Author's analysis

Table 3.9 Factors influencing home garden production

	Cowpea	Ladies finger	Pumpkin	Red Amaranthus	Mango	Jackfruit	Drumstick leaves	Colocasia	Chilli	Turmeric
HG area	**0.924**	**0.261**	**0.445**	**1.120**	**2.232**	**4.734**	**0.282**	**0.527**	**0.276**	**0.440**
	(0.000)* **	**(0.000)*** **	**(0.072)* **	**(0.000)*** **	**(0.000)*** **	**(0.000)*** **	**(0.003)*** **	**(0.000)*** **	**(0.000)*** **	**(0.055)* **
Total land	0.030	0.003	-0.016	0.022	0.199	0.226	0.001	-0.011	0.003	0.024
	(0.645)	(0.9)	(0.865)	(0.756)	(0.19)	(0.505)	(0.976)	(0.813)	(0.879)	(0.786)
Fertilizer	-0.174	0.760	-0.457	**2.641**	2.315	3.632	-0.709	0.341	**0.816**	0.914
	0.885	0.117	0.789	**(0.04)** **	0.402	0.556	0.274	0.675	**(0.043)** **	0.564
Animal/poultry waste	**3.711**	**0.694**	**3.538**	0.469	**13.425**	**28.900**	**1.295**	**1.877**	**0.871**	**3.007**
	(0.000)* **	**(0.041)** **	**(0.003)*** **	0.603	**(0.000)*** **	**(0.000)*** **	**(0.004)*** **	**(0.001)*** **	**(0.002)*** **	**(0.007)*** **
Ash	-0.557	**0.643**	**2.325**	**-2.381**	**-7.070**	**-15.471**	**-0.815**	**1.810**	**0.455**	0.782
	0.446	**(0.029)** **	**(0.025)** **	**(0.002)*** **	**(0.000)*** **	**(0.000)*** **	**(0.038)** **	**(0.000)*** **	**(0.063)* **	0.414
Well	**1.813**	0.280	**1.953**	**3.096**	**3.593**	-4.231	0.218	-0.385	0.220	0.211
	(0.029) **	0.4	**(0.096)* **	**(0.000)*** **	**(0.058)* **	0.317	0.624	0.49	0.426	0.846
Household size	-0.059	-0.074	0.145	0.143	**1.088**	0.981	0.091	**-0.263**	0.106	0.182
	0.778	0.375	0.624	0.52	**(0.023)** **	0.358	0.419	**(0.062)* **	0.129	0.506
Kids	-0.230	0.094	-0.269	0.589	**-1.835**	-1.313	0.184	0.322	**-0.246**	-0.616
	0.54	0.534	0.613	0.142	**(0.033)* **	0.494	0.362	0.204	**(0.05)* **	0.212
Constant	1.196	-0.058	0.304	-1.020	-0.493	0.120	-0.367	0.925	-0.149	-0.656
	0.217	0.882	0.824	0.323	0.824	0.981	0.481	0.156	0.645	0.605

Notes: *** Significant at one percent level ** Significant at five percent level * Significant at ten percent level

Source: Author's analysis

Production and maintenance costs of home garden for the sample households usually include costs associated with plants, seeds and nets. Cost of maintenance would be different depending upon the size of the home garden and whether the home garden is a structured or unstructured one. Three out of six home garden sample households maintain unstructured home gardens (two in the landless and one in the agricultural minority category).

3.3.3 Consumption

An agricultural household consumes partly from own production and partly from market purchase. If food is consumed from home production then revenue is not earned and food expenditures are not incurred. However, this reduces the amount of out of pocket expenditure that the households would have to pay in the market to purchase these food products. Since the households sell these produces only after meeting their own consumption needs, food is purchased outside from the market only if the production falls below households' annual total consumption of each of the produce. Food frequency/dietary intake survey data from the APM project was used to come up with the households' annual consumption requirements. This calculated annual consumption levels do not represent an optimal diet or even necessarily a nutritional diet under any standards. This is just the diet for the households converted to annual numbers using the information provided by household members. The model assumes the annual total consumption of each food crop cultivated (calculated as raw amounts consumed per household multiplied by frequency of consumption) to be constant over the optimization and do not change with the changing market prices or production levels. If purchased food quantity is X_p and market retail price is P_r, consumption expenditure could be represented as

$$C = X_p * P_r$$

3.4 Applying Market Shocks to the Farm Optimization Model

Agricultural households always operate in an uncertain environment. Uncertainties mainly occur from the fluctuations in the prices of outputs and inputs such as labor and fertilizer, rainfall, etc. Different shocks are applied to the model to analyze the economic contribution of home gardens under a variety of different market fluctuations. Sensitivity analyses are important when evaluating economic benefits, in order to ascertain the extent to which agricultural systems are susceptible to market forces (Mohan et.al. 2006). These analyses, in a single period context, are conducted by adding 50% increments and decrements to the prices of labor, fertilizer and agricultural and home garden produces. Applying these changing market fluctuation scenarios to each household model would help to understand households' and their home gardens' responses to these situations.

3.5 Developing the Farm Household Optimization Models across Time from 1990 to 2012

The potential economic contribution of home gardens across time was estimated by developing the optimization models for each of the sample household models across time using historical data on farm and retail prices and production/yield levels for agricultural crops such as paddy, coffee, areca nut, rubber, plantain, ginger and elephant foot yam (production levels unavailable), rural agricultural wages and rainfall statistics in the Wayanad district over the period of 1990-2012. The household production level for major agricultural crops across time was calculated using the household production ratio to the district production level in the base year (2012). The farm and retail prices for home garden production are kept constant over the optimization due to the unavailability of data over this period. The variability across time in farm prices and production levels for all major agriculture produce, retail prices for agricultural food crops, input prices such as fertilizer prices and wages and inputs such as rainfall are presented in tables 3.10

and 3.11. The biggest variability affecting income likely comes from variability in prices of cash crops (much bigger coefficients of variation) and fertilizer. The simulations are an attempt to illustrate the implications of potential home gardens on variability in household income, assuming that the home garden and agricultural activities stay constant (although affected by different prices and costs). So households are assumed to have produced or attempted to produce the same agricultural products across time and to have grown the same home garden products across time (in reality the households may have adjusted their production of annual crops in response to different market and household characteristics over time). The simulation is mainly to account for variation in some of the key market forces in modelling the household impact of home gardens.

Table 3.10 Standard deviation and Coefficient of Variation of agriculture production, farm and retail prices

	Paddy	***Ginger***	***Arecanut***	***Plantain***	***Coffee***	***Rubber***	***Elephant foot yam***
Farm Prices							
Mean	*571.77*	*4351.64*	*3748.23*	*899.87*	*5298.25*	*5961.16*	*591.76*
SD	*262.49*	*2654.39*	*2793.01*	*537.14*	*2601.15*	*5401.64*	*524.15*
CV	*0.46*	*0.61*	*0.75*	*0.60*	*0.49*	*0.91*	*0.89*
Retail Prices							
Mean	*14.13*	*18.83*		*12.68*			*10.21*
SD	*6.70*	*10.11*		*6.90*			*8.44*
CV	*0.47*	*0.54*		*0.54*			*0.83*
Agriculture production							
Mean	*378605.36*	*213468.21*	*42669.64*	*116060.36*	*397116.79*	*48005.36*	
SD	*89374.55*	*59101.53*	*17336.03*	*46275.65*	*142429.49*	*27397.46*	
CV	*0.24*	*0.28*	*0.41*	*0.40*	*0.36*	*0.57*	

Source: Author's analysis

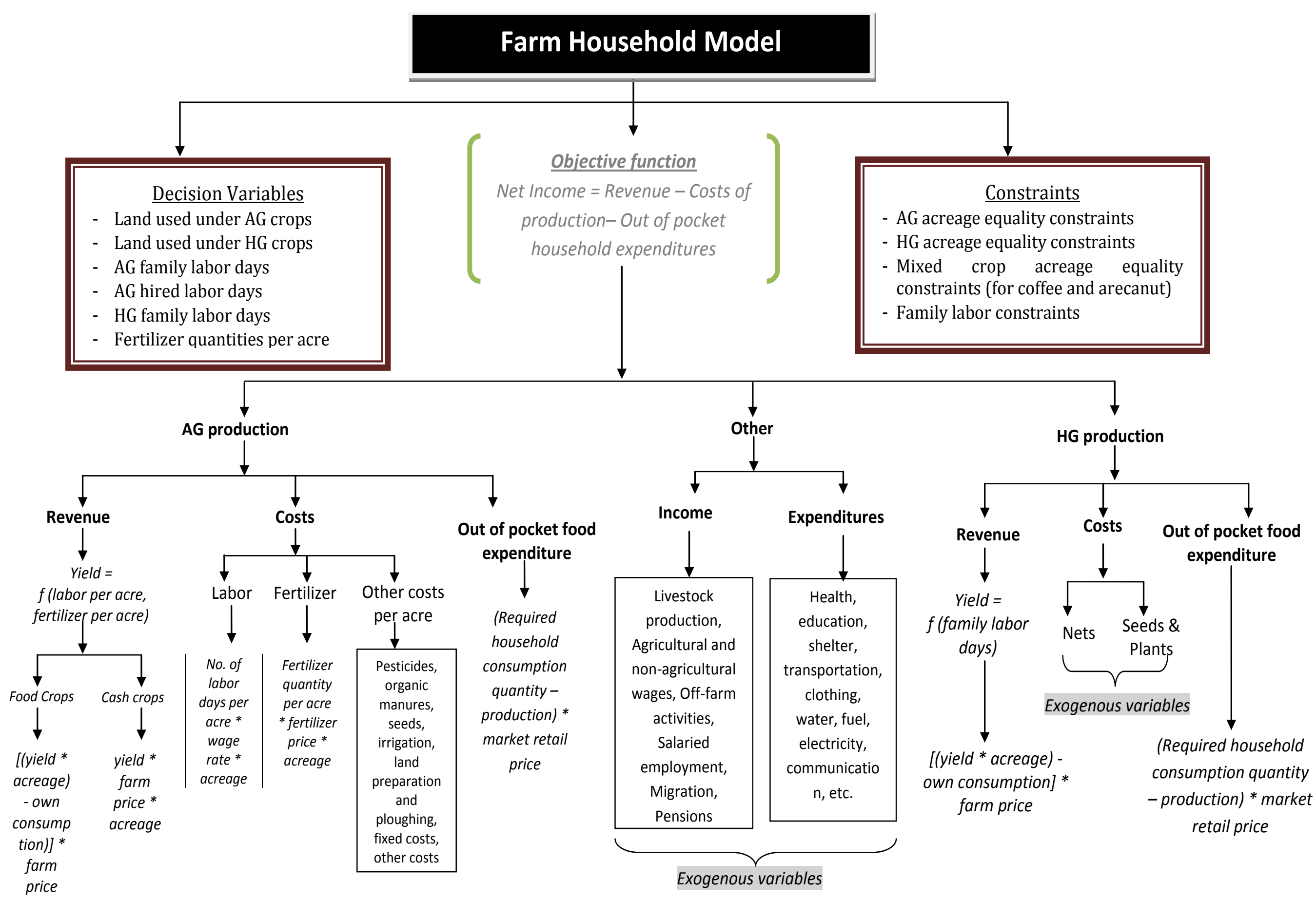
Table 3.11 Standard deviation and Coefficient of Variation of input prices and rainfall

	Fertilizer prices				Wages	Rainfall
	Urea	NPK	MOP	DAP		
Mean	385.95	8.37	499.31	954.86	73.10	1883.02
SD	110.65	3.33	366.70	439.36	37.01	340.05
CV	0.29	0.40	0.73	0.46	0.51	0.18

Source: Author's analysis

As discussed above, the following illustration presents the whole structure of a farm household model, including the relationships between variables in the objective (figure 3.1).

Figure 3.1 Representation of a Farm Household Model



With the developed parameters for household production and consumption, the farm household models are established for each sample household in all household categories to optimize or maximize the objective function i.e. net income from agriculture, home garden and other income-earning activities (based upon the household's production structure), over variable costs and expenditure, by changing the land, labor and fertilizer inputs, given the land and labor constraints. Based on the yield responsive regression results, a relationship between yield, labor per acre and fertilizer per acre is established for agricultural production by using Cobb-Douglas production functions. In the home garden production side, the model developed a link between the family labor days and yield of crops. Optimizations are conducted under baseline scenarios and uncertain conditions by applying market shocks to farm prices, market prices, fertilizer prices and agricultural wages. In addition, variations in market forces over time is accounted by running simulations from 1990-2012 by using respective prices for agricultural crops, fertilizer and labor. The results obtained from the optimizations are discussed in the next chapter.

CHAPTER 4

RESULTS AND DISCUSSIONS

This chapter analyzes the results from the production-consumption optimization models for all the sample agricultural majority, agricultural minority and landless households with and without home gardens. The optimal model solutions which include optimal net income, agricultural and home garden production and consumption patterns, under given base conditions are discussed in the first section of the chapter. The second section focuses on the households' and their home gardens' response to the market fluctuations in output and input prices. The net income response when home gardens are no longer included in the household activities of home garden households are explained in the third section. The last part of this chapter is devoted to understanding the variability in the net income and the potential contributions of home gardens across time. Following is a list of all the simulations run in order to arrive at the results (Table 4.1).

Table 4.1 List of simulations

- *Optimized farm household models under base conditions for agricultural majority, agricultural minority with and without home gardens and landless households with home gardens*
- *Simulations under different market scenarios* o *When agricultural wages are increased and decreased by 50 % for agricultural majority, agricultural minority with and without home gardens and landless households with home gardens* o *When agricultural farm prices are increased and decreased by 50 % for agricultural majority, agricultural minority with and without home gardens* o *When fertilizer prices are increased and decreased by 50 % for agricultural majority, agricultural minority with and without home gardens* o *When farm prices for home garden produces are increased and decreased by 50 % for agricultural majority, agricultural minority and landless*

households with home gardens o *When market retail prices for home garden produces are increased and decreased by 50 % for agricultural majority, agricultural minority and landless households with home gardens*
- *Simulations when home garden is taken away from the agricultural majority and minority home garden household models under following market scenarios* o *When agricultural wages are increased and decreased by 50 % for agricultural majority, agricultural minority with and without home gardens and landless households with home gardens* o *When agricultural farm prices are increased and decreased by 50 % for agricultural majority, agricultural minority with and without home gardens* o *When fertilizer prices are increased and decreased by 50 % for agricultural majority, agricultural minority with and without home gardens* o *When market retail prices for home garden produces are increased and decreased by 50 % for agricultural majority, agricultural minority and landless households with home gardens*
- *Simulations for twenty years (1990-2012) using each years' corresponding output prices, agricultural wages, fertilizer prices and production levels for agricultural majority, agricultural minority with and without home gardens and landless households with home gardens*

4.1 Optimal Solutions of Farm Optimization Models for Household Categories

The optimal model solutions for all households, after solving the linear programming problem outlined in the previous chapter, are discussed in this section. This farm household model tries to maximize the net income of the household from agricultural and home garden production and from other income-earning activities, over variable costs and expenditure, by changing the land, labor and fertilizer inputs for production, subject to land and labor constraints. The base runs in the optimization model reflect the optimal production and consumption patterns by adjusting the above mentioned decision variables i.e., usage of land, labor (both family and hired labor) and fertilizer per acre. The model changes things away from the actual situation because there is the possibility of households achieving an increased net income or an improved livelihood status, just by adjusting the production inputs in the best possible way and thereby ensuring higher production levels and better management of households' consumption requirements.

Table 4.2 summarizes the actual and model optimum net income that can be achieved by households in each category under the households' base conditions. Per acre net income is shown for all landed (agricultural majority and minority) households. The model optimum values, regardless of the categories, are much higher than the actual values (more than double for majority of households) and indicate households' ability to enhance net income situations by reallocating land and labor among crops (reallocating available labor days between crops and wage employment for landless households), and by adjusting the fertilizer application. As mentioned above, the value of objective function reflects the income earned from all the activities the households are involved in, not just the agricultural and the home garden production. That explains the large differences seen in values within the category itself. The changes in decision variables for all sample households during optimization are presented in appendix (section a.7). Due to higher produce prices of cash crops, the optimal models allocated more land to coffee, arecanut and rubber in the optimum scenarios of majority of households, except for one household in each of the agricultural home garden categories (HH 281 & HH 192). This result stems from the static nature of the model since these crops are plantation crops that would require some years to develop. In further research, constraints on the level of production of these crops could accommodate the long run requirements for increases in production. Optimum values for the use of own labor indicate that farm households tend to allocate more of their family labor into the cultivation of home garden crops and hire required labor for agricultural production. However, landless households seem to take away their available family labor days from home garden management because of the higher wage levels and profits they can earn from agricultural wage employment.

Table 4.2 Model Optimum and Actual Net Income of the Households (per acre)

	AG majority HG		AG majority no HG		AG minority HG		AG minority no HG		Landless HG	
	HH 281	HH 546	HH 300	HH 137	HH 192	HH 816	HH 722	HH 264	HH 293	HH 256
Optimum	*69157.13*	*1179875.98*	*76766.84*	*10750.18*	*28924.04*	*727171.86*	*224403.1*	*126835.6*	*48381.63*	*130118.6*
Actual	*39236.57*	*49574.17*	*47249*	*-11427.2*	*-2906.04*	*482708.96*	*172329.9*	*93953.32*	*12668.20*	*113045.1*

Source: Author's analysis

The following discussion breaks the objective function into different parts. The model optimum revenue and costs of agriculture production and out-of-pocket food expenditure for crops cultivated under farm production for all landed sample households are given in Table 4.3. All households earn positive profits under the model optimum solution. Out-of-pocket expenditure occurs when the home produced quantity of food crops do not meet households' annual consumption requirement of that product. Paddy, ginger, elephant foot yam and plantain are the major food crops cultivated by the sample households. Since rice is a common staple and consumed on a daily basis, annual consumption levels of rice for all households are very high compared to other three products. Usually the households are able to cover their consumption needs from their own production and the results also show only a small amount (or even no expenditure at all for some households) spent in the market for the home-grown major food products and these amounts are low compared to their revenue earning levels. Information on each household's optimum production levels of food and cash crops and own and purchased consumption levels are given in table 4.4. Details showing how these levels change for each cultivated agricultural crop under optimizations are provided in appendix (section a.8). The produced, marketed, own-consumed and purchased quantities of these major agricultural crops are the optimum levels calculated by the model. However, the total consumption levels are the actual data derived from the dietary intake survey and held constant in the model.

Table 4.3 Financial Pattern of Agricultural Production (in Rupees)

		Revenue from marketing (per acre)	Costs (per acre)	Out of pocket food expenditure	Revenue-cost-expenditure
AG majority HG	HH 281	100396.73	39992.42	0.00	60404.31
	HH 546	1218152.3	24188.86	7218.33	1186745.10
AG majority w/o HG	HH 300	168749.93	36251.29	449.50	132049.14
	HH 137	118168.74	52244.28	0.00	65924.46
AG minority HG	HH 192	41736.868	23537.98	7283.98	10914.91
	HH 816	53266.727	39369.06	804.90	13092.77
AG minority w/o HG	HH 722	133652.19	25369.1	0.02	108283.07
	HH 264	112896.4	6721.099	437.52	105737.78

Source: Author's analysis

Table 4.4 Production and Consumption Pattern of Agricultural Production (in Kgs)

		Total production (food crops)	Total production (cash crops)	Sold quantity	Own consumption	Purchased quantity	Total consumption
AG majority HG	HH 281	6677.50	190.02	6360.56	506.96	0.00	506.96
	HH 546	6969.06	35957.51	42715.64	210.93	261.72	472.65
AG majority w/o HG	HH 300	2109.25	3000.60	4937.15	172.70	16.30	189.00
	HH 137	90.55	1296.71	1384.65	2.60	0.00	2.60
AG minority HG	HH 192	2431.98	9.37	2425.21	16.15	264.10	280.25
	HH 816	539.12		532.67	6.45	28.75	35.20
AG minority w/o HG	HH 722	4824.31		4544.06	280.25	0.00	280.25
	HH 264	7202.18		7196.97	5.22	15.58	20.80

Source: Author's analysis

A part of households' net income earnings in the objective function comes from the home garden. Sample households with home gardens can earn a considerable amount of profit from the marketing of surplus produce (Table 4.5). The profits and their percentage contribution of home garden to the net income levels are significantly higher for agricultural minority households (20% and 39%) compared to households in other two categories. The percentage contribution of home gardens for agricultural majority households seem to be smaller because of their higher net income levels. Households also attach benefits to the home gardens in terms of the value they derive from the home consumption of the produce. In other words, this is the extra value the households otherwise would have to pay to purchase from the market. Value of own consumption for each of the home garden produce are calculated at their own respective market retail prices in the base year 2012, which was collected from the Government of Kerala publications (Price statistics, Department of Economics and Statistics, and market price reports by Krishi Bhavan, Wayanad). All households are able to save considerable amounts of money in terms of their food purchase and, sometimes these savings/consumption values are higher than the actual profit earned through marketing surplus home garden produce which reflect the survey responses that home garden produces are mostly used for home consumption. Households can use these earned profits and savings from home garden to meet other household expenditures. Aggregate quantity of home garden produce consumed, marketed and purchased by each sample households is provided in Table 4.6. More detailed information how production, sales and consumption of each home garden produce changes during optimizations are given in appendix (section a.8). In the actual settings, households sell only a small quantity of home garden produce and marketing is uncommon based on survey responses. Contrary to this, sale of surplus produce is high in the base model since the base model optimizes income by putting the value on sales. However, only the surplus produces, after home consumption, are sold in the market. Along with that, households will have to purchase at least their own consumption when the production of some home garden products doesn't cover the household's consumption needs.

Table 4.5 Contributions of Home Gardens

	AG majority HG		AG minority HG		Landless HG	
	HH 281	**HH 546**	**HH 192**	**HH 816**	**HH 293**	**HH 256**
Profit	*2660.10*	*1893.36*	*7913.30*	*65534.89*	*190.56*	*1004.53*
%	*2.43*	*0.04*	*19.54*	*39.18*	*0.39*	*0.77*
Consumption Value	*7811.25*	*1383.58*	*1420.94*	*1298.20*	*377.78*	*330.44*
HG area (in acres)	*0.03*	*0.01*	*0.01*	*0.03*	*0.005*	*0.02*

Source: Author's analysis

Table 4.6 Production and Consumption Pattern of Home Garden Production (in Kgs)

		Total production	*Sold quantity*	Own consumption	*Purchased Quantity*	*Total consumption*
AG majority	HH 281	*373.15*	*131.47*	*241.68*	*46.45*	*288.132*
	HH 546	*161.58*	*111.05*	*50.53*	*82.47*	*133.00*
AG minority	HH 192	*384.62*	*340.32*	*44.29*	*188.72*	*233.011*
	HH 816	*7228.42*	*7158.62*	*69.80*	*173.22*	*243.02*
Landless	HH 293	*50.39*	*30.05*	*20.34*	*47.36*	*67.7*
	HH 256	*75.40*	*63.80*	*11.60*	*139.50*	*151.10*

Source: Author's analysis

Compared to other two categories, landless households benefit very little in terms of the profits and consumption value derived from their home gardens. This can be attributed to the lower diversity in the production structure of landless households' home gardens. Survey results also pointed out that the percentage of landless households who believed home gardens could contribute to their dietary diversity were much smaller compared to agricultural households. The number and types of crops cultivated could make a great difference in benefits deriving from home gardens. Simulations which allowed landless households to grow a few more crops such as, elephant foot yam, brinjal, tomato, ginger, ash gourd, radish and pumpkin in their home gardens showed improvements in the households' overall economic level and in the contribution of home gardens through higher profits and higher consumption values (Table 4.7). Adjustments in production, sales and consumption in the diversified home gardens are given in appendix (tables a.8.9 & a.8.10). For these landless households, cultivation of elephant foot yam seems as if it would contribute significantly to the profits derived from their home gardens.

Table 4.7 Contribution of diversified home gardens for landless households

	HH 293		**HH 256**	
	Original	**With diversified HG**	**Original**	**With diversified HG**
Net income	48381.63	50417.63	130118.6	130436.5
Profit	190.56	2673.21	1004.53	1696.55
%	0.39	5.30	0.77	1.30
Consumption Value	377.78	514.12	330.44	1217.24

Source: Author's analysis

The shift of family labor days from home garden production to outside employment due to higher wages can be another reason for such little contribution. Since family labor days are directly linked with the yield of home garden crops, this shift can have a great effect upon the profits and consumption value derived from home gardens. Allocating their labor days for agricultural wage employment could help them to achieve more income and this income can be used to meet rest of their consumption requirement. The original model assumed both agricultural majority and minority household to allocate their available family labor days between agricultural and home garden production. However, a few other simulations are conducted assuming all these farm households allocate some of their family labor days for outside employment along with cultivation and the results are provided in appendix (section a.9). The higher wage levels for agricultural employment forces all most all households to take away their family labor days from home garden and agricultural cultivation and thereby reduces the contribution of home gardens in the total household net income. Although the profits and percentage contribution of agricultural minority households reduced drastically with the addition of outside employment in the model, consumption values are found to be higher. A few other optimizations are also conducted by adding shocks to agricultural wages to see the changes in family labor days allocation between agriculture, home garden and outside employment (Appendix a.9). With the decrease in agricultural wage rates, the model for most of the households tend to allocate more labor days to home garden or agricultural production which increased the percentage contribution of home gardens. For the landless households, 50% and 75% reduction in wage rates did not cause the model to shift more labor to home garden cultivation because of higher profitability in allocating more of their labor for wage employment. The labor days allocation to home garden remained at the minimum level. However, around 95% decrease in wages resulted in allocating all of their available labor days for the maintenance and cultivation of home garden crops and increased the level of profits and consumption value. These results imply that during slack employment seasons or off-seasons, home gardens could benefit landless households to maintain their basic livelihood needs by ensuring food and income security.

4.2 <u>Sensitivity Analysis</u>

Households' responses to different economic conditions were tested by adding market shocks to the model. The major market shocks occur from the changes in the output prices, and in the input prices which include costs related to labor, and fertilizer. Since consumption is also taken into account in the model, households' response to changes in market retail prices of home garden produces are also analyzed in this section. Although the households' total consumption levels are held fixed in the model, fluctuations in the retail prices could affect the own consumption and sold quantities, and thereby the net income levels. The net income of the household is expected to increase when the output prices are higher and input prices are lower, and vice versa. Optimizations were conducted after making 50% changes to each of these prices in each of the household models. Table 4.8 summarizes the percentage change response in net income from the baseline value under all the above mentioned scenarios. Figure 4.1, 4.2 and 4.3 graphically portrays these responses for agricultural majority, agricultural minority and landless households respectively. Adjustments in decision variables under these market shocks are shown in the appendix (Section a.7).

A fifty percentage decrease in the price of agricultural labor resulted in higher net incomes (and lower net incomes when the wages are 50% higher) to agricultural majority and minority households. However, the percentage increase (or decrease) in net incomes for agricultural minority without home garden households were marginal compared to all other farm households. At the same time, an increase in agricultural wages means higher income for the landless households and they are expected to use more of their available own labor days for the employment in daily farm-wage activities. In accordance with that, positive percentage changes in net incomes were observed for landless households when the price of labor is higher.

Similarly, the landless households' percentage changes in net incomes were found to be negative when the wages are lower. While changes in agricultural wages resulted in drastic shifts to the net income for landless households, agricultural majority and minority households experience dramatic shifts with fluctuations in farm prices. These shifts were substantial for agricultural majority without home garden households, compared to the other categories. Among all the market fluctuations in the input costs, fertilizer price changes had lower impacts on the households' net income levels.

Home garden households responded positively to the increases in produce prices and decreases in market prices. Similarly, the net income of the households was found to be less with lower produce prices and higher retail prices. The agricultural minority households experienced the most variability in net incomes under home garden market price fluctuations. The lower variability in net income for agricultural majority and landless households under these scenarios can be attributed to the home gardens smaller percentage share in the value of the objective function for these two household categories.

Comparing the home garden and no home garden households in farm household categories, home garden households, in most of the cases, are more resilient to all the market fluctuations (clearly visible in the agricultural majority category). The net incomes of the households with home gardens are more stable even during the negative market shocks, in terms of their smaller percentage change from the optimum income level.

Table 4.8 Percentage changes in net income from the baseline under different scenarios

	AG majority HG		AG majority no HG		AG minority HG		AG minority no HG		Landless HG	
	HH 281	HH 546	HH 300	HH 137	HH 192	HH 816	HH 722	HH 264	HH 293	HH 256
Wages up	*-23.34*	*-10.87*	*-17.47*	*-1.87*	*-16.02*	*-24.46*	*-3.03*	*-0.31*	*161.22*	*54.88*
Wages down	*17.21*	*5.24*	*12.15*	*56.72*	*23.62*	*22.04*	*3.90*	*0.15*	*-161.22*	*-54.88*
AG farm prices up	*74.35*	*47.98*	*110.37*	*577.12*	*78.93*	*18.03*	*29.79*	*44.38*		
AG farm prices down	*-58.52*	*-56.57*	*-114.72*	*-502.02*	*-68.25*	*-20.60*	*-28.86*	*-44.50*		
Fertilizer prices up	*-4.73*	*-1.47*	*-3.96*	*-23.14*	*-10.58*	*-11.08*	*-0.77*	*-1.35*		
Fertilizer prices down	*4.23*	*11.39*	*2.34*	*59.97*	*8.97*	*21.28*	*0.76*	*1.31*		
HG farm prices up	*7.41*	*5.39*			*7.25*	*48.73*			*0.38*	*0.42*
HG farm prices down	*-4.13*	*-1.37*			*-11.37*	*-31.57*			*-0.05*	*-0.08*
HG retail prices up	*-0.43*	*-7.16*			*-12.67*	*-25.89*			*-1.03*	*-1.13*
HG retail prices down	*0.39*	*9.93*			*12.15*	*14.09*			*1.22*	*1.42*

Source: Author's analysis

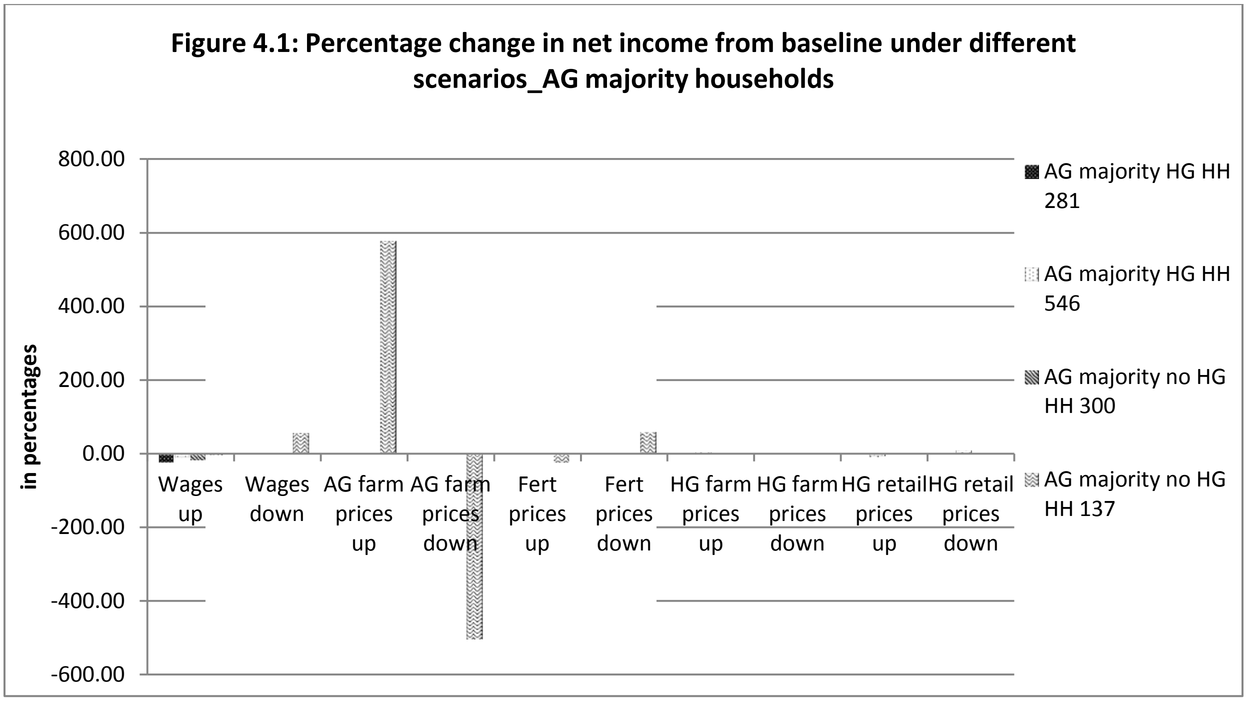


Figure 4.1: Percentage change in net income from baseline under different scenarios_AG majority households

Source: Author's analysis

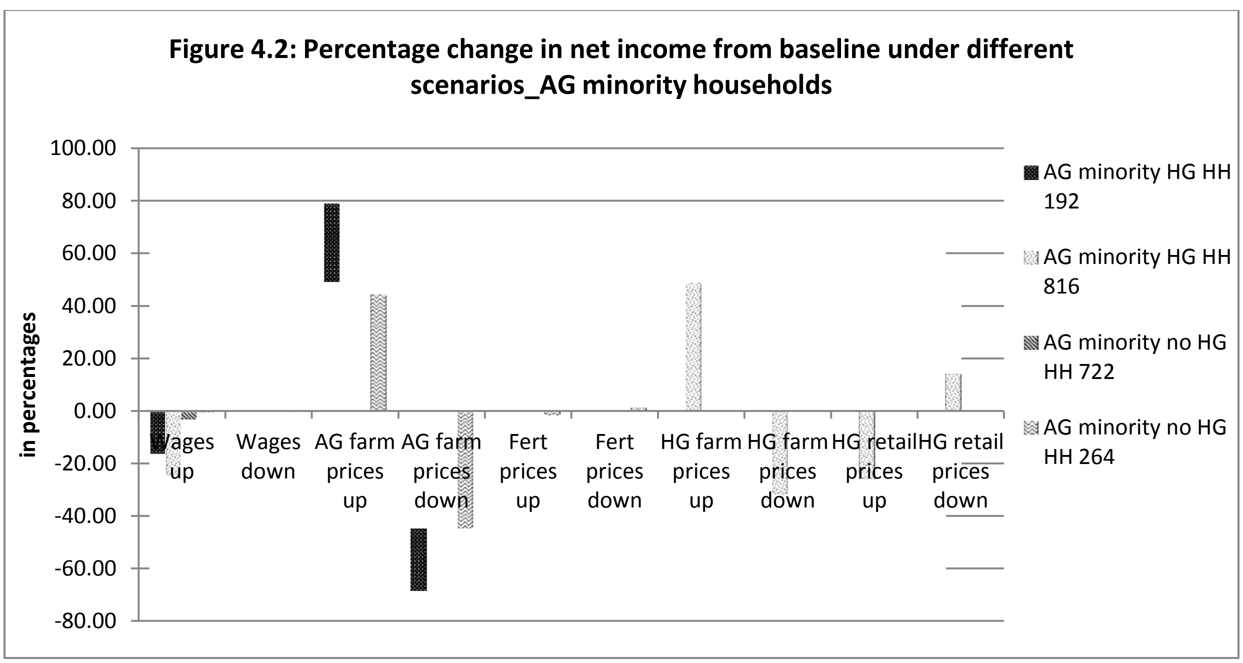
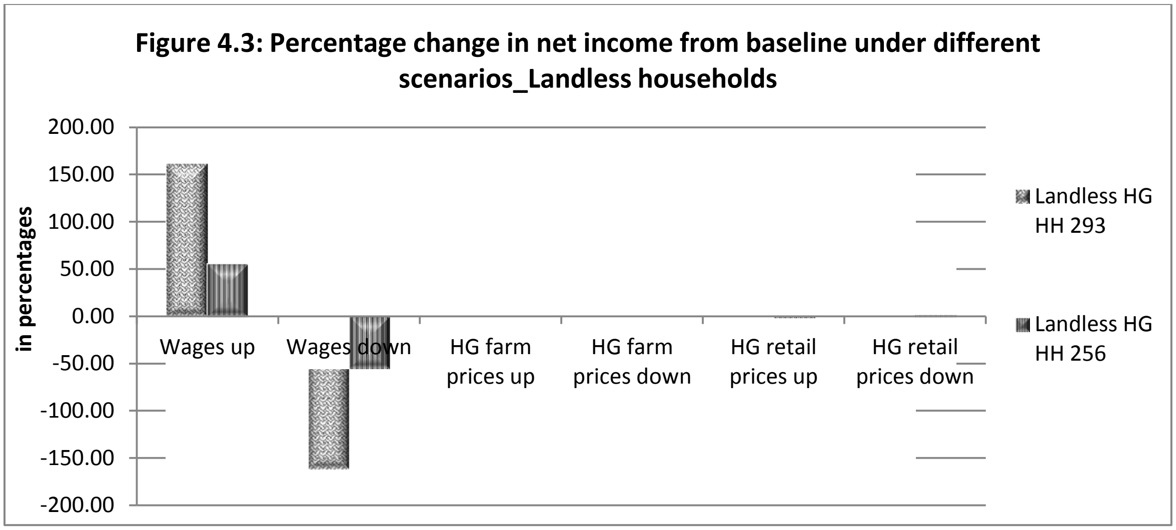


Figure 4.2: Percentage change in net income from baseline under different scenarios_AG minority households

Source: Author's analysis



Source: Author's analysis

As mentioned in table 4.8, the market fluctuations in the prices of home garden produce had less impact on the agricultural majority and landless households as compared to the agricultural minority households. The percentage contributions of home gardens to the net income of each household under all market shock scenarios, provided in table 4.9, can provide an explanation for the above observation. The contributions of home gardens in agricultural majority and landless category households to their total net income level under all scenarios are found to be marginal compared to that of agricultural minority households. However, the percentage contributions of home gardens in terms of the profit derived from marketing of the produce are positive in all scenarios for agricultural majority and minority households. The landless households did not derive any profits from home gardens when their produce prices are lower and retail prices for those produce are higher. Among all the market scenarios, contributions of home gardens in most of the households were higher when the farm prices of their home garden produce are increased by fifty percent. These findings are important since the agricultural minority households i.e., the households whose agricultural production is relatively small in terms of revenue, constitute more than half of the total sample population (56.89% and 13.97% in the agricultural minority with and without home garden categories respectively). However, only 7.58% and 0.6% of households come under the agricultural majority home garden and without home garden categories respectively, where agricultural production is relatively large in terms of revenue. The percentage of households with no land for agricultural production is also lower as compared to the agricultural minority category (16.57% and 4.39% in the landless with and without home garden categories respectively).

Table 4.9 Percentage contributions of home gardens to the net income under different scenarios

	AG majority HG		AG minority HG		Landless HG	
	HH 281	**HH 546**	**HH 192**	**HH 816**	**HH 293**	**HH 256**
Wages up	*1.22*	*0.04*	*10.80*	*20.99*	*0.15*	*0.50*
Wages down	*7.11*	*0.01*	*8.48*	*49.10*	*0.64*	*1.71*
AG farm prices up	*0.97*	*0.04*	*10.92*	*50.77*		
AG farm prices down	*7.42*	*0.29*	*43.16*	*24.41*		
Fertilizer prices up	*8.74*	*0.04*	*2.13*	*31.77*		
Fertilizer prices down	*0.94*	*0.29*	*17.93*	*49.41*		
HG farm prices up	*9.33*	*0.60*	*23.64*	*60.45*	*1.06*	*1.19*
HG farm prices down	*1.48*	*0.02*	*4.27*	*6.21*	*-0.18*	*-0.06*
HG retail prices up	*2.74*	*0.37*	*12.11*	*16.81*	*-0.18*	*-0.05*
HG retail prices down	*0.93*	*0.05*	*11.89*	*45.12*	*0.64*	*0.76*

Source: Author's analysis

Table 4.10 shows how the profits from home gardens varied across different market scenarios and their percentage changes from the baseline profit value. In absolute terms, households earned positive profits from home gardens under all market fluctuations, except for landless households when home garden farm prices were lower and retail prices were higher. It can be seen from table 4.10 that profits from home garden for farm households are much less from the baseline profits when the agricultural wages are increased by fifty percent. The reason can be attributed to the shift of family labor from home garden to agricultural production to reduce the costs of hired labor. This can have adverse effect on the home garden production due to the linkage between family labor and yield in the model specification. However, the farm wage fluctuations did not have any effect on the home garden profits for landless households. Profits increased by large percentages from baseline for all home garden households with an increase in the produce prices and similarly, decreased when the produce prices went down.

Table 4.10 Profits from home gardens under different scenarios

	AG majority				AG minority				AG majority			
	HH 281		HH 546		HH 192		HH 816		HH 293		HH 256	
	Value (in Rs.)	*% change from baseline*	*Value (in Rs.)*	*% change from baseline*	*Value (in Rs.)*	*% change from baseline*	*Value (in Rs.)*	*% change from baseline*	*Value (in Rs.)*	*% change from baseline*	*Value (in Rs.)*	*% change from baseline*
Wages up	1023.46	-61.53	1763.23	-6.87	3671.20	-53.61	26517.39	-59.54	190.56	0.00	1004.53	0.00
Wages down	9104.21	242.25	516.43	-72.72	4244.68	-46.36	100221.95	52.93	190.56	0.00	1004.53	0.00
AG farm prices up	1846.31	-30.59	2578.67	36.20	7913.30	0.00	100221.95	52.93				
AG farm prices down	3362.559	26.41	5822.67	207.53	5548.252	-29.89	32420.50	-50.53				
Fertilizer prices up	9096.029	241.94	1990.40	5.13	771.4946	-90.25	47249.70	-27.90				
Fertilizer prices down	1075.889	-59.55	14805.85	681.99	7913.301	0.00	100221.95	52.93				
HG farm prices up	10953.81	311.78	29028.80	1433.19	10264.91	29.72	150382.92	129.47	516.0935	170.83	1549.29	54.23
HG farm prices down	1549.041	-41.77	738.73	-60.98	1534.021	-80.61	7107.40	-89.15	-85	-144.61	-72.51	-107.22
HG retail prices up	2977.699	11.94	15571.60	722.43	4283.258	-45.87	20837.38	-68.20	-85	-144.61	-60.02	-105.97
HG retail prices down	1023.464	-61.53	2319.97	22.53	5400.717	-31.75	86090.36	31.37	315.729	65.69	1004.53	0.00

Source: Author's analysis

Regardless of the category, all households derived positive consumption values from home gardens under all market fluctuations (Table 4.11). Although the profits derived from home gardens decreased from the baseline value with a decrease in home garden produce prices, most of the households benefited more in terms of consumption value. The percentage increases in the consumption values were really high for agricultural minority and landless households under that market scenario. Households often struggle to meet the required intake of these products when the market retail prices are high. However, the positive percentage changes in consumption values from baseline for most of the households indicate that having a home garden would help the households to solve this problem by meeting the consumption requirement instead of selling in the market. In a similar way, a decrease in consumption values for home-grown produce with a decrease in the retail prices indicate that low market prices help households to manage their required consumption by purchase from the market.

Table 4.11 Consumption value derived from home gardens under different scenarios

	AG majority				AG minority				AG majority			
	HH 281		HH 546		HH 192		HH 816		HH 293		HH 256	
	Value (in Rs.)	% change from baseline	Value (in Rs.)	% change from baseline	Value (in Rs.)	% change from baseline	Value (in Rs.)	% change from baseline	Value (in Rs.)	% change from baseline	Value (in Rs.)	% change from baseline
Wages up	5376.42	-31.17	1990.70	43.88	1610.50	13.34	3322.57	155.94	377.78	0.00	330.44	0.00
Wages down	8568.92	9.70	675.69	-51.16	1148.17	-19.20	1312.33	1.09	377.78	0.00	330.44	0.00
AG farm prices up	7299.30	-6.55	1702.00	23.01	1420.94	0.00	1312.33	1.09				
AG farm prices down	8186.78	4.81	1659.60	19.95	1071.87	-24.57	2789.59	114.88				
Fertilizer prices up	8568.92	9.70	1128.63	-18.43	3674.76	158.62	3229.93	148.80				
Fertilizer prices down	5399.77	-30.87	1449.24	4.75	1420.94	0.00	1312.33	1.09				
HG farm prices up	8557.11	9.55	1811.15	30.90	1258.83	-11.41	1312.33	1.09	236.73	-37.34	330.44	0.00
HG farm prices down	8033.35	2.84	680.85	-50.79	3317.00	133.44	3445.63	165.42	628.56	66.38	1297.64	292.70
HG retail prices up	11976.78	53.33	2265.96	63.77	1327.75	-6.56	4003.19	208.36	882.72	133.66	1946.46	489.05
HG retail prices down	2688.21	-65.59	799.67	-42.20	945.41	-33.47	606.40	-53.29	118.37	-68.67	165.22	-50.00

Source: Author's analysis

4.3 <u>Simulating Home Garden Household Models without Home Gardens</u>

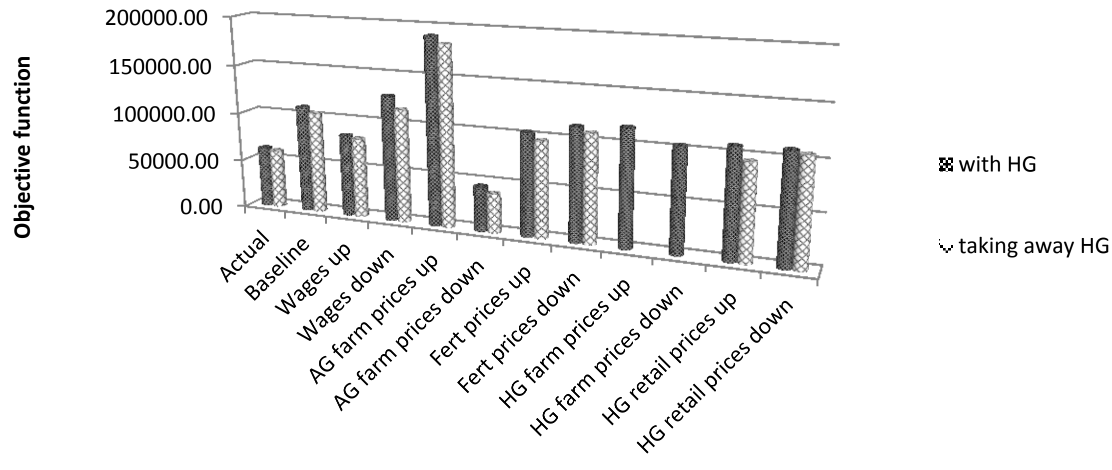
Although comparing the households with and without home garden in the same category offers some insights and quantifications of the contributions of home gardens to that particular household category, these values might be largely dependent upon each household's socio-economic and demographic conditions, size of the home gardens, types of products cultivated in the home gardens and other invisible characteristics specific to them. Comparing the household with home garden results to scenarios as if that same household had never had a home garden might provide a better comparison. In order to analyze these effects, the model considers zero acreage and labor allocation to home gardens, for the households with home gardens under agricultural majority and minority categories, which results in zero production of home garden products. Optimizations were carried out under different scenarios after taking out home garden from the model. Without home garden production, households have to depend completely on the market to meet their annual diet requirements of vegetables, tubers, greens, fruits, spices and herbs that are previously cultivated in their own home gardens. Table 4.12 shows the percentage change in the net income of each household when the home garden is no longer included in the household activity. The responses of objective functions when home garden production is zero and positive under different market scenarios are illustrated for agricultural majority households in figures 4.4 and 4.5, and for agricultural minority households in figures 4.6 and 4.7. It is clear that all the households are affected negatively under baseline conditions and other market fluctuation scenarios. The households who do not depend on farm production as their major livelihood source seem to have more adverse effects of not having home gardens. In the original model, these households had benefited with high contribution of their home gardens to the net income levels in terms of the profits earned. Less percentage changes in the objective functions for the agricultural majority category shows their ability to cope up easily without home gardens comparative to the households in the agricultural minority category.

Table 4.12 Percentage change in the objective function when home garden is taken away from the model

	AG majority HG		AG minority HG	
	HH 281	**HH 546**	**HH 192**	**HH 816**
Actual	-2.99	-0.35	-59.13	-4.69
Baseline	-5.27	-8.47	-11.15	-33.41
Wages up	-2.77	-2.06	-26.24	-12.17
Wages down	-9.79	-11.35	-9.85	-43.11
AG farm prices up	-3.77	-12.85	-6.02	-39.21
AG farm prices down	-12.80	-12.66	-42.94	-20.34
Fertilizer prices up	-6.79	-15.67	-16.96	-25.42
Fertilizer prices down	-4.40	-5.22	-7.81	-44.87
HG retail prices up	-11.76	-3.36	-19.39	-12.44
HG retail prices down	-2.47	-7.75	-4.29	-40.15

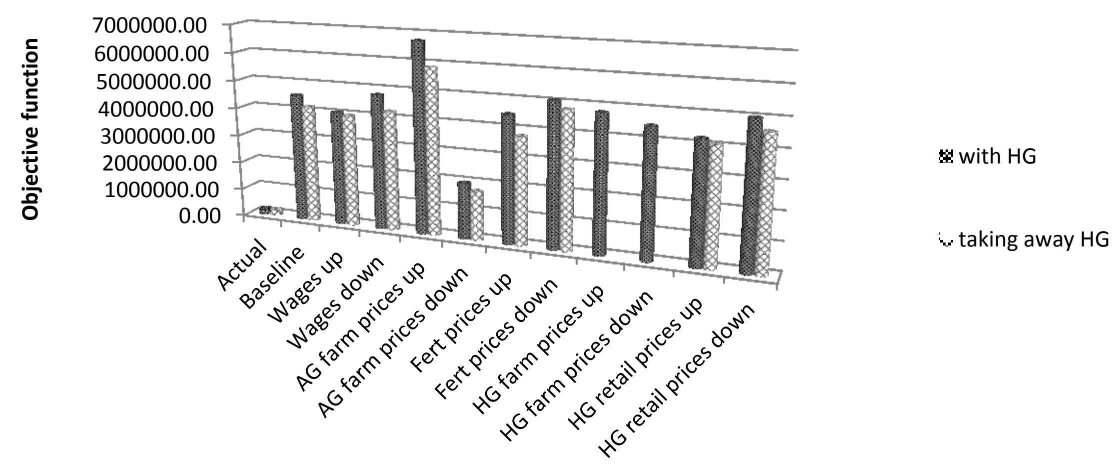
Source: Author's analysis

Figure 4.4 ***Percentage change in the objective function when home garden is taken away from the model_AG majority household (HH 281)***



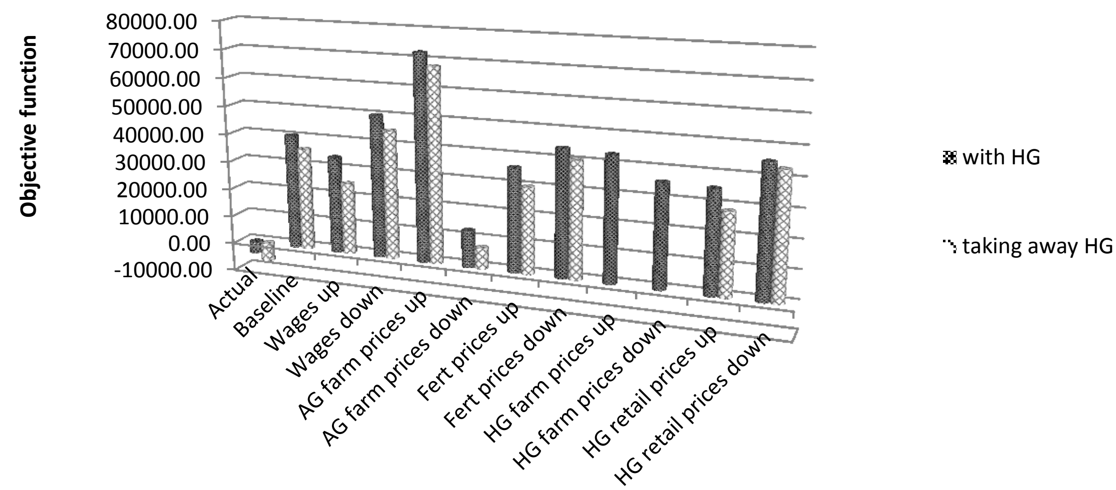
Source: Author's analysis

Figure 4.4 ***Percentage change in the objective function when home garden is taken away from the model_AG majority household (HH 546)***



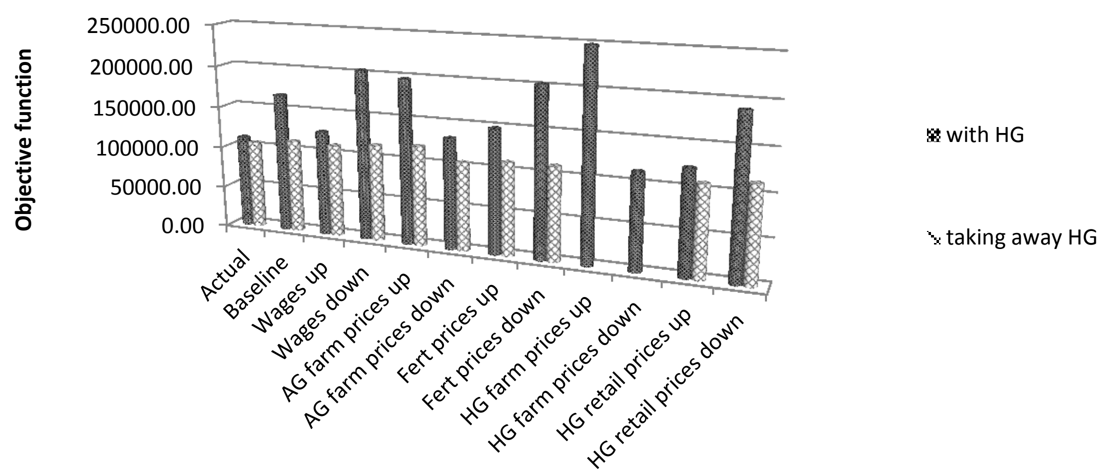
Source: Author's analysis

Figure 4.4 ***Percentage change in the objective function when home garden is taken away from the model_AG minority household (HH 192)***



Source: Author's analysis

Figure 4.4 ***Percentage change in the objective function when home garden is taken away from the model_AG minority household (HH 816)***



Source: Author's analysis

4.4 Variability across Time from 1990 to 2012

While all previous analyses captured home gardens' contributions in different household categories under different scenarios in the baseline year (2012), the following analysis is carried out to understand how having a home garden over the last twenty years (1990-2012) might have helped the households with their overall variability in economic conditions. The farm and market prices of major agricultural products, fertilizer prices and agricultural wages corresponding to each of the twenty years are used to optimize the farm household models across time. The production levels for farm crops are changed according to each household's production ratio to the district production level. The farm and retail prices for home garden produce are kept constant at the 2012 price level due to the lack of data. Table 4.13 shows the mean, standard deviation and coefficients of variation of net income across time. The actual values represent the original net income levels before optimization and baseline values represent the optimum net income households can achieve. For the home garden households, the actual values do not include the profits from home garden. It was assumed that these households did not maintain home gardens originally. However, the baseline values in the home garden categories are the optimized net income levels from home garden production and other income generation activities specific to each household. Average net income is represented on an acre level for the farm households. The negative average income values for some farm households can be attributed to the low farm prices for their crops, and low agricultural wages for landless households. The coefficients of variation values show that home garden households in the agricultural majority and landless categories experienced lower variability in their net income level across time when they had home gardens. However, the agricultural minority households with home gardens did not respond the same way. They seem to show more variability with home gardens rather than without home gardens across time. The optimized net income levels for agricultural majority households without home gardens had lower variability than the actual levels. Tables 4.14 and 4.15 show the variability in the profits earned and consumption value derived from home garden across time. The home garden profits for households are found to be more variable than the consumption value. However, one landless household did not appear to have any variability in home garden contributions across time. In the landless household models, only the agricultural wages or the income the households receive from farm wage employment change across time. This change might not have enough effect to make any impact on the home garden production of this particular landless household.

Table 4.13 Coefficient of Variation of net income across time (1990-2012)

	AG majority with home garden				***AG majority without home garden***			
	HH 281		**HH 546**		**HH 300**		**HH 137**	
	Actual	**Baseline**	**Actual**	**Baseline**	**Actual**	**Baseline**	**Actual**	**Baseline**
Mean	*7177.48*	*57579.27*	*4781.26*	*355783.84*	*-32859.06*	*-23604.58*	*-61721.77*	*-44465.79*
SD	*15360.06*	*38401.31*	*23967.22*	*314063.85*	*29706.15*	*36158.98*	*18322.88*	*18752.95*
CV	*2.14*	*0.67*	*5.01*	*0.88*	*-0.90*	*-1.53*	*-0.30*	*-0.42*

	AG minority with home garden				***AG minority without home garden***			
	HH 192		**HH 816**		**HH 722**		**HH 264**	
	Actual	**Baseline**	**Actual**	**Baseline**	**Actual**	**Baseline**	**Actual**	**Baseline**
Mean	*-10261.88*	*11036.76*	*445064.74*	*641373.54*	*129815.89*	*144772.74*	*43958.57*	*56070.67*
SD	*1484.63*	*6512.96*	*16898.27*	*162863.12*	*17136.65*	*31709.90*	*19541.79*	*27805.18*
CV	*-0.14*	*0.59*	*0.04*	*0.25*	*0.13*	*0.22*	*0.44*	*0.50*

	Landless with home garden			
	HH 293		**HH 256**	
	Actual	**Baseline**	**Actual**	**Baseline**
Mean	*-71383.04*	*-59776.25*	*24613.67*	*31101.14*
SD	*29761.23*	*38690.75*	*31254.25*	*35420.82*
CV	*-0.42*	*-0.65*	*1.27*	*1.14*

Source: Author's analysis

Table 4.14: Coefficient of Variation of home garden profits across time (1990-2012)

	AG majority HG		**AG minority HG**		**Landless HG**	
	HH 281	**HH 546**	**HH 192**	**HH 816**	**HH 293**	**HH 256**
Mean	*5702.46*	*6572.28*	*7290.70*	*27075.99*	*211.42*	*1004.53*
SD	*3166.88*	*6097.95*	*1427.73*	*30149.00*	*48.72*	*0.00*
CV	*0.56*	*0.93*	*0.20*	*1.11*	*0.23*	*0.00*

Source: Author's analysis

Table 4.15: Coefficient of Variation of consumption value of home gardens across time (1990-2012)

	AG majority HG		**AG minority HG**		**Landless HG**	
	HH 281	**HH 546**	**HH 192**	**HH 816**	**HH 293**	**HH 256**
Mean	*8088.07*	*1512.21*	*1438.17*	*2487.22*	*354.27*	*330.44*
SD	*893.18*	*437.04*	*94.39*	*1047.56*	*54.90*	*0.00*
CV	*0.11*	*0.29*	*0.07*	*0.42*	*0.15*	*0.00*

Source: Author's analysis

In the chapter, results from various simulations conducted for sample households in different household categories are discussed. Optimization results under baseline scenarios indicated wide differences between originally earned net income and optimum net income that can be achieved by adjusting the inputs for production. Although all home garden households earned positive profits and consumption value, the percentage contribution of home gardens to the net income level was found to be significantly high for agricultural minority households compared to other two categories. Applying fifty percent changes in agricultural farm prices, fertilizer prices, wages, produce and market prices of home garden crops highlighted home gardens ability to contribute to the households' economic security by providing income and saving on food expenditure. Most of the home garden households, relative to households without home gardens, achieved more stable net incomes even during negative market shocks (clearly visible in the agricultural majority category), in terms of their smaller percentage change from the optimum income level. Comparison of home garden households to scenarios as if that same household had never had a home garden resulted in negative effects on the households' net income levels. Simulations across time from 1990-2012, with market variability in wages prices and costs indicated higher mean and less coefficient of variation in net incomes when households maintain home gardens.

CHAPTER 5

CONCLUSIONS AND LIMITATIONS

The thesis consisted of four chapters. The first chapter provided a background to the study and discussed the importance of looking at the economic impacts of home gardens in the Kerala context. Given the background, the research problem was analyzed and the specific objectives of the study were presented. In section 1 of chapter 2, the review of literature relating to the impacts of home garden on the food, nutritional, income and the livelihood security, and on the decision making power of women in the household, were discussed. Literature on the models and methods used to evaluate the economic impacts of home garden, and usage of linear optimization models in the farm household business context, were also reviewed. The second section of chapter 2 looked into the selection of sample households from a total of 501 participant households, under the APM project, used to build the household model and provide an analysis of the household characteristics in general, and in terms of home garden management of landless, agricultural majority and agricultural minority household categories. Chapter 3 provided the conceptual framework of the structure of production-consumption farm optimization models for different household categories and discussed the inputs used to develop the models. Results from the optimizations of farm household models under baseline, uncertain and across time scenarios were presented in chapter 4. The present chapter provides a summary of the study and discusses the major findings and conclusions relating to the specific objectives of the research. In addition, the limitations and policy implications are discussed.

5.1 <u>Summary and Major Findings of the Study</u>

Globally, home gardens have been documented as an important supplemental source contributing to food and nutritional security and livelihoods (Galhena, et.al. 2013). The viability, affordability and sustainability of these farming systems motivated the APM project to undertake home gardens as one of the interventions to achieve food, nutritional, economic and livelihood security at individual, household and community levels. In the context of decreasing interest in the cultivation of food crops in Kerala and heavy dependence on other states to make available the required quantity of these food items, the existence of home gardens could offer households safe and chemical-free food. Although most households in Wayanad already had home gardens, the unavailability of quality seeds, attacks by pests, crabs and hens were causing them to become uninterested or even withdraw from the maintenance of these homestead agricultural systems. However, these households expressed large interest in improving their home gardens if they could manage these constraints. This led the APM project to provide support in terms of distributing quality seeds, plants and nets along with trainings on garden design and management. Various analyses of the project were able to point out the increase in food and nutritional security of the participant households. However, the benefits of home gardens go beyond food and nutritional security, especially for resource-poor families, by contributing to income generation, improved livelihoods, and overall household economic welfare, as well as promoting entrepreneurship and rural development (Trinh, et.al. 2003; Calvet-Mir, et.al. 2012; Galhena, et.al. 2013). This study particularly focused on assessing the economic impacts of home gardens for different household categories.

The first objective of this thesis was to build production optimization models with fixed consumption for the following 6 specific household types: landless households, where land for agricultural production is zero, with and without home gardens; landholding households, where agricultural production is relatively large in terms of its share in the total household income (between 35-100%), with and without home gardens; landholding households, where agricultural production is relatively small in terms of its share in the total household income (below 35%), with and without home gardens. The study developed the models for sample households from each of the above mentioned categories by establishing technical coefficients and parameters from the literature and from analysis of data collected from all project households. The models were set up to optimize the net income of each individual farm household business from agriculture, home garden and other income-earning activities (based upon the household's production structure), over variable costs and expenditure, by changing the land, labor and fertilizer inputs for production, given the land and labor constraints of each household.

Using these optimization models, the study assessed the economic contribution of home gardens to these households under different circumstances. Under the baseline conditions, with actual reported prices of inputs and outputs, households have the potential to earn much higher net incomes, positive profits from the sale of home garden produce and save considerable amounts of money through home consumption of grown products. Among the household categories, the benefits accruing from home gardens were higher for agricultural minority households and least for landless households. Profits derived from home gardens had significant percentage contributions (20% and 39%) to the net income levels of agricultural minority households, which are important, since this respective household category constitutes 71% of the total sample population. However, less dietary diversity in the production structure caused landless households to accrue lower value or benefits from home gardens, relative to other households. Through the efficient management of small lands, these landless households can derive more diversity and profits from home gardens. Although the home gardens in the agricultural majority category provided the households with some additional profit and consumption value, the percentage contributions of home gardens were really small due to the households' higher net income levels. It was found that the households who cultivated more and diversified products were able to earn higher profits and consumption value.

Economic contributions of home gardens and net income variability under uncertain situations were assessed by applying input and output price market shocks to the models. Households were able to derive positive profits and consumption value from home gardens under all market fluctuations (except negative profits for landless households when home garden farm prices were lower and retail prices were higher). Farm households (Agricultural majority and minority) experienced dramatic shifts in the net income level under fluctuations in the output prices of major agricultural crops cultivated in their farms. The agricultural wage fluctuations resulted in major variability in the income situation of landless households. Due to the higher contributions of home gardens (both under baseline and uncertain scenarios), the agricultural minority households faced higher income variability during fluctuations in the farm and retail prices of home garden produce. It was found that under uncertain negative market conditions, households with home gardens (mainly in the agricultural majority category) were able to maintain more stable net incomes, in terms of their smaller percentage change from the baseline income level, compared to no-home garden households. After removing home gardens from the home garden sample households, in order to have better comparisons, the results indicated that households were better off when they had home gardens as part of their household activity and the negative effects on the net incomes were higher for the agricultural minority category. Simulating the household models across time from 1990-2012, with market variability in wages, prices and costs, showed higher means and lower coefficients of variation in the net income levels when the households had home gardens. All these results from the simulations pointed out that home gardens contributed positively to the overall economic situation of all households, with significant impacts for households who did not depend on agricultural production for their major source of revenue. These findings become more significant if you consider that 71% of the total sample population belongs to the agricultural minority category.

Although it was seen from the analysis of data that women (both female head and daughter in the household) are more involved in the production and maintenance of home gardens, the household models couldn't capture any specific relationship highlighting differences depending on the gender of the household head and the economic contribution of home garden to the household. The economic impacts of home gardens were more dependent on the types and number of crops cultivated, farm prices, land used and labor days allocated. The time-use data also did not find any significant -differences in the time allocations to home garden by the female and male headed households.

The last objective of the thesis was to look at whether maintaining a home garden has improved the livelihoods of households by supplementing income or food or by sharing produce. The data collected through the surveys had revealed that home consumption dominated in the usage of home garden produce, with marketing being very uncommon. Also, the households reported that they benefitted from more diversified and chemical-free foods in the household food basket, rather than supplementary income from sales. However, the optimized household models indicated that households can produce larger quantities of home garden products by adjusting the available resources, enabling them to earn considerable amount of income by selling the surplus produce. In this way, households could improve their livelihood by achieving both food and income security through the efficient use of home gardens. For most of the households, the marketed quantity dominated the own-consumed quantity in the optimized scenarios.

5. 2 Limitations and/ Recommendations for Further Research

A few tradeoffs were associated with the decision to have selected individual household models in this research. On one hand, developing models for individual households provide more accurate household level results since the data used are specific to the household and their characteristics. Developing household models using the average values from a category will not completely capture the variances in data due to the high variability in the range of data within the category itself. On the other hand, the data for individual households are sensitive, and therefore the results do not completely represent the sample population. As well households were modelled on the basis of their actual decisions made i.e., optimal production for the set of crops/home garden products they grew. Future analysis could illustrate potentially what are the optimal crops/products to grow given economic pressures. Estimating more rigorous dynamic costs for tree crops would be another way to enhance the quality of the analysis and determine whether or not tree crops should be grown by more households.

The annual average farm and market price data is used to derive the revenue and the food expenditures of the households. However, these prices are variable across a year and households' decision-making relating to the marketing or consumption of the produced quantities is dependent upon these changing prices. Households could sell all of their produce right away if the produce prices were high and buy the required amount of that product from the market for consumption later. Also, under low farm price situations, there is a possibility that households save their produce to sell later, when prices have increased. Due to the unavailability of weekly farm and retail prices, the household model could not capture these price effects on the household's decision making. Further studies could develop the household model to capture these effects.

In developing models across time, the produce and market price levels of crops cultivated in the home garden were kept constant at the baseline year data due to the lack of price data from 1990-2012. This could have had a great effect on the variability in net income of the household over time. Households were assumed to have produced the same agricultural products and the same home garden products across time. However, in reality the households may have adjusted their production of annual crops in response to different market and household characteristics over time and their actual revenue positions been very different based on annual crop selection.

Since the production structure of sample households includes tree crops such as coffee, arecanut and rubber, which are not annual crops, the study should be restructured as a dynamic model rather than as a series of static models. .The production structure of all the sample households in the agricultural majority category included the cultivation of tree crops. However, this was not prominent in the agricultural minority category with just one household involved in the tree crop production.

With only two female headed home garden households in the sample, the optimization model could not illustrate relationships between the gender of the household head and economic contribution of home gardens. However the time allocation data collected showed no significant differences in the time allocation to home gardens of the male and female headed households suggesting no impacts of gender on the economic value derived from home gardens.

In capturing the economic decision making of landless households over time, the model developed in the study only accounts for the influence of agricultural wages. Further studies could focus on developing a more inclusive model for landless households to capture all the decisions made by those households – and perhaps better capturing collective home gardening which is a more important scenario for those households - since these are the households who require more benefits from social, economic and policy perspectives.

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APPENDIX A

Table a.1: Production Level of Major Agricultural Crops in Wayanad District from 1990-2012 (in Kgs)

Year	*Rice*	*Coffee*	*Arecanut*	*Ginger*	*Rubber*	*Plantain*
1990	41974000	16060000	2800000	23019000	2586000	7922000
1991	42883000	16730000	3430000	28978000	2426000	9200000
1992	50337000	32020000	4600000	25901000	2575000	10679000
1993	46609000	36460000	6330000	18653000	2740000	15776000
1994	50492000	36460000	4750000	26654000	2879000	12688000
1995	46654000	33800000	6010000	22394000	3015000	11915000
1996	37563000	34820000	7580000	24857000	3217000	13199000
1997	39733000	38259000	2011000	22369000	3561000	12068000
1998	34689000	39126000	1478000	22717000	3828000	15050000
1999	44761000	48180000	1736000	21965000	3907000	26798000
2000	33802000	58500000	2699000	20984000	3955000	19078000
2001	32076000	54110000	2682000	18084000	4038000	16210000
2002	31326000	52697000	3237000	15164000	4753000	14283000
2003	28421000	54650000	4192000	21257000	6230000	13329000
2004	29206000	45775000	5711000	32376000	6685000	12928000
2005	28385000	50025000	6035000	38823000	6722000	15766000
2006	30722000	49000000	5617000	23385000	8710000	11651000
2007	32079000	40240000	4627000	17054000	8085000	10984000
2008	33861000	47510000	5518000	19713000	8600000	10679000
2009	33157000	49950000	5385000	18439000	8400000	7487000
2010	27911000	55275000	7062000	19414000	9000000	6668000
2011	23526000	57350000	6079000	20028000	9570000	9850000
2012	28052000	57350000	5796000	11846000	9570000	7211000

Sources: Agricultural Statistics publications by Department of Economics and Statistics, Kerala (Wayanad & Vikas Bhavan, Thiruvanathapuram)

Table a.2: Farm Prices of Major Agricultural Crops in Wayanad District from 1990-2012 (Rs/Kg)

Year	*Rice*	*Coffee*	*Arecanut*	*Ginger*	*EFY*	*Rubber**	*Plantain*
1990	2.76	24.23	20.63	5.11	1.12	21.29	3.00
1991	3.67	26.67	27.43	3.57	1.95	21.41	3.76
1992	3.96	27.20	27.48	4.35	2.91	25.50	4.15
1993	3.95	32.48	43.75	6.12	3.33	25.69	4.93
1994	4.85	49.48	45.00	8.51	2.83	36.38	6.15
1995	5.17	69.73	50.00	10.59	3.11	52.04	5.78
1996	5.67	54.10	19.59	7.75	3.34	49.01	7.42
1997	5.20	57.17	19.15	6.23	3.69	35.80	6.99
1998	6.34	64.23	57.30	12.31	5.03	29.94	7.61
1999	6.40	53.38	43.69	18.69	3.69	30.99	6.57
2000	6.63	34.73	25.00	14.19	2.85	30.36	7.80
2001	5.57	24.14	17.00	5.81	3.29	32.28	7.23
2002	5.83	25.01	25.00	6.48	5.54	39.19	6.98
2003	6.55	29.83	31.00	15.51	7.74	50.40	8.49
2004	6.58	30.68	23.41	20.12	6.64	55.71	10.14
2005	5.55	46.50	24.82	14.18	6.03	66.99	8.36
2006	6.18	54.56	27.50	6.46	5.10	92.04	10.52
2007	6.91	67.63	35.03	12.64	4.84	90.85	11.94
2008	8.73	84.42	27.75	25.07	5.14	101.12	9.68
2009	9.02	72.33	58.90	28.57	8.93	114.98	18.92
2010	11.03	69.92	63.03	30.75	16.30	190.03	17.21
2011	10.06	95.50	107.98	15.78	14.15	208.05	14.33
2012	11.70	124.71	126.23	20.00	23.53	177.78	25.43

Sources: Market price reports by Krishi Bhavan, Wayanad
Price Statistics publications by Department of Economics and Statistics, Kerala (Wayanad & Vikas Bhavan, Thiruvanathapuram)
**Rubber prices in Kerala (*Indian Rubber Statistics, Rubber board of India)

Table a.3: Market Retail Prices of Major Food Crops in Wayanad District from 1990-2012 (Rs/Kg)

Year	Rice	EFY	Ginger	Plantain
1990	5.36	2.22	6.55	5.96
1991	5.66	3.26	4.08	6.40
1992	7.59	4.17	5.96	5.21
1993	8.28	4.84	7.4	6.40
1994	8.7	4.24	12.5	7.71
1995	9.8	4.88	15.15	7.94
1996	10.15	5	13.15	7.89
1997	11.21	6.2	11.53	9.33
1998	11.51	7.07	15.26	8.89
1999	13.15	7.07	29.37	9.14
2000	12.82	6.33	20.5	10.45
2001	12.15	6.95	14.58	11.52
2002	11.985	9.66	13.55	10.08
2003	12.53	13.08	24.75	10.29
2004	19.54	11.33	30.55	14.73
2005	12.15	10.65	14	11.45
2006	13.26	9.28	12.41	14.21
2007	14.1	7.91	19.88	14.57
2008	17.23	8.52	30.38	21.94
2009	18.44	10	45.94	18.10
2010	23.86	26.74	31.5	17.03
2011	24.75	26.76	32.24	19.11
2012	27.58	28	33.625	28.08

Sources: Market price reports by Krishi Bhavan, Wayanad
Price Statistics publications by Department of Economics and Statistics, Kerala (Wayanad & Vikas Bhavan, Thiruvanathapuram)

Table a.4: Fertilizer prices in India from 1990-2012 (Rs/Kg)

Year	*Urea*	*NPK*
1990	2.35	3.50
1991	3.23	4.00
1992	2.76	6.00
1993	2.76	6.00
1994	3.25	6.96
1995	3.25	8.28
1996	3.55	7.41
1997	3.66	7.30
1998	3.91	7.30
1999	4.00	7.57
2000	4.60	7.84
2001	4.60	8.07
2002	4.83	8.37
2003	4.83	8.31
2004	4.83	8.31
2005	4.83	8.31
2006	4.83	8.31
2007	4.83	8.31
2008	4.83	7.57
2009	4.83	6.84
2010	5.31	14.06
2011	5.31	16.50
2012	5.34	17.40

Source: Department of Fertilizers, India

Table a.5 Rural and Urban Agricultural Wages in Wayanad from 1990-2012

Year	Rural (male)	Rural (female)	Urban (male)	Urban (female)
1990	28.00	20.00	30.00	22.00
1991	30.00	20.32	35.00	25.16
1992	45.00	25.00	50.00	30.00
1993	50.00	30.00	57.08	35.00
1994	55.00	35.00	60.00	40.00
1995	60.00	40.00	65.00	45.00
1996	71.67	46.67	80.00	51.67
1997	78.48	51.74	86.74	58.48
1998	90.00	55.00	100.00	65.00
1999	95.00	56.25	110.00	67.50
2000	100.00	61.04	120.00	72.50
2001	98.75	55.52	118.33	73.43
2002	85.00	55.00	100.00	60.00
2003	85.00	55.00	100.00	60.00
2004	88.75	56.25	105.00	62.50
2005	92.50	57.50	110.00	65.00
2006	100.00	60.00	110.00	65.00
2007	114.71	68.82	126.18	76.32
2008	125.00	75.83	143.75	86.25
2009	145.83	130.42	191.66	141.66
2010	187.50	137.50	220.83	170.83
2011	225.00	150.00	250.00	175.00
2012	250.00	170.55	275.00	200.50

Source: Krishi Bhavan, Wayanad

Table a.6 Monthly Rainfall Statistics in Wayanad from 1985-2013 (in mm)

Year	January	February	March	April	May	June	July	August	Septembe	October	Novembe	December	Annual
1985	13.6	3.4	75.8	93	56	574.6	178.6	313.2	114.5	109.4	170.2	26	1728.3
1986	72.4	49.2	93.6	139.1	76.4	425.9	197.5	401.6	99	200.4	37.1	26.4	1818.6
1987	0.4	0	0	63.7	247.2	263.5	136.6	263.4	171.4	143.4	136.9	0	1426.5
1988	0	61.6	74.4	126	84.6	275.8	524.4	336.7	385.2	96	9	12	1985.7
1989	0	0	65.6	95.2	140.8	284.6	618.4	221.2	149.2	234.2	13.4	0	1822.6
1990	23.8	13.8	27.8	39.4	229.8	208	268.8	373.8	48	376.2	59.8	12.2	1681.4
1991	1	34	43.8	156.2	192.6	397.3	395.12	365	83.8	215.2	102.4	0	1986.42
1992	0	0	0	44.4	234	587	535.2	315.2	196	181.6	224.8	0	2318.2
1993	11.6	0	69.8	197.8	225.8	377.6	483.6	271.6	66.4	335	46.4	47.6	2133.2
1994	74.6	0.6	15.8	202.6	198	541.2	885.6	238	172.2	231	131.2	0	2690.8
1995	1.6	19.6	2.6	261.2	253.4	255.2	513.6	442	229.8	222.6	116	0	2317.6
1996	19.2	0	0	131.6	0	446.4	408.8	251.4	256.2	368.4	49.8	50.6	1982.4
1997	21	21.8	53.8	138.6	101.8	305	527.4	380.4	164	237	160.6	40	2151.4
1998	0.6	0	35.8	61.2	96.8	353.2	524.8	200	133.5	167.6	120.6	34.4	1728.5
1999	16	0	18.4	100.2	136.2	187.2	435.8	192.8	36	395	40.6	0.6	1558.8
2000	0.8	1.4	1.4	110.8	107	335	222.4	395.3	271.5	138.2	53.8	106.2	1743.8
2001	0	47.2	12	12	101.6	232	313	194.1	140.8	100.2	88.8	10.2	1446.1
2002	0	0.6	29	93.4	89	170.4	168.2	219.4	48.2	266.1	24.2	0	1108.5
2003	4.8	16	104.2	131.4	74.6	208	281.4	211.8	55.6	349.63	83.2	0	1520.63
2004	0	10	35.8	132.4	258.6	384.2	299.4	357.8	142	171.2	108.4	0	1899.8
2005	25.6	2.8	54.2	147	96.6	270.6	697.2	278.8	166.2	317.6	99	12.6	2168.2
2006	30	0	85.4	97	349.2	333	375.8	272	240.4	99.4	165.6	0	2047.8
2007	1.2	16.2	5.2	94.8	135.2	284.8	619.4	398.8	262.4	170.4	26.8	8	2023.2
2008	0	41.2	178.8	75.2	66.2	224.2	277.4	358.4	89.6	401.8	15.2	3	1731
2009	0	0	118	30	121.4	214	901.2	131.6	197.2	110.8	218.2	35	2077.4
2010	68.4	25.4	12.4	80.6	124.6	270.2	478.2	249	90.8	167.8	279.6	4.8	1851.8
2011	0	38.8	50	184.8	82.2	510.6	362.8	354.6	179	245.6	61	0	2069.4
2012	1	1.4	14.6	167	89.6	185.2	129.6	348.2	170	80.8	124.4	9	1320.8
2013	0	7.6	139	77.6	91.4	646.2	626.4	286.6	193.4	156	42.2	2.4	2268.8

Sources: Krishi Vigyan Kendra (Regional Agricultural Research Station), Ambalavayal, Wayanad
Kerala Agricultural University
Regional Coffee Research Station (RCRS), Chundale, Wayanad
Agricultural Statistics (DES, Wayanad & Thiruvanathapuram)

a.7 Adjustments in decision variables under optimizations: Actual, baseline and uncertain scenarios

Table a.7.1 AG Majority with Home Garden Household (HH 281)

HH 281- AG Majority with Home Garden	AG Acreage					Family Labor						Hired Labor					HG family labor days	Fertilizer qty				
	Paddy	*Coffee*	*Arecanut*	*Ginger*	*EFY*	*Paddy*	*Coffee*	*Arecanut*	*Ginger*	*EFY*	*Total*	*Paddy*	*Coffee*	*Arecanut*	*Ginger*	*EFY*		*Paddy*	*Coffee*	*Arecanut*	*Ginger*	*EFY*
Actual	0.500	0.600	0.600	0.200	0.250	6.00	7.00	6.00	9.00	8.00	36.00	23.00	18.00	12.00	14.00	8.00	26	40.00	50.00	50.00	50.00	50.00
Baseline	0.040	0.091	0.091	0.141	1.277	0.00	13.26	0.00	17.51	0.00	30.77	40.00	15.77	25.00	23.01	40.00	31	3.62	13.72	1.23	56.43	383.16
Wages up	0.048	0.221	0.221	0.131	1.150	0.00	9.14	21.21	0.00	13.65	44.00	11.65	20.86	3.79	11.79	7.23	18	1.00	23.14	19.90	35.41	345.01
Wages down	0.044	0.213	0.213	0.208	1.085	0.00	0.00	0.00	0.00	0.00	0.00	40.00	15.85	25.00	60.00	40.00	62	1.38	0.84	19.16	83.02	313.29
AG farm prices up	0.038	0.252	0.252	0.285	0.975	20.76	15.09	0.00	0.00	0.00	35.85	19.24	6.94	25.00	60.00	40.00	26	3.43	8.90	22.70	114.04	91.07
AG farm prices down	0.023	0.052	0.052	0.018	1.457	15.38	7.93	3.37	0.00	0.00	26.68	0.00	5.80	0.00	0.25	40.00	35	2.05	3.28	4.71	0.34	255.86
Fert prices up	0.018	0.116	0.116	0.118	1.297	0.00	0.00	0.00	0.00	0.00	0.00	15.81	30.00	25.00	7.17	40.00	62	0.70	10.68	10.47	17.40	307.94
Fert prices down	0.061	0.127	0.127	0.057	1.305	1.11	1.29	15.14	26.30	0.00	43.84	18.42	23.34	0.00	0.87	40.00	18	5.46	19.12	11.47	22.64	391.57
HG farm prices up	0.041	0.103	0.103	0.080	1.326	7.92	0.22	0.00	0.00	0.00	8.14	32.08	28.98	25.00	16.42	40.00	54	3.66	15.41	9.25	32.12	349.54
HG farm prices down	0.130	0.130	0.130	0.004	1.286	0.00	0.00	0.00	0.00	27.77	27.77	40.00	30.00	10.57	8.05	10.23	34	11.69	19.53	6.78	0.60	385.69
HG retail prices up	0.011	0.151	0.151	0.053	1.335	4.50	3.37	14.90	4.97	1.22	28.96	18.31	25.44	7.27	29.36	36.98	33	0.69	16.08	9.57	20.22	270.30
HG retail prices down	0.019	0.061	0.061	0.328	1.142	14.88	29.12	0.00	0.00	0.00	44.00	10.59	0.88	7.55	60.00	40.00	18	1.72	3.65	2.37	108.88	342.53

Table a.7.2 AG Majority with Home Garden Household (HH 546)

HH 546- AG Majority with Home Garden	AG Acreage						Family Labor							Hired Labor						HG family labor days	Fertilizer qty					
	Paddy	*Coffee*	*Arecanut*	*Ginger*	*EFY*	*Rubber*	*Paddy*	*Coffee*	*Arecanut*	*Ginger*	*EFY*	*Rubber*	*Total*	*Paddy*	*Coffee*	*Arecanut*	*Ginger*	*EFY*	*Rubber*		*Paddy*	*Coffee*	*Arecanut*	*Ginger*	*EFY*	*Rubber*
Actual	0.500	2.000	2.000	0.150	0.200	1.000	10.00	8.00	6.00	9.00	4.00	20.00	57.00	20.00	10.00	2.00	8.00	6.00	2.00	12	60.00	0.00	0.00	20.00	20.00	70.00
Baseline	0.202	2.927	2.927	0.156	0.140	0.426	0.00	0.00	16.88	0.00	8.40	8.51	33.80	3.91	20.63	8.12	60.00	16.71	0.85	35	0.67	100.45	263.43	55.22	41.86	46.82
Wages up	0.141	2.517	2.517	0.145	0.251	0.795	39.02	0.00	2.37	0.00	3.71	15.90	61.00	0.98	2.51	22.63	7.26	19.46	1.59	8	18.69	377.62	226.57	2.73	8.54	5.06
Wages down	0.041	3.367	3.367	0.083	0.174	0.186	23.90	0.00	24.45	0.00	3.96	3.71	56.03	9.75	0.03	0.55	21.33	2.71	0.37	13	6.10	220.31	303.01	2.76	52.11	20.43
AG farm prices up	0.193	2.829	2.829	0.033	0.504	0.292	0.00	0.00	6.95	0.00	10.21	5.83	22.99	40.00	30.00	18.03	52.13	6.83	0.58	46	0.07	424.32	254.59	13.02	31.07	32.07
AG farm prices down	0.122	2.775	2.775	0.634	0.021	0.297	0.00	0.00	4.71	13.96	0.00	5.95	24.62	2.68	15.93	20.29	12.04	40.00	0.59	44	3.16	91.76	189.39	94.73	2.12	15.34
Fert prices up	0.035	2.872	2.872	0.462	0.075	0.405	0.00	13.25	0.00	0.00	23.68	8.09	45.02	40.00	15.29	24.14	60.00	7.17	0.81	24	5.30	14.77	258.51	99.91	3.17	10.57
Fert prices down	0.014	3.662	3.662	0.013	0.075	0.087	0.00	0.48	22.01	0.00	0.00	1.74	24.23	7.39	11.56	2.99	60.00	2.75	0.17	45	1.01	96.59	329.54	5.10	4.96	9.59
HG farm prices up	0.204	3.370	3.370	0.051	0.120	0.105	0.00	0.00	7.98	0.75	0.00	2.09	10.82	24.13	0.46	17.02	59.25	5.32	0.21	58	30.67	307.30	303.33	2.43	36.00	4.10
HG farm prices down	0.308	2.955	2.955	0.032	0.112	0.443	11.60	0.53	0.00	0.00	40.00	8.86	61.00	28.40	20.34	25.00	2.36	0.00	0.89	8	13.25	301.98	265.97	2.00	6.24	7.52
HG retail prices up	0.221	2.665	2.665	0.570	0.381	0.012	0.00	0.00	15.01	0.00	6.70	0.24	21.96	17.42	15.15	9.99	3.53	0.85	0.02	47	6.35	73.61	239.82	64.67	5.04	1.34
HG retail prices down	0.043	3.483	3.483	0.129	0.004	0.191	0.00	23.11	0.00	0.00	0.00	3.83	26.94	1.34	6.89	25.00	60.00	40.00	0.38	42	6.39	50.32	313.43	47.03	0.57	7.56

Table a.7.3 AG Majority without Home Garden Household (HH 300)

HH 300 - AG Majority without Home Garden																	
	AG Acreage				Family Labor					Hired Labor				Fertilizer qty			
	Paddy	*Coffee*	*Arecanut*	*EFY*	*Paddy*	*Coffee*	*Arecanut*	*EFY*	*Total*	*Paddy*	*Coffee*	*Arecanut*	*EFY*	*Paddy*	*Coffee*	*Arecanut*	*EFY*
Actual	0.5	1.5	1.5	0.5	8	12	10	8	38	26.00	50.00	68.00	10.00	50.00	200.00	200.00	50.00
Baseline	0.006	1.922	1.922	0.571	0	0	0	38	38	7.25	75.00	90.00	0.00	0.67	288.37	288.37	171.45
Wages up	0.007	1.558	1.558	0.935	7	0	31	0	38	24.50	75.00	58.76	40.00	0.72	204.97	233.69	280.51
Wages down	0.008	1.925	1.925	0.567	0.93	0	0	37.07	38	39.07	75.00	90.00	2.93	0.86	288.76	288.76	168.66
AG farm prices up	0.006	2.054	2.054	0.441	0	0	0	38	38	15.27	75.00	90.00	2.00	0.61	308.08	308.08	132.17
AG farm prices down	0.120	1.944	1.944	0.436	20	6	9	2	38	14.04	68.61	74.87	12.65	13.19	203.72	291.58	24.51
Fert prices up	0.013	1.903	1.903	0.585	38	0	0	0	38	0.00	75.00	90.00	40.00	1.38	285.39	285.39	175.45
Fert prices down	0.011	2.309	2.309	0.180	23	0	0	15	38	0.00	75.00	90.00	1.10	0.89	346.28	346.28	54.12

Table a.7.4 AG Majority without Home Garden Household (HH 137)

HH 137 - AG Majority without Home Garden													
	AG Acreage			Family Labor				Hired Labor			Fertilizer qty		
	Plantain	*Coffee*	*Arecanut*	*Plantain*	*Coffee*	*Arecanut*	*Total*	*Plantain*	*Coffee*	*Arecanut*	*Plantain*	*Coffee*	*Arecanut*
Actual	0.4000	1.0000	1.0000	7.00	5.00	8.00	20.00	20.00	10.00	10.00	200.00	200.00	200.00
Baseline	0.0612	1.3388	1.3388	0.00	0.00	20.00	20.00	16.16	30.00	5.00	31.22	301.23	301.23
Wages up	0.0001	1.3999	1.3999	0.00	20.00	0.00	20.00	0.02	10.00	25.00	0.08	189.18	314.97
Wages down	0.0074	1.3926	1.3926	0.00	20.00	0.00	20.00	2.01	10.00	25.00	3.75	313.34	313.34
AG farm prices up	0.0005	1.3995	1.3995	0.23	0.00	19.77	20.00	1.96	30.00	5.23	0.22	277.86	314.88
AG farm prices down	12.7150	62.3500	63.1150	0.00	18.47	1.53	20.00	2.01	11.53	23.47	38.01	57.64	202.77
Fert prices up	0.1150	1.2850	1.2850	3.57	0.00	16.43	20.00	0.00	30.00	8.57	58.63	289.13	289.13
Fert prices down	0.0038	1.3962	1.3962	0.00	0.00	20.00	20.00	1.59	30.00	5.00	1.93	314.15	314.15

Table a.7.5 AG Minority with Home Garden Household (HH 192)

HH 192 - AG Minority with Home Garden	AG Acreage				Family Labor					Hired Labor				HG family labor days	Fertilizer qty			
	Paddy	*Coffee*	*Arecanut*	*EFY*	*Paddy*	*Coffee*	*Arecanut*	*EFY*	*Total*	*Paddy*	*Coffee*	*Arecanut*	*EFY*		*Paddy*	*Coffee*	*Arecanut*	*EFY*
Actual	0.5000	0.3900	0.3900	0.5000	0	1	0	0	1	35	7	5	25	8	25.00	40.00	150.00	100.00
Baseline	0.0218	0.0138	0.0138	1.3544	0	0	0	0	0	1	10	0	33	9	1.73	0.73	0.94	333.77
Wages up	0.0001	0.0120	0.0120	1.3779	0	0	0	0	0	0	0	0	32	9	0.00	0.07	1.35	323.29
Wages down	0.0412	0.0003	0.0003	1.3485	1	2	0	0	3	24	0	0	40	6	3.71	0.00	0.05	404.54
AG farm prices up	0.0001	0.0362	0.0362	1.3537	0	0	0	0	0	0	0	1	40	9	0.01	5.43	4.59	406.11
AG farm prices down	0.0026	0.0111	0.0111	1.3763	1	0	0	2	3	0	1	0	12	6	0.15	0.82	2.09	211.23
Fert prices up	0.0023	0.0010	0.0010	1.3867	0	0	3	0	3	7	6	0	40	6	0.16	0.12	0.04	312.68
Fert prices down	0.1064	0.0037	0.0037	1.2799	0	0	0	0	0	19	5	0	40	9	9.58	0.56	0.26	383.96
HG farm prices up	0.0308	0.0009	0.0009	1.3583	0	1	0	0	1	25	0	1	33	8	0.46	0.13	0.01	255.01
HG farm prices down	0.0011	0.0006	0.0006	1.3883	0	0	0	1	2	22	3	3	28	7	0.10	0.02	0.23	416.49
HG retail prices up	0.0024	0.0090	0.0090	1.3786	0	0	0	4	4	11	4	1	36	5	0.04	1.04	1.17	270.16
HG retail prices down	0.0026	0.0039	0.0039	1.3835	0	0	0	0	0	1	0	0	40	9	0.23	0.06	0.38	396.01

Table a.7.6 AG Minority with Home Garden Household (HH 816)

HH 816 - AG Minority with Home Garden	AG Acreage		Family Labor			Hired Labor		HG family labor days	Fertilizer quantity	
	Ginger	*EFY*	*Ginger*	*EFY*	*Total*	*Ginger*	*EFY*		*Ginger*	*EFY*
Actual	0.1	0.1	4.00	8.00	12	3.00	2.00	25	25.00	25.00
Baseline	0.199	0.001	0.74	0.00	1	13.14	5.27	36	68.64	0.06
Wages up	0.099	0.101	0.00	0.00	0	0.17	2.90	37	7.84	30.26
Wages down	0.186	0.014	0.00	0.00	0	60.00	40.00	37	74.27	4.30
AG farm prices up	0.161	0.039	0.00	0.00	0	0.01	6.15	37	2.34	11.83
AG farm prices down	0.194	0.006	0.00	0.00	0	4.48	0.11	37	77.63	1.78
Fert prices up	0.160	0.040	0.00	0.00	0	5.03	7.73	37	63.93	12.05
Fert prices down	0.174	0.026	0.00	0.00	0	6.35	0.03	37	69.42	7.93
HG farm prices up	0.160	0.040	0.00	0.00	0	0.25	0.55	37	0.41	12.13
HG farm prices down	0.119	0.081	9.36	4.94	14	5.50	2.74	23	47.54	24.34
HG retail prices up	0.138	0.062	4.79	7.99	13	0.00	0.29	24	28.33	18.56
HG retail prices down	0.172	0.028	3.84	1.36	5	2.00	0.00	32	31.26	8.37

Table a.7.7 AG Minority without Home Garden Household (HH 722)

HH 722 - AG Minority without Home Garden												
	AG Acreage		Family Labor			Hired Labor		Total Labor		Fertilizer qty	
	Paddy	*EFY*	*Paddy*	*EFY*	*Total*	*Paddy*	*EFY*	*Paddy*	*EFY*	*Paddy*	*EFY*
Actual	0.4	0.4	10	16	26	10.00	10.00	20	26	25.00	100.00
Baseline	0.005	0.795	0	26	26	12.64	14.00	13	40	0.42	238.61
Wages up	0.007	0.793	0	26	26	12.12	7.65	12	34	0.63	237.86
Wages down	0.009	0.791	0	26	26	40.00	14.00	40	40	0.82	237.28
AG farm prices up	0.004	0.796	0	26	26	13.00	14.05	13	40	0.32	238.76
AG farm prices down	0.010	0.790	0	26	26	11.72	0.00	12	26	0.90	237.02
Fert prices up	0.005	0.795	0	26	26	12.62	13.98	13	40	0.43	238.10
Fert prices down	0.005	0.795	0	26	26	12.68	14.00	13	40	0.41	238.65

Table a.7.8 AG Minority without Home Garden Household (HH 264)

HH 264- AG Minority without Home Garden											
	AG Acreage		Family Labor			Hired Labor		Total Labor		Fertilizer qty	
	Plantain	*EFY*	*Plantain*	*EFY*	*Total*	*Plantain*	*EFY*	*Plantain*	*EFY*	*Plantain*	*EFY*
Actual	0.5000	1.0000	15	23	38	6.00	5.00	21	28	75.00	60.00
Baseline	0.0000	1.5000	0	38	38	0.00	2.00	0	40	0.01	450.00
Wages up	0.0022	1.4978	1	37	38	0.00	2.72	1	40	1.11	449.34
Wages down	0.0004	1.4996	0	38	38	0.02	2.00	0	40	0.18	449.89
AG farm prices up	0.0007	1.4993	0	38	38	0.09	2.00	0	40	0.34	445.90
AG farm prices down	0.0071	1.4929	0	38	38	0.02	2.34	0	40	3.54	447.79
Fert prices up	0.0004	1.4996	0	38	38	0.02	2.00	0	40	0.22	449.87
Fert prices down	0.0012	1.4988	0	38	38	0.09	2.00	0	40	0.50	449.65

a.8 Changes in production, sales and consumption of agricultural and home garden crops: actual and model optimum values

Table a.8.1 *AG Majority with Home Garden Household (HH 281)*

	Agriculture					Home Garden												
	Paddy	*Coffee*	*Arecanut*	*Ginger*	*EFY*	Tomato	Ladies finger	Red amaranthus	Bittergourd	Ash gourd	Pumpkin	Chowchow	Banana	Drumstick	Mango	Coconut	Turmeric	Other
	Acreage																	
Actual	0.5	0.6	0.6	0.2	0.25	0.001034	0.001034	0.001034	0.001034	0.001034	0.001034	0.001034	0.001034	0.001034	0.001034	0.001034	0.001034	0.017586
Optimum	0.040	0.091	0.091	0.141	1.277	0.00101	0.00101	0.00101	0.00101	0.00101	0.00101	0.00101	0.00101	0.00101	0.00101	0.00101	0.00101	0.01788
	Production																	
Actual	1200	140	340	840	960	6.00	6.00	8.00	6.00	15.00	10.00	15.00	20	8	15	50	25	130
Optimum	1295.95	112.14	77.89	1125.41	4256.14	7.04	7.04	9.38	7.04	17.59	11.73	17.59	23.45279	9.381118	17.5896	58.63199	29.31599	157.39
	Marketed quantity																	
Actual	700.58	140	340	839.22	953.24	3.00	0.80	0.00	2.40	0.00	0.00	3.00	12.8	0	1.74	0	0	66.75
Optimum	796.53	112.14	77.89	1124.63	4249.38	4.04	1.84	0.02	3.44	0.00	0.00	5.59	16.25279	0.281118	4.329596	0	4.315993	91.37
	Own consumption quantity																	
Actual	499.42			0.78	6.76	3.00	5.20	8.00	3.60	15.00	10.00	12.00	7.2	8	13.26	50	25	63.25
Optimum	499.42			0.78	6.76	3.00	5.20	9.36	3.60	17.59	11.73	12.00	7.2	9.1	13.26	58.63199	25	66.01
	Purchased quantity																	
Actual	0.00			0.00	0.00	0.00	0.00	1.36	0.00	11.00	3.00	0.00	0	1.1	0	24.46	0	23.70
Optimum	0.00			0.00	0.00	0.00	0.00	0.00	0.00	8.41	1.27	0.00	0	0	0	15.82801	0	20.94

Table a.8.2 <u>AG Majority with Home Garden Household (HH 546)</u>

	Agriculture						Home Garden								
	Paddy	***Coffee***	***Arecanut***	***Ginger***	***EFY***	***Rubber***	**Cowpea**	**Bitter gourd**	**Red Amaranthus**	**Mango**	**Guava**	**Jackfruit**	**Suppota**	**Rose Apple**	**Tulsi**
Acreage															
Actual	0.500	2.000	2.000	0.150	0.200	1.000	0.001111	0.001111	0.001111	0.001111	0.001111	0.001111	0.001111	0.001111	0.001111
Optimum	0.202	2.927	2.927	0.156	0.140	0.426	0.0001	0.0092	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Production															
Actual	1000	200	900	2100	960	600	25.00	5.00	10.00	50.00	5.00	50.00	5.00	5.00	2.00
Optimum	103.28	551.73	35145.43	5846.82	1018.96	260.35	6.60	121.45	2.64	13.20	1.32	13.20	1.32	1.32	0.53
Marketed quantity															
Actual	635.00	200	900	2096.35	856.00	600	17.20	0.00	2.80	16.20	0.00	16.20	0.00	0.00	0.00
Optimum	0.00	551.73	35145.43	5843.17	914.96	260.35	0.00	111.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Own consumption quantity															
Actual	365.00			3.65	104.00		7.80	5.00	7.20	33.80	5.00	33.80	5.00	5.00	2.00
Optimum	103.28			3.65	104.00		6.60	10.40	2.64	13.20	1.32	13.20	1.32	1.32	0.53
Purchased quantity															
Actual	0.00			0.00	0.00		0.00	5.40	0.00	0.00	7.00	0.00	8.00	8.00	0.00
Optimum	261.72			0.00	0.00		1.20	0.00	4.56	20.60	10.68	20.60	11.68	11.68	1.47

Table a.8.3 <u>AG Minority with Home Garden Household (HH 192)</u>

	Agriculture				Home Garden									
	Paddy	***Coffee***	***Arecanut***	***EFY***	**EFY**	**Diascorrea**	**Colocasia**	**Jackfruit**	**Papaya raw**	**Red amaranthus**	**Mango**	**Coconut**	**Turmeric**	**Others**
	Acreage													
Actual	0.5	0.39	0.39	0.5	0.000714	0.0007143	0.000714	0.000714	0.000714	0.00071429	0.000714	0.000714	0.000714	0.003571
Optimum	0.022	0.014	0.014	1.354	0.0087	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0005
	Production													
Actual	500	15.6	15.6	1050	25.00	20.00	15.00	20.00	14.00	2.00	20.00	130.00	20.00	26
Optimum	9.65	8.97	0.41	2422.34	342.56	3.15	2.36	3.15	2.21	0.32	3.15	20.48	3.15	4.095
	Marketed quantity													
Actual	226.25	15.60	15.60	1043.50	18.50	0.00	0.00	0.00	0.00	0.00	0.00	92.77	19.64	11.584
Optimum	0.00	8.97	0.41	2415.84	336.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.79	1.474
	Own consumption quantity													
Actual	273.75			6.50	6.50	20.00	15.00	20.00	14.00	2.00	20.00	37.23	0.36	14.416
Optimum	9.65			6.50	6.50	3.15	2.36	3.15	2.21	0.32	3.15	20.48	0.37	2.621
	Purchased quantity													
Actual	0.00			0.00	0.00	0.00	37.00	32.00	4.00	4.50	6.00	0.00	0.00	0
Optimum	264.10			0.00	0.00	16.85	49.64	48.85	15.80	6.19	22.85	16.76	0.00	11.795

Table a.8.4 AG Minority with Home Garden Household (HH 816)

	Agriculture		Home Garden									
	Ginger	*EFY*	Brinjal	Bittergourd	Diascorrea	Jackfruit raw	Papaya raw	Mango	Jack fruit	Papaya	Rose apple	Other
	Acreage											
Actual	0.1	0.1	0.001111	0.001111	0.001111	0.001111	0.001111	0.001111	0.001111	0.001111	0.001111	0.02
Optimum	0.199	0.001	0.0001	0.0001	0.0001	0.0274	0.0001	0.0001	0.0001	0.0001	0.0001	0.0018
	Production											
Actual	240	120	10.00	7.00	6.00	200.00	80.00	60.00	300.00	30.00	8.00	69.00
Optimum	536.67	2.45	1.31	0.91	0.78	7154.01	10.44	7.83	39.16	3.92	1.04	9.01
	Marketed quantity											
Actual	236.00	88.80	0.00	4.00	0.00	187.00	74.00	19.18	274.00	24.00	0.00	1.90
Optimum	532.67	0.00	0.00	0.00	0.00	7141.01	4.44	0.00	13.16	0.00	0.00	0.00
	Own consumption quantity											
Actual	4.00	31.20	10.00	3.00	6.00	13.00	6.00	40.82	26.00	6.00	8.00	67.10
Optimum	4.00	2.45	1.31	0.91	0.78	13.00	6.00	7.83	26.00	3.92	1.04	9.01
	Purchased quantity											
Actual	0.00	0.00	0.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	56.70
Optimum	0.00	28.75	9.09	2.09	5.22	0.00	0.00	32.99	0.00	2.08	6.96	114.79

Table a.8.5 AG Majority without Home Garden Households (HH 300 & HH 137)

Agricultural Production							
	HH 300				HH 137		
	Paddy	***Coffee***	***Arecanut***	***EFY***	***Plantain***	***Coffee***	***Arecanut***
	Acreage						
Actual	0.5	1.5	1.5	0.5	0.4	1	1
Optimum	0.006	1.922	1.922	0.571	0.061	1.339	1.339
	Production						
Actual	1000	1300	1100	1320	400	170	700
Optimum	166.20	1606.44	1394.16	1943.05	90.55	315.96	980.75
	Marketed quantity						
Actual	817.50	1300	1100	1313.50	397.40	170	700
Optimum	0.00	1606.44	1394.16	1936.55	87.95	315.96	980.75
	Own consumption quantity						
Actual	182.50			6.50	2.60		
Optimum	166.20			6.50	2.60		
	Purchased quantity						
Actual	0.00			0.00	0.00		
Optimum	16.30			0.00	0.00		

Table a.8.6 AG Minority without Home Garden Households (HH 722 & HH 264)

Agricultural Production				
	HH 722		HH 264	
	Paddy	***EFY***	***Plantain***	***EFY***
	Acreage			
Actual	0.4	0.4	0.5	1
Optimum	0.005	0.795	0.000010	1.500
	Production			
Actual	600	2400	800	4200
Optimum	273.75	4550.56	0.02	7202.17
	Marketed quantity			
Actual	326.25	2393.50	784.40	4194.8
Optimum	0.00	4544.06	0.00	7196.97
	Own consumption quantity			
Actual	273.75	6.50	15.60	5.20
Optimum	273.75	6.50	0.02	5.20
	Purchased quantity			
Actual	0.00	0.00	0.00	0.00
Optimum	0.00	0.00	15.58	

Table a.8.7 <u>*Landless with Home Garden Household (HH 293)*</u>

	Home Garden								
	Beans	Cowpea	Pumpkin	Colocasia	Papaya raw	Red Amaranthus	Jackfruit	Chilli	Turmeric
					Acreage				
Actual	0.005556	0.005556	0.005556	0.005556	0.005555556	0.005556	0.005556	0.005555556	0.005556
Optimum	0.001	0.011111	0.001	0.001	0.001	0.001	0.031889	0.001	0.001
					Production				
Actual	3.00	5.00	3.00	2.00	8.00	6.00	15.00	2	2
Optimum	0.27	5.00	0.27	0.18	0.72	0.54	43.05	0.18	0.18
					Marketed quantity				
Actual	0.00	0.00	0.00	0.00	0.00	0.00	2.00	0	0
Optimum	0.00	0.00	0.00	0.00	0.00	0.00	30.05	0	0
					Own consumption quantity				
Actual	3.00	5.00	3.00	2.00	8.00	6.00	13.00	2	2
Optimum	0.27	5.00	0.27	0.18	0.72	0.54	13.00	0.18	0.18
					Purchased quantity				
Actual	4.80	0.00	4.80	4.50	0.00	9.60	0.00	0	0
Optimum	7.53	0.00	7.53	6.32	7.28	15.06	0.00	1.82	1.82

Table a.8.8 <u>*Landless with Home Garden Household (HH 256)*</u>

	Home Garden							
	Ladies finger	Cowpea	Bittergourd	Red Amaranthus	Guava	Banana	Turmeric	Tulsi
				Acreage				
Actual	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025
Optimum	0.001	0.001	0.001	0.001	0.001	0.013	0.001	0.001
				Production				
Actual	3.00	10.00	1.00	6.00	4.00	20.00	5.00	1
Optimum	0.78	2.60	0.26	1.56	1.04	67.60	1.30	0.26
				Marketed quantity				
Actual	0.00	0.00	0.00	0.00	2.40	16.00	3.91	0
Optimum	0.00	0.00	0.00	0.00	0.00	63.60	0.21	0
				Own consumption quantity				
Actual	3.00	10.00	1.00	6.00	1.60	4.00	1.10	1
Optimum	0.78	2.60	0.26	1.56	1.04	4.00	1.10	0.26
				Purchased quantity				
Actual	12.60	68.00	2.00	40.80	0.00	0.00	0.00	0
Optimum	14.82	75.40	2.74	45.24	0.56	0.00	0.00	0.74

Table a.8.9 ***Landless household with diversified home garden*** *(HH 293)*

	Diversified Home Garden												
	Beans	**Cowpea**	**Pumpkin**	**Colocasia**	**Red Amaranthus**	**Chilli**	**Turmeric**	**Bittergourd**	**EFY**	**Tomato**	**Brinjal**	**Ladies finger**	**Ginger**
Acreage													
Actual	0.003846	0.003846	0.003846	0.003846	0.003846154	0.003846	0.003846	0.003846154	0.003846	0.003846	0.003846	0.003846	0.003846
Optimum	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.038	0.001	0.001	0.001	0.001
Production													
Actual	3.00	5.00	3.00	2.00	8.00	6.00	15.00	6	25	6	5	6	20
Optimum	0.39	0.65	0.39	0.26	1.04	0.78	1.95	0.78	123.5	0.78	0.65	0.78	2.6
Marketed quantity													
Actual	0.00	0.00	0.00	0.00	0.00	4.00	13.00	0	18.5	0	0	0	17.66
Optimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	117	0	0	0	0.26
Own consumption quantity													
Actual	3.00	5.00	3.00	2.00	8.00	2.00	2.00	6	6.5	6	5	6	2.34
Optimum	0.39	0.65	0.39	0.26	1.04	0.78	1.95	0.78	6.5	0.78	0.65	0.78	2.34
Purchased quantity													
Actual	4.80	0.00	4.80	4.50	7.60	0.00	0.00	1.8	0	0	2.8	1.8	0
Optimum	7.41	4.35	7.41	6.24	14.56	1.22	0.05	7.02	0	5.22	7.15	7.02	0

Table a.8.10 ***Landless household with diversified home garden*** *(HH 256)*

	Diversified Home Garden												
	Ladies finger	Cowpea	Bittergourd	Red Amaranthus	Turmeric	Tomato	Brinjal	Radish	Ash gourd	Pumpkin	Chowchow	EFY	Ginger
Acreage													
Actual	0.001538	0.001538	0.001538462	0.001538462	0.001538	0.001538	0.001538	0.001538	0.001538	0.001538	0.001538462	0.001538	0.001538
Optimum	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.007817	0.001183
Production													
Actual	3.00	10.00	1.00	6.00	5.00	6.00	5.00	6	15	10	15	25	20
Optimum	1.27	4.23	0.42	2.54	2.11	2.54	2.11	2.535	6.3375	4.225	6.3375	82.56257	10
Marketed quantity													
Actual	0.00	0.00	0.00	0.00	3.91	0.00	0.00	0	4.6	0	0	17.2	10
Optimum	0.00	0.00	0.00	0.00	1.02	0.00	0.00	0	0	0	0	74.76257	0
Own consumption quantity													
Actual	3.00	10.00	1.00	6.00	1.10	6.00	5.00	6	10.4	10	15	7.8	10
Optimum	1.27	4.23	0.42	2.54	1.10	2.54	2.11	2.535	6.3375	4.225	6.3375	7.8	10
Purchased quantity													
Actual	12.60	68.00	2.00	40.80	0.00	0.00	0.00	0	0	3	0	0	0
Optimum	14.33	73.78	2.58	44.27	0.00	3.47	2.89	3.465	4.0625	8.775	8.6625	0	8.01E-09

a.9 Changes in family labor days allocation to farm production, home garden production and outside employment under different optimizations

Table a.9.1 *AG Majority with Home Garden Household (HH 281)*

	Net Income	HG profit	HG contribution	HG consumption Value	AG family labor days	HG family labor days	Outside employment days
Actual	61993.78	1856.54	2.99	7400.78	36	26	28
Model Optimum without outside employment	109268.26	2660.10	2.43	7811.25	31	31	
Model Optimum with outside employment	215968.27	1009.81	0.47	5407.63	0	18	71
50 % decrease in wages	95586.76	1425.72	1.49	6438.02	17	22	50
75 % decrease in wages	84056.08	6204.88	7.38	8559.40	41	49	0

Table a.9.2 *AG Majority with Home Garden Household (HH 546)*

	Net Income	HG profit	HG contribution	HG consumption Value	AG family labor days	HG family labor days	Outside employment days
Actual	191356.29	670.66	0.35	2841.15	57	12	44
Model Optimum without outside employment	4554321.28	1893.36	0.04	1383.58	34	35	
Model Optimum with outside employment	4815547.63	3131.30	0.07	1921.29	27	54	32
50 % decrease in wages	4351984.43	1399.04	0.03	742.64	88	8	16
75 % decrease in wages	3816721.69	2729.48	0.07	1414.37	55	35	22

Table a.9.3 <u>AG Minority with Home Garden Household (HH 192)</u>

	Net Income	HG profit	HG contribution	HG consumption Value	AG family labor days	HG family labor days	Outside employment days
Actual	-4068.45	2405.51	59.13	5550.06	1	8	27
Model Optimum without outside employment	40493.65	7913.30	19.54	1420.94	0	9	
Model Optimum with outside employment	34808.39	1110.14	3.19	2933.07	4	5	27
50 % decrease in wages	8625.34	2277.49	26.40	1597.77	2	9	25
75 % decrease in wages	5040.65	578.18	11.47	1032.82	0	5	31

Table a.9.4 <u>AG Minority with Home Garden Household (HH 816)</u>

	Net Income	HG profit	HG contribution	HG consumption Value	AG family labor days	HG family labor days	Outside employment days
Actual	111023.06	5206.10	4.69	4536.20	12	25	33
Model Optimum without outside employment	167249.53	65534.89	39.18	1298.20	1	36	
Model Optimum with outside employment	152474.17	1527.97	1.00	1975.48	0	17	53
50 % decrease in wages	96977.35	1636.20	1.69	1876.31	0	17	53
75 % decrease in wages	69643.71	1476.88	2.12	942.86	0	17	53

Table a.9.5 <u>*Landless with Home Garden Household (HH 293)*</u>

	Net Income	HG profit	HG contribution	HG consumption Value	HG family labor days	Outside employment days
Actual	12668.20	-66.66	0.00	921.56	30	50
Model Optimum with outside employment	48381.63	190.56	0.39	377.78	15	65
50 % decrease in wages	-29618.37	190.56	0.64	377.78	15	65
75 % decrease in wages	-68618.37	190.56	0.28	377.78	15	65
95 % decrease in wages	-105087.68	2568.80	2.44	530.23	80	0

Table a.9.6 <u>*Landless with Home Garden Household (HH 256)*</u>

	Net Income	HG profit	HG contribution	HG consumption Value	HG family labor days	Outside employment days
Actual	113045.07	317.07	0.28	744.32	20	53
Model Optimum with outside employment	130118.65	1004.53	0.77	330.44	13	60
50 % decrease in wages	58708.65	1004.53	1.71	330.44	13	60
75 % decrease in wages	23003.65	1004.53	4.37	330.44	13	60
95 % decrease in wages	-6560.03	6493.761	-98.99	982.53	73	0

a.10 Adjustments in decision variables when simulating home garden household model without home gardens: Actual, baseline and uncertain scenarios

Table a.10.1 AG Majority with Home Garden Household (HH 281)

HH 281 - AG Majority with Home Garden (taking out home garden from the household model)																				
	AG Acreage					Family Labor						Hired Labor					Fertilizer qty				
	Paddy	*Coffee*	*Arecanut*	*Ginger*	*EFY*	*Paddy*	*Coffee*	*Arecanut*	*Ginger*	*EFY*	*Total*	*Paddy*	*Coffee*	*Arecanut*	*Ginger*	*EFY*	*Paddy*	*Coffee*	*Arecanut*	*Ginger*	*EFY*
Actual	0.500	0.600	0.600	0.200	0.250	6	7	6	9	8	36	23.00	18.00	12.00	14.00	8.00	40.00	50.00	50.00	50.00	50.00
Baseline	0.102	0.013	0.013	0.215	1.220	0	0	0	36	0	36	40.00	1.36	1.25	12.12	40.00	8.04	0.35	1.14	86.14	263.33
Wages up	0.098	0.226	0.226	0.099	1.128	9	18	9	0	0	36	3.51	5.83	7.50	6.79	25.02	2.12	24.38	15.61	38.34	297.37
Wages down	0.014	0.113	0.113	0.037	1.387	18	0	2	2	13	36	1.80	27.03	3.58	7.08	26.56	0.93	15.88	10.16	14.69	367.30
AG farm prices up	0.107	0.211	0.211	0.069	1.162	0	29.87	0.00	6.13	0	36	15.08	0.13	25.00	34.39	40.00	9.63	31.68	18.34	27.78	271.43
AG farm prices down	0.055	0.084	0.084	0.122	1.289	9	1	0	12	13	36	8.94	1.84	8.62	4.92	21.24	4.55	3.38	6.78	39.09	265.52
Fert prices up	0.073	0.052	0.052	0.293	1.133	12	2	0	18	4	36	19.66	18.90	7.49	17.33	33.95	3.14	2.15	2.26	86.18	232.38
Fert prices down	0.081	0.103	0.103	0.095	1.270	0	0	14	2	19	36	40.00	30.00	0.00	32.51	20.65	3.96	12.13	6.36	20.59	381.08
HG retail prices up	0.019	0.107	0.107	0.177	1.247	4	10	2	2	18	36	13.94	6.44	17.75	46.17	10.01	0.83	7.97	6.78	59.57	215.55
HG retail prices down	0.017	0.145	0.145	0.179	1.209	19	2	0	14	0	36	3.34	19.33	14.04	6.10	36.89	0.66	11.57	7.78	53.38	251.98

Table a.10.2 AG Majority with Home Garden Household (HH 546)

HH 546- AG Majority with Home Garden (taking out home garden from the household model)																									
	AG Acreage						Family Labor							Hired Labor						Fertilizer qty					
	Paddy	*Coffee*	*Arecanut*	*Ginger*	*EFY*	*Rubber*	*Paddy*	*Coffee*	*Arecanut*	*Ginger*	*EFY*	*Rubber*	*Total*	*Paddy*	*Coffee*	*Arecanut*	*Ginger*	*EFY*	*Rubber*	*Paddy*	*Coffee*	*Arecanut*	*Ginger*	*EFY*	*Rubber*
Actual	0.500	2.000	2.000	0.150	0.200	1.000	10.00	8.00	6.00	9.00	4.00	20.00	57.00	20.00	10.00	2.00	8.00	6.00	2.00	60.00	0.00	0.00	20.00	20.00	70.00
Baseline	0.319	2.642	2.642	0.342	0.405	0.143	5.05	1.28	25.00	19.31	3.52	2.85	57.00	8.33	20.81	0.00	0.00	0.00	0.29	41.00	65.13	214.61	94.73	32.41	6.60
Wages up	0.309	3.030	3.030	0.205	0.200	0.107	9.61	2.28	10.92	32.05	0.00	2.13	57.00	23.31	15.19	7.38	0.00	8.03	0.21	14.30	454.01	244.64	79.80	4.35	2.57
Wages down	0.077	2.795	2.795	0.669	0.115	0.194	0.00	0.34	16.87	24.28	11.63	3.89	57.00	14.14	2.95	6.77	0.00	5.63	0.39	2.64	403.60	236.18	229.36	1.27	12.50
AG farm prices up	0.144	2.489	2.489	0.112	1.022	0.083	25.32	2.38	18.40	8.52	0.72	1.66	57.00	3.54	23.49	3.36	8.61	38.15	0.17	1.74	71.34	211.45	40.89	16.61	1.58
AG farm prices down	0.068	2.227	2.227	0.182	0.280	1.093	0.00	22.04	0.00	2.73	10.37	21.86	57.00	10.86	2.12	19.49	50.96	25.91	2.19	6.22	219.03	200.40	68.97	55.99	91.20
Fert prices up	0.168	2.744	2.744	0.518	0.114	0.307	4.22	7.54	19.58	4.36	15.17	6.14	57.00	5.70	0.00	0.00	0.00	2.14	0.61	23.05	351.14	227.14	18.42	16.48	4.05
Fert prices down	0.029	3.274	3.274	0.163	0.201	0.184	0.00	5.77	17.72	9.94	19.90	3.67	57.00	2.24	13.18	7.28	0.00	20.10	0.37	4.31	491.04	294.63	60.07	48.46	0.77
HG retail prices up	0.214	2.759	2.759	0.279	0.164	0.433	7.24	2.94	0.25	31.24	6.66	8.67	57.00	2.82	16.47	24.75	0.00	0.23	0.87	16.05	163.89	188.39	44.81	29.41	41.06
HG retail prices down	0.368	3.034	3.034	0.106	0.082	0.260	0.00	25.39	11.10	15.30	0.00	5.21	57.00	12.27	4.61	13.90	44.70	10.92	0.52	5.22	34.36	273.06	18.41	24.51	17.02

Table a.10.3 AG Minority with Home Garden Household (HH 192)

HH 192 - AG Minority with Home Garden (taking out home garden from the household model)																	
	AG Acreage				Family Labor					Hired Labor				Fertilizer qty			
	Paddy	*Coffee*	*Arecanut*	*EFY*	*Paddy*	*Coffee*	*Arecanut*	*EFY*	*Total*	*Paddy*	*Coffee*	*Arecanut*	*EFY*	*Paddy*	*Coffee*	*Arecanut*	*EFY*
Actual	0.5	0.39	0.39	0.5	0	1	0	0	1	35.00	7.00	5.00	25.00	25.00	40.00	150.00	100.00
Baseline	0.101	0.030	0.030	1.259	0	0	1	0	1	6.88	6.35	0.00	40.00	6.56	3.09	2.66	377.67
Wages up	0.222	0.015	0.015	1.152	0	1	0	0	1	0.07	4.60	1.69	16.38	4.41	2.32	2.44	186.93
Wages down	0.042	0.038	0.038	1.310	0	0	1	0	1	16.62	7.35	0.00	34.60	2.23	1.88	3.92	392.86
AG farm prices up	0.007	0.004	0.004	1.379	0	0	0	1	1	0.02	0.24	4.97	39.01	0.36	0.24	0.85	272.81
AG farm prices down	0.011	0.047	0.047	1.332	0	0	0	1	1	0.71	5.01	0.96	29.06	0.99	3.26	6.48	399.46
Fert prices up	0.147	0.019	0.019	1.224	0	1	0	0	1	8.90	10.56	0.66	39.65	1.80	1.88	7.41	94.46
Fert prices down	0.038	0.003	0.003	1.349	0	0	0	1	1	9.50	3.92	1.75	32.67	1.83	0.05	0.06	404.79
HG retail prices up	0.006	0.092	0.092	1.291	0	0	1	0	1	22.27	7.48	1.26	40.00	0.55	13.63	31.08	387.41
HG retail prices down	0.016	0.018	0.018	1.355	0	1	0	0	1	0.35	0.00	0.00	40.00	1.46	1.36	0.59	406.60

Table a.10.4 AG Minority with Home Garden Household (HH 816)

HH 816 - AG Minority with Home Garden (taking out home garden from the household model)									
	AG Acreage		Family Labor			Hired Labor		Fertilizer quantity	
	Ginger	*EFY*	*Ginger*	*EFY*	*Total*	*Ginger*	*EFY*	*Ginger*	*EFY*
Actual	0.1	0.1	4.00	8.00	12	3.00	2.00	25.00	25.00
Baseline	0.200	0.000	12.00	0.00	12	8.09	0.00	80.00	0.00
Wages up	0.199	0.001	12.00	0.00	12	0.07	0.04	79.47	0.00
Wages down	0.200	0.000	12.00	0.00	12	47.97	0.01	79.98	0.01
AG farm prices up	0.200	0.000	12.00	0.00	12	34.07	0.01	79.95	0.00
AG farm prices down	0.200	0.000	12.00	0.00	12	0.00	0.00	79.97	0.02
Fert prices up	0.200	0.000	12.00	0.00	12	8.09	0.00	80.00	0.00
Fert prices down	0.200	0.000	12.00	0.00	12	8.11	0.00	79.99	0.00
HG retail prices up	0.200	0.000	12.00	0.00	12	7.85	0.00	79.82	0.09
HG retail prices down	0.200	0.000	12.00	0.00	12	8.38	0.01	79.97	0.02

a.11 <u>Time-use data calculated annually for the male and female heads of the sample households</u>

Table a.11.1 Agricultural Majority Households with Home Garden

	HH 281 (AG majority with HG)			HH 546 (AG majority with HG)		
Activities	**Male head**	**Female head**	**Others (daughter/ mother-in-law)**	**Male head**	**Female head**	**Others (daughter-in-law)**
Household Chores	7	90	15	6	64	72
Farm related	28	13	6	0	4	4
Home garden maintenance	0	26	25	12	0	12
Livestock maintenance	9	0	44	0	3	
Work	160	0		147	0	
Health and Recreation	140	152		189	163	
Taking care of others	0	0		0	0	
Social activities	1	4		1	0	
Total	345	285		355	234	

Table a.11.2 Agricultural Minority Households with Home Garden

	HH 816 (AG minority with HG)		HH 192 (AG minority with HG)
Activities	**Male head**	**Female head**	**Female head**
Household Chores	15	59	73
Farm related	0	0	0
Home garden maintenance	20	5	8
Livestock maintenance	41	0	0
Work	0	43	87
Health and Recreation	211	154	197
Taking care of others	0	0	0
Social activities	1	4	1
Total	288	265	364

Table a.11.3 Landless Households with and without Home Garden

	HH 293 (Landless with HG)		HH 67 (Landless w/o HG)		
Activities	**Female head**	**Others (daughter-in-law)**	**Male head**	**Female head**	**Others (daughter-in-law)**
Household Chores	24	77	7	13	62
Farm related					
Home garden maintenance	30	0			
Livestock maintenance	0	3	0	0	
Work	10		143	130	
Health and Recreation	201		141	146	
Taking care of others	3	53	0	0	
Social activities	1		1	1	
Total	269		292	290	

Table a.11.4 Agricultural Majority Households without Home Garden

	HH 300 (AG majority w/o HG)		HH 137 (AG majority w/o HG)	
Activities	**Male head**	**Female head**	**Male head**	**Female head**
Household Chores	8	77	15	86
Farm related	75	35	17	9
Home garden maintenance				
Livestock maintenance	0	0	0	39
Work	56	0	0	0
Health and Recreation	201	200	236	137
Taking care of others	0	0	0	0
Social activities	1	5	1	0
Total	341	317	269	271