

CHAPTER 3

ANALYTICAL FRAMEWORK FOR RURAL HOUSEHOLDS RESOURCE ALLOCATION DECISIONS AMONG COMPETING LIVELIHOOD ACTIVITIES

3.1 Introduction

Agricultural households in developing countries depend on farm, off-farm and natural resource activities for their livelihoods. These activities compete for household resources and households have to make decisions on how to allocate their resources among these activities. In this chapter, an analytical framework is developed for analysing the factors that influence household resource allocation and supply decisions for competing livelihood activities, including wetland activities in the context of a household labour resource allocation problem. The chapter is divided into three main sections. The first section reviews the empirical literature on the factors that influence rural household labour allocation decisions for competing livelihood activities, including natural resource use activities. The second section presents the analytical household model, derives optimality conditions and discusses the analytical results. The final section gives a concluding summary of the chapter.

3.2 Review of selected literature on the determinants of rural household labour allocation decisions for competing livelihood activities

There is widespread acknowledgement that the extent to which rural households incorporate natural resources into their livelihood activities varies considerably across different households. Similarly, the manner in which households allocate their resources among livelihood activities is different.

Many empirical studies have examined the socio-economic factors, which influence rural household decisions on the use of natural resources, in the context of a labour resource allocation problem. Most of these studies used agricultural household models as the analytical framework for analysing labour allocation decisions made by rural

households. The reduced form approach is then used as the basis for empirical estimation of the factors influencing labour allocation and production decisions. However, three different approaches are used for empirical estimation of the reduced form functions. These approaches are: single equation estimation approaches (e.g. Tobit models and ordinary least-squares regression models); two-stage estimation techniques; and system estimation approaches. The first approach applies single equation econometric approaches to estimate the individual reduced form or structural equations, mainly using ordinary least-squares methods. Two-stage (or three-stage) least-squares methods are appropriate where there is need to take into account endogeneity, because single equation ordinary least-squares methods yield biased estimates. Lastly, system estimation approaches jointly estimate equations as a system taking into account across-equation error correlations, yielding unbiased and efficient estimates where such error correlations exist. Selected studies, which applied these approaches in analysing household resource allocation decisions and supply decisions, are reviewed below.

Chen *et al.* (2006) developed a household labour allocation model to analyse the factors that determine the choice of energy and labour allocation for fuelwood collection in rural China. The household model captures a situation in which a household allocates labour across crop production, off-farm work, fuelwood collection and leisure. The empirical model consisted of three reduced form equations for the quantity of fuelwood collected, the time spent collecting fuelwood and the quantity of coal consumed. The explanatory variables used in the three equations are: stove ownership; household characteristics (household size, share of adults, education of household members and household wealth); distance from the forest; total cultivated area; household exogenous income; and village dummies to capture price differences of agricultural goods, marketed goods, coal and off-farm wage rates. A Tobit model is used for empirical estimation of the reduced form equations. The results of the study showed that education and wealth play a role in explaining fuelwood collection and the time input into it. Both education and wealth were found to be negatively related to fuelwood collection. The negative relationship between wealth and fuelwood collection is consistent with the findings of Shackleton and Shackleton (2006), who found for a rural area in South Africa that fuelwood consumption significantly decreases with a household's wealth status although this

was not always true for other non-timber forest products (NTFP). Based on their findings Chen *et al.* (2006) concluded that the promotion of alternative energy sources, the investment in rural infrastructure and policies to stimulate basic education in rural areas can reduce pressure on forest resources.

Dayal (2006) developed a household model that captures the interrelationships between grazing, crop production and fuelwood collection to examine the factors that influence decisions on the levels of extraction of forest biomass by rural households in India. The household model, developed in this study, added the complementary aspects between activities by assuming that rural households can collect fuelwood by: spending labour time for fuelwood collection only; collecting fuelwood while grazing; and/or collecting fuelwood while spending time on crop production. In addition, the model captures the fact that agricultural residues can be used as an energy source and as livestock feed. Also dung is used as a source of energy and as fertilizer in crop production. The empirical model is based on the reduced form equations related to the levels of biomass extracted as functions of exogenous variables. The regressors include household characteristics, such as: household size: quantity of males; social order; wealth (type of house); number of cattle; number of goats; land area; and village dummies. A Tobit model was used for empirical estimation. The study found that location, ownership of biogas and social order are significant factors influencing the levels of extraction of forest biomass. Based on the results, it was concluded that installing biogas plants can potentially reduce pressure on forest biomass.

Heltberg *et al.* (2000) used a non-separable household model to study the links between forest scarcity and household energy consumption. The model focuses on the substitution of fuelwood and other domestic energy sources including crop residues, animal dung and biogas for rural households in Rajasthan, India. They developed a household model to capture household labour allocation to agriculture (crop and livestock production), off-farm work and fuelwood collection. Three reduced form equations showing the amount of fuelwood that was collected, the amount of labour and time spent on collecting and the private energy consumption (animal dung, crop residues and wood from own farm) as functions of all exogenous variables, were estimated empirically using the maximum entropy approach. The study observed that fuelwood collection time, household endowments of land, labour, livestock and trees

and village-level indicators of forest stock and access are significant in explaining fuel mix at household level. It concluded that rural households respond to forest scarcity and increased fuelwood collection time by substituting fuels from private sources for forest fuelwood.

A number of studies have used two-stage estimation techniques for empirical estimation. For example, Matshe and Young (2004) developed a household model to analyse off-farm labour allocation decisions of rural households in Zimbabwe. They used a double hurdle model to empirically model the joint decisions to participate in the off-farm labour market and the decision regarding the amount of labour time allocated to off-farm work. Their results showed that education, gender, asset holding, remittances and land holding influence household off-farm labour supply decisions among rural households. They found that education, access to productive assets and remittances are positively related to labour supply for off-farm work. The study concluded that females are less likely to engage in off-farm activities than males due to the various commitments to activities that women have within the household.

Adhikari (2002) constructed a household production model to explore the socio-economic factors influencing household labour allocation decisions for the collection and gathering of non-timber forest products (NTFP) in Nepal. The household model captures a household engaged in crop and livestock production as well as NTFP collection activities. The production functions for firewood, fodder, cut grass and leaf litter were specified as Cobb-Douglas functions and estimated as log-linear functions using two-stage least-squares method to capture the potential endogeneity of labour used in the production of the different forest products. The explanatory variables included in the production functions consist of: labour time allocated to the collection of forest products; household demographic variables (ethnicity, sex, education and household size); ownership of tools; labour time spent on activities; membership to organisations; and household endowments (landholding size and livestock assets). The study concluded that poor households were facing limited access to community forestry and therefore were less dependent on forest resources than households who were relatively better off.

Jolliffe (2004) developed an agricultural household model to examine how education affects household allocation of labour between farm and off-farm activities and farm and off-farm profits in rural Ghana. To capture these effects, household utility was modelled as a function of leisure and the sum of farm and off-farm profits. The reduced form farm and off-farm labour supply and farm and off-farm profits equations were empirically estimated using a two-stage least-squares approach to capture the direct and indirect effect of education on labour allocation and farm and off-farm profitability. The two-stage estimation approach was adopted to capture the potential endogeneity of labour. The study concluded that off-farm work has a much higher return to education than farm work and increased education results in reallocation of labour from farm work to off-farm work and therefore increases off-farm profit. Fafchamps and Quisumbing (1998) found a similar result in a study in rural Pakistan.

Very few studies used the systems approach for empirical estimation. For example, Fisher *et al.* (2005) developed a household labour allocation model to examine the determinants of livelihood activity choices affecting forest use among rural households in Malawi. In their household model they assumed that households allocate family labour across three livelihood activities, namely: maize production; forest activities; and non-forest activities. The empirical model comprised of a system of three reduced form labour share equations. A system estimation approach similar to that used in commodity or factor demand systems used to estimate the labour share equations jointly using constrained maximum likelihood method assuming that the labour allocation decisions across activities are related. Explanatory variables included in the empirical model are: household characteristics (age and education of the head of the household); farm size; dependency ratio; shadow prices or wages of forest and non-forest activities; and the price of maize. Their study found that labour share that is allocated to forest activities is negatively related to the return to non-forest employment, secondary education of the household head and wealth.

Though there is a large body of empirical literature on the determinants of rural household labour allocation for competing livelihoods activities (including natural products), no study yet has analysed the factors determining household decisions on the use of wetland products in the context of an overall household labour allocation

problem. To date, existing studies which attempted to look at the factors influencing decisions on use of wetland resources mainly focused on relating household socio-economic characteristics and the different type of uses of wetland resources using statistical and single equation econometric approaches, which are not based on a structural behavioural model of the rural household decision-making process. For example, Mulugeta *et al.* (2000) used a discriminant analysis to study the socio-economic factors influencing the decision to cultivate wetlands in the Metu and Yayu-Hurumu Weredas of Illubabor zone in southwest Ethiopia. Using household survey data, their results showed that wetland cultivators: are less wealthy; are young; have large family sizes; own small landholdings; have less livestock; own few farm implements; and are food insecure.

Mulugeta (2004) applied a binomial logit model to assess the factors that influence the decision to cultivate wetlands in Kemise, Illubabor zone of south-western Ethiopia. The study found that wetland cultivators had large family sizes, with more male members and suffered less out-migration of family members in the preceding years in comparison to non-cultivators. Contrary to the findings of Mulugeta *et al.* (2000), this study found that wetland cultivators are wealthier households who have access to productive assets, earn more cash income, use more agricultural inputs and generally enjoy higher yields than non-wetland cultivators.

Chiputwa *et al.* (2006) used a series of binomial logit models to examine the factors influencing the decision to cultivate wetlands and collect wetland natural products in a wetland system situated in the southwestern part of Zimbabwe. Their results showed that wetland cultivation is positively and significantly related to irrigation plot ownership, income from non-agricultural activities and to the total land area, but is negatively related to the number of livestock. They also found that male-headed households are more likely to engage in wild fruit and reeds collection as well as cultural practices than their female counterparts. The education level of the head of a household significantly reduced the likelihood of a household engaging in sedge collections and the use of wetlands for cultural purposes.

Using household survey data from selected wetland sites in Tanzania, McCartney and Van Koppen (2004) used cross tabulations to analyse the relationship between

wetland uses and a household's wealth status. They found that poor households are more likely to use wetlands for the collection of reeds, sedges and domestic water than the medium ranked and rich households. Medium ranked households were more likely to use wetlands for cropping than the poor and rich households. However, their results showed that the proportion of a household's income derived from wetland cultivation is highest among the rich households compared to the poor and medium ranked households. This suggests that the rich households were more dependent on wetland cropping than the other two wealth classes. In addition, they found that wealthier households were more likely to use wetlands for livestock grazing than poor households.

Based on case studies of selected wetlands in Zambia, Masiyandima *et al.* (2004) found that poor households are more likely to engage in the collection of natural products and wetland cultivation than the wealthier households. However, in contrast to the findings by McCartney and Van Koppen (2004), their results showed that poor households obtain a significantly higher proportion of their household's income from wetland cultivation than the medium and wealthier households, suggesting that poor households were more dependent on wetland cultivation for their livelihood than the medium and wealthier households. The differences in findings could be attributed to the differences in biophysical and socio-economic conditions across sites.

As mentioned earlier, most of the empirical studies on wetlands to date have focused on assessing the factors that influence the type of uses of wetland products. While such analyses are important, it is essential for policy purposes to go a step further and analyse the factors which influence the level of dependence on wetland products (measured in terms of quantities of wetland products collected or the proportion of income derived from wetland products). This is because, as demonstrated by Narain *et al.* (2008), it is possible that those households that are less likely to participate in a natural resource use activity are actually more dependent (i.e. collect more quantities) if they engage in that use.

Few studies have attempted to look at the factors that influence households' decisions on the use of wetland products. For example, Turpie *et al.* (1999) used a simple bivariate analysis to compare the quantities of wetland natural products collected by

rural households of different wealth classes in selected wetlands in the Zambezi basin in southern Africa. They found evidence of decreasing levels of collection of wetland natural products (reeds, sedges, palm leaves and thatching grass) with an increase in wealth status in the Barotse floodplain wetlands (western Zambia) as well as the Lower Shire floodplain wetlands (in Malawi and Mozambique). However, in the Caprivi wetlands in Namibia and Zambia they found that wealthier households harvested more natural products than the poor, presumably because wealthier households are larger and therefore have a higher demand for resources and also have more labour resources to collect products. These findings show that the effect of wealth on the demands for wetland natural products is mixed and can vary across sites.

Kipkemboi *et al.* (2007) analysed the socio-economic factors that influence the dependence on wetland products by households in the Lake Victoria wetlands in Kenya using a multiple linear regression model. A household's dependence on wetland products was measured in terms of the quantity of wetland products collected. Independent variables included in the model are: household size; the age and education level of the respondents; gender; and access to wetlands. Their results showed that females are more dependent on wetland products than males; a finding they attributed to the fact that in rural areas women are more directly involved in household food provision and interact with the environment on a daily basis. They also found that poor and middle-income households are more dependent on wetlands for both cultivation and natural products, while wealthy households are less dependent on wetlands as they obtain significant non-farm income to meet household demands.

The empirical studies reviewed in this section generally confirm that household socio-economic characteristics influence household labour allocation and production decisions among rural households. However, the factors influencing household resource allocation decisions and production decisions vary with local context and type of resources. To date, empirical studies, which attempted to examine factors influencing rural household decisions on use of wetland products, have used econometric approaches. These econometric approaches are not based on any structural behavioural model of rural household decision-making behaviours. The major contribution of this work is that the factors that influence rural household

decisions on the use of wetland products by formally modelling household resource use decision-making process based on a structural household model, which takes into account the fact that rural households engage in multiple livelihood activities, which compete for resources (e.g. labour, capital and land).

The above literature highlights the relevance of the agricultural household modelling approach in analysing rural household labour allocation, production and supply decisions in developing countries. As households in the study area both produce and consume wetland products and agricultural output (Adekola, 2007), the agricultural household modelling approach is most appropriate for analysing household labour allocation and supply decisions for wetland and agricultural products (Singh *et al.*, 1986; Chen *et al.*, 2006).

3.3 The Analytical Framework

The neoclassical model of a farm household (agricultural household model) described by Singh *et al.* (1986) has been the main analytical approach used for analysing resource allocation, production and consumption decisions made by rural households in developing countries. This approach is based on the observation that rural households in subsistence economies are joint producers and consumers. The households can separate production and consumption decisions by first maximising profit from food production and use the profits from production to maximise utility from consumption. The major difference between the farm household model and the pure consumption model is that in the latter the household budget is exogenously fixed whereas in the former it is influenced by production decisions that contribute to income through farm profits.

The author drew upon the neoclassical model of the farm household presented in Singh *et al.* (1986) to develop a model for analysing factors influencing household labour allocation and supply decisions. The model presented below captures the situation of a farm household engaged in crop production, livestock production, off-farm work and wetland product collection.

The model assumes that a representative household maximises its utility, which is dependent on: the consumption of a composite wetland product (X_H); agricultural grain (X_G); livestock product (X_N); market good (X_M); and leisure time (L_Z). Household utility is assumed to vary with different household characteristics (Ω), including family size and the age of household members, which may influence household consumption preferences. For the sake of simplicity, it is assumed that the market good, X_M , is purchased from the market. Thus, the household utility maximisation problem is defined as:

$$\text{Max } U = U(X_H, X_G, X_M, X_N, L_Z; \Omega) \quad (3.1)$$

The quantity of the wetland product consumed by the household (X_H) is equal to the wetland product harvested from the wetland by the household (X_H^H), plus the quantity purchased from the market (X_H^P), minus the quantity sold in the market (X_H^S):

$$X_H = X_H^H + X_H^P - X_H^S \quad (3.2)$$

The production constraint of the wetland product describes harvesting of the wetland product as a function of household labour allocated to wetland products collection (L_H), household characteristics (Ω), which influence the harvesting of wetland products (such as household size and education level of the household) and a vector of production technology parameters (β):

$$X_H^H = X_H^H(L_H, \beta; \Omega) \quad (3.3)$$

The household also depends on grain production for its livelihood. The production technology for the agricultural grain (G_q) is: a function of household labour allocated to agricultural production (L_G); a vector of household asset endowments influencing grain production, such as land and farm implements (ploughs and hoes) (ω); a composite input capturing all the inputs used in grain production, which are purchased

from the market, such as fertiliser and seeds (Y_G); and the production technology parameter (α).

$$G_q = G_q(\alpha, L_G, Y_G; \omega) \quad (3.4)$$

The household can purchase additional agricultural grain (G_q^p) from the market to meet any consumption requirements, which are not supplied by its own production. In addition, the household can sell surplus grain (G_q^s) in the market and hence faces a grain balance of:

$$X_G = G_q + G_q^p - G_q^s \quad (3.5)$$

The household is also engaged in livestock activities that supply meat and milk products. The production of a composite livestock product (V_N) is: a function of labour time spent grazing animals (L_V); and other livestock inputs such as water (N) and production technology parameters (θ).

$$V_N = V_N(L_V, N, \theta) \quad (3.6)$$

As is the case with agricultural grain, livestock products can be bought and sold in the market. Thus, the amount of livestock products consumed (X_N) is equal to the amount produced by the household (V_N) plus the amount purchased from the market (V_N^p) minus the amount sold in the market (V_N^s):

$$X_N = V_N + V_N^p - V_N^s \quad (3.7)$$

Household cash expenditures are constrained by the income from selling the agricultural grain, livestock product, wetland product, off-farm labour income and exogenous income (E). Exogenous income includes income in the form of pension, social grants and remittances. The household can spend income on purchasing wetland products, livestock products, agricultural grain, market goods and agricultural

inputs used in grain production. Farm inputs, Y_G , are bought but not sold. It is assumed that all market prices are exogenous. Cash expenditures cannot exceed the total cash income. Thus the household budget constraint is given by:

$$P_H X_H^S + P_G G_q^S + P_V V_N^S + L_o W_o + E \geq P_M X_M + P_H X_H^P + P_G G_q^P + P_V V_N^P + P_Y Y_G + P_N N \quad (3.8)$$

Where P_H ; P_G ; P_V ; P_M ; P_Y ; P_N ; W_o ; E refer to market prices of the wetland product, agricultural grain, livestock product, market good, inputs used in grain production, livestock inputs, exogenous off-farm wage rates and exogenous household income (non-wage income), respectively. L_o refers to the labour time spent on off-farm wage work.

Households have limited total labour time available (L_T) and divide this time between wetland product collection, off-farm activities, grain production, livestock activities and leisure. Thus, household labour time constraint is given by:

$$L_T = L_H + L_o + L_G + L_V + L_Z \quad (3.9)$$

The decision problem for the subsistence farm household is to maximise the utility function (3.1) subject to production, budget and time constraints specified in 3.2 to 3.9 above. The Lagrangian for an internal solution to this problem is:

$$\begin{aligned} \ell = & U\{X_M, X_H, X_G, X_N, L_Z; \Omega\} - \lambda_1 (X_H^H - X_H^H(L_H, \beta; \Omega)) - \lambda_2 (G_q - G_q(\alpha, L_G, Y_G; \omega)) \\ & - \lambda_3 (V_N - V_N(L_V, N, \theta)) - \lambda_4 (P_M X_M + P_H X_H^P + P_G G_q^P + P_V V_N^P + P_Y Y_G + P_N N - P_H X_H^S \\ & - P_G G_q^S - P_V V_N^S - L_o W_o - E) - \lambda_5 (L_H + L_o + L_G + L_V + L_Z - L_T) \end{aligned} \quad (3.10)$$

There are 21 decision variables to solve in the model, which are:

$$L_H; L_G; L_V; L_o; Y_G; N; X_M; X_H^H; X_H^S; X_H^P; G_q; V_N; G_q^P; G_q^S; V_N^P; V_N^S; \lambda_1; \lambda_2; \lambda_3; \lambda_4; \lambda_5$$

Therefore, one needs 21 equations to solve these 21 endogenous variables. From the first order conditions with respect to these decision variables, a system of 21 reduced form equations are derived. The system of equations, A1.1 to A1.21 in Appendix A1, gives the complete set of 21 equations needed to solve the 21 endogenous variables. All endogenous variables will be reduced form functions of the set of exogenous variables in the model, which are: P_H ; P_G ; L_T ; P_V ; P_M ; P_Y ; P_N ; W_o ; E ; Ω ; β ; α ; θ ; and ω .

First order conditions A1.1, A1.2, A1.3 and A1.4 show how the household allocates its labour among the productive activities and leisure. The four conditions show that the optimum labour allocation is such that the marginal value of labour across the productive activities is equalised. By rearranging the first order conditions A1.8, A1.11 and A1.12 to $\frac{\partial U}{\partial X_H} = \lambda_1$; $\frac{\partial U}{\partial G_q} = \lambda_2$ and $\frac{\partial U}{\partial V_N} = \lambda_3$, respectively and then substitute the λ 's in the first order conditions A1.1, A1.2 and A1.3. The three conditions will also show that, at the optimum, the household allocates its labour across the productive activities that the marginal utility of labour in each of the activities is equal and is also equal to the marginal utility of leisure (λ_5) (which represents the shadow wage or opportunity cost of household labour time). This shadow wage is internal to each household and depends on the full set of exogenous variables.

First order condition A1.4 can be rearranged to $\lambda_4 W_o = \lambda_5$. This condition shows that the decision on the participation in off-farm work is influenced by: off-farm wage rates (W_o); marginal utility of income (λ_4); and the marginal utility of leisure (λ_5). The marginal utility of leisure can be equal to or higher than the off-farm wage rate. If it is equal, the household participates in off-farm work. If it is higher than the wage rate, the household will not supply labour to off-farm work.

First order condition A1.8 shows that in making decisions on the collection of a wetland product, a household equates the marginal utility of consuming the wetland product collected to the shadow costs of collecting the product (λ_1) (which represents the opportunity cost of supplying labour for collecting the wetland product).

Similarly, the first order condition A1.11 shows that the household makes grain production decisions by equating the marginal utility of consuming grains produced with the marginal costs of grain production (λ_2) (which represents the opportunity cost of labour used in grain production).

First order conditions A1.10, A1.13 and A1.15 relate to purchasable wetland, grain and livestock products and give us the familiar consumer theory results that the marginal rate of substitution between two goods purchased in positive quantities is equal to the ratio of their relative prices. In addition, these first order conditions also show that the household can improve its welfare by purchasing additional products from the market. However, in making the decision to purchase products from the market the household compares the costs of purchasing (the price) and the marginal utility gained from consuming purchased products (the welfare benefit). This result is the fundamental micro-economic theory of consumer behaviour, which states that a consumer equates the marginal utility to the price (or the marginal cost of collecting or producing its own) in purchasing goods from the market.

The selling of products (wetland, livestock and grain) reduces household welfare. The first order conditions for the decision to sell products A1.9, A1.14 and A1.16 show that the marginal rate of substitution between two goods is equal to the ratio of their relative prices. These first order conditions also show that in making the decision to sell a product in the market the household equates the marginal utility of income (λ_4) derived from selling the product to the marginal utility forgone by choosing not to consume the product (welfare loss to the household). At the optimum, the marginal utility of income across the products is equalised at (λ_4). In summary, the first order conditions for selling and purchasing decisions show that those households that sell and purchase products face a market price.

Conditions A1.17, A1.18 and A1.19 recover the production functions for: wetland products; grain and livestock products, which are functions of labour; production parameters; inputs (for the case of grain and livestock); and household endowment characteristics. First order conditions A1.20 and A1.21 recover the full budget and time constraints, respectively.

3.4 Concluding Summary

Rural households allocate their labour, capital and other resources between competing livelihood activities that include crop and livestock production, off-farm activities, harvesting of wetland resources and leisure. Households decide on the allocation of resources between these activities which maximises their utility given their resource endowment; prices; the efforts required (production technology); and household characteristics.

This chapter developed an analytical framework for analysing household labour allocation and production decisions for different livelihood activities including wetland activities. Drawing on previous works, an agricultural household model was developed as the analytical framework for analysing determinants of household labour allocation and supply decisions. The reduced form equations derived from the household model will be the basis for empirical analysis of the determinants of labour allocation and supply decisions for wetland products and agricultural output presented in the next chapter.

CHAPTER 4

EMPIRICAL MODEL AND RESULTS OF THE DETERMINANTS OF HOUSEHOLD RESOURCE ALLOCATION AND SUPPLY DECISIONS

4.1 Introduction

This chapter presents the empirical model for examining the determinants of household labour allocation and product supply decisions based on the analytical framework developed in Chapter 3. It also discusses results of the empirical analysis. The first section of the chapter gives a brief description of the study area. Section two presents data and data collection methods while a survey of the main uses of the studied wetland system is presented in the third section. Section four presents the empirical model and discusses the econometric estimation procedures used in the empirical analysis. Empirical results are presented and discussed in section five and a concluding summary of the chapter is given in section six.

4.2 Description of the study area

4.2.1 Location of the area

This study was carried out in the Ga-Mampa wetland, which lies in the catchment of the Mohlalapsi River; a tributary of the Olifants River in the middle part of the Limpopo basin in South Africa. The wetland is a riverine system covering an area of approximately 120 ha (Kotze, 2005). The catchment is characterised by seasonal rainfall that largely occurs during the summer months (October to April). The area is located in the former homeland³ area of Lebowa in Mafefe Ward 24 of the Lepelle-Nkumpi municipality in the Capricorn district of the Limpopo province in the northern part of South Africa. Typical of the former homelands of South Africa: the area is predominantly rural; employment levels are low; basic infrastructure is lacking; and poverty levels are high. In 2006, it was estimated that 2 800 people (394

³ These are also termed native reserves or tribal lands which were delineated under the Natives Land Act of 1913 (Wickins, 1981) for black people. They are typically located in marginal areas with low rainfall, less fertile soils and lack of access to basic services such as water and education facilities.

households) reside in the two main villages around the wetland, which represents 18% of the total population of the ward (Adekola, 2007).

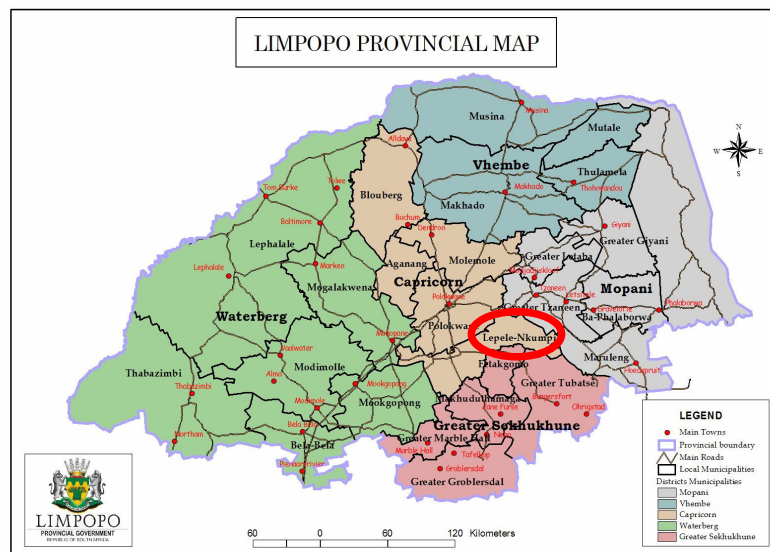
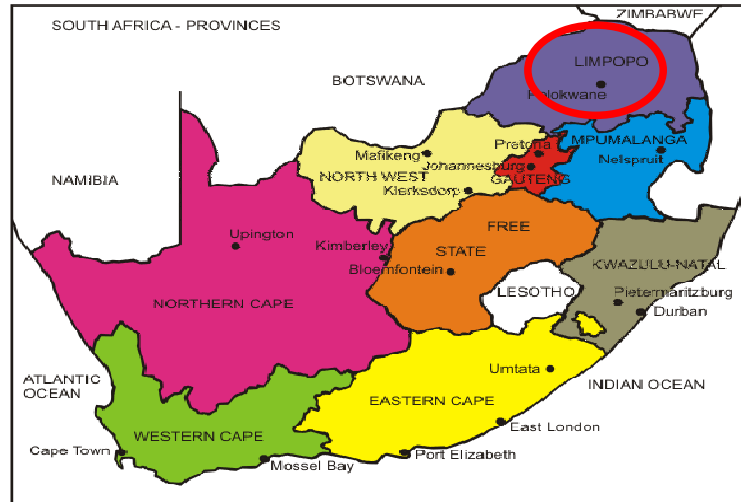


Figure 4.1: Maps showing the location of the Limpopo province and the Ga-Mampa area (Adekola, 2007)

4.2.2 Characterisation of the hydrology and ecology as well as trade-offs between ecosystem services in the studied wetland system

The Ga-Mampa wetland lies along the Mochlapitsi River. The geology underlying the wetland is a complex assemblage of sedimentary rocks, such as banded ironstone, chert and limestone. The soil formations in the wetland reflect the strong influence of the underlying parent rock material, climatic features and biological activity. Much of the wetland consists of fine-textured, poorly drained soils deposited on the valley floor by the river as well as well-drained sandy soils to sandy loam soils (Ferrand, 2004). The poorly drained areas support extensive organic (peat) soils maintained by permanent saturation and are surrounded by seasonally to temporarily saturated areas with predominantly mineral soils. The wetland soils support subsistence crop production although the productivity of the wetland soils has been undermined by progressive depletion of soil organic matter due to active tillage, artificial drainage and erosion (Kotze, 2005). In contrast, the adjacent hill slopes and dryland areas tend to have fragile, shallow, sandy soils with less agricultural potential.

The geology of the studied area supports groundwater storage. Dolomitic rocks, shales and banded ironstone, which are the main geological feature of the wetland, have an intermediate to high groundwater storage capacity (Kotze, 2005). In the wetland, shallow weathered aquifers are recharged by groundwater outflows from the adjacent hillslopes (Tinguery, 2006).

Most of the utilisable water in the Mochlapitsi catchment area is in the form of surface water. The wetland is an integral part of the hydrograph of the catchment. The Mochlapitsi River shows marked seasonal and inter-annual variation in flow due to seasonal and inter-annual variation in rainfall and unpredictable climate events such as floods and droughts. The seasonal and inter-annual variation in the river flow affects the welfare of communities in the Ga-Mampa area, as it is the main source of potable and irrigation water (Chiron, 2005).

Previous studies on the hydrology of the wetland system highlighted that there are some hydrological interactions between the wetland, Mochlapitsi River and the Olifants River. Darradi *et al.* (2006) reported that there is a common perception by

stakeholders living outside the Ga-Mampa valley that the wetland performs important hydrological functions, most notably the maintenance of dry season flow in the Olifants River downstream. McCartney (2005) investigated this phenomenon using historical flow data of the Mohlalapsi and Olifants Rivers and showed that the Mohlalapsi catchment contributes 3.9% of the mean annual runoff and approximately 16% of average flows at the end of the dry season (Figure 4.2).

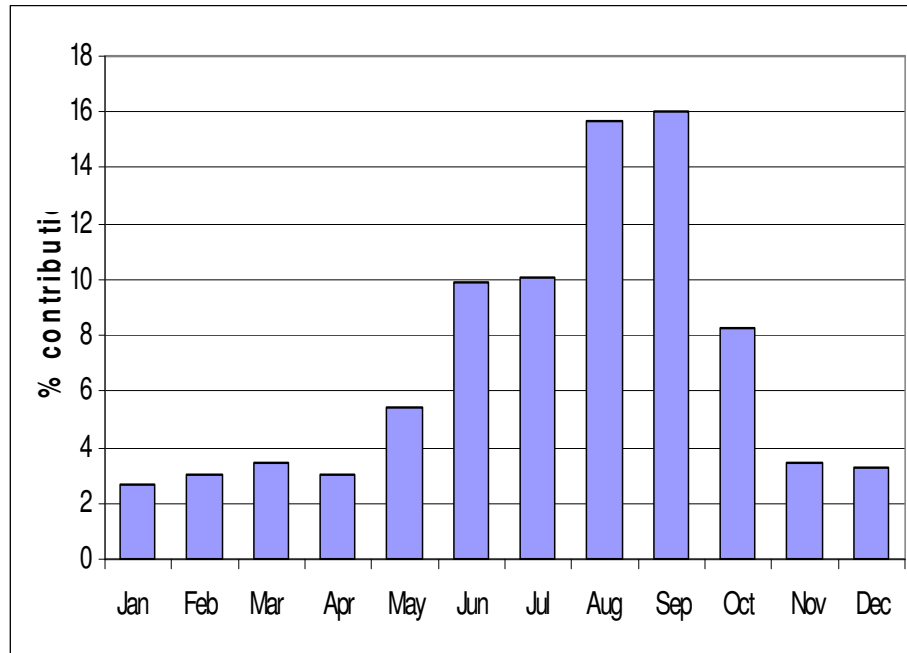


Figure 4.2: Contribution percentage of flow (i.e. monthly average) from the Mohlalapsi catchment to the Olifants River (McCartney 2005)

An ecological assessment study of the Ga-Mampa wetland by Kotze (2005) concluded that the hydrological input by the river to the wetland is very low and the wetland hydrology appears to be maintained predominantly by upstream flow and seepage of groundwater from the adjacent hillslopes. McCartney (2005) confirmed that the hydrology of the wetland is dominated by groundwater inflow from the surrounding catchment as shown by the presence of a large number of springs located at the edges of the wetland and close to the break of the slope at the valley sides. The main hydrological fluxes in the studied wetland are shown in the schematic diagram (Figure 4.3).

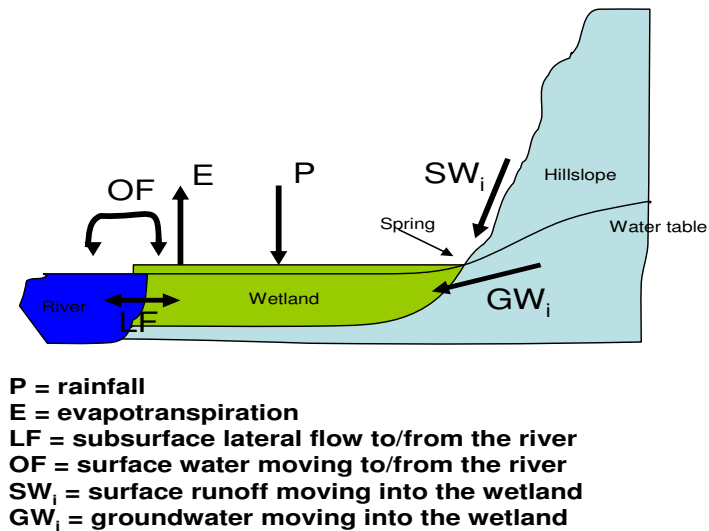


Figure 4.3: Conceptual picture of the main hydrological fluxes in the Ga-Mampa wetland (McCartney, 2005)

The vegetation in the Ga-Mampa area comprises of relatively natural grassland vegetation and a distinct upper layer of woody plants (Sarron, 2005). Bushy vegetation dominates the surrounding mountains while riparian forests grow adjacent to the river channel or at the transition from the steep hillslope to the valley floor (Kotze, 2005). The valley bottom vegetation is predominantly herbaceous and the wetland supports different vegetation types, which vary according to their particular site preferences. The most extensive plant species in the wetland are reeds (*Phragmites australis* and *Phragmites mauritanus*) and sedges, which are used for construction and craft material, respectively. A wide range of edible plants occur across the wetland. Table 4.1 shows the vegetation characteristics of the Ga-Mampa wetland.

Table 4.1: Vegetation characteristics of the Ga-Mampa wetland

Vegetation type	Predominant species	Structure	Site characteristics	Natural extent
<i>Phragmites</i> marsh	Predominantly <i>Phragmites mauritianus</i> but also with <i>Phragmites australis</i>	Very tall (>3m) uniform stands	Permanently wet areas on the valley floor and in the river channel and its margin	Very extensive
<i>Cladium mariscus</i> marsh	<i>Cladium mariscus</i>	Very dense uniform stands (2m)	Permanently wet areas on the valley floor	Limited
Mixed marsh	<i>Pycreus mundii</i> , <i>Thelypteris interrupta</i> cf., <i>Leersia hexandra</i> and <i>Phragmites mauritianus</i>	Variable (0.5-2 m)	Permanently wet areas on the valley floor	Moderately extensive
<i>Typha capensis</i> marsh	<i>Typha capensis</i>	Uniform stands (2-3 m)	Primarily within the river channel in permanently inundated sites	Limited primarily to within the main stream channel
<i>Miscanthus junceus</i> meadow	<i>Miscanthus junceus</i>	Dense clumps (2 m) interspersed with short	On the valley floor in areas with seasonal wetness	Extensive
Mesic grassland	<i>Cynodon dactylon</i> and <i>Phragmites mauritianus</i>	Short (mainly <0.5 m)	On the valley floor in areas with sandy, moderately well drained soils	Limited
Hygrophilous grassland	<i>Paspalum dilatatum</i> , <i>Pycreus mundtii</i> , <i>Phragmites mauritianus</i> , and <i>Imperata cylindrica</i>	Short (mainly <0.5 m)	On the valley floor in areas with somewhat poorly drained soils (temporarily saturated)	Extensive, particularly along the margins
Riparian forest	<i>Syzygium cordatum</i> , <i>Rauvolfia caffra</i> and <i>Ficus sycomorus</i>	Generally closed canopy, >5 m	Adjacent to the river channel or at the transition from steep hillslope to valley floor where shallow, surface water is readily available to the trees	Moderately extensive

Source: Kotze (2005)

As will be discussed in detail later, the studied wetland provides several services with trade-offs between them. Trade-offs between wetland services occur locally and in the short term between crop production and livestock grazing while natural vegetation compete for land, water and labour resources. At a larger spatial scale, there is a potential trade-off between crop production and the river flow regulation and water supply downstream. In the long term, continuous use of wetland for agriculture may undermine the ecological integrity of the wetland through depletion of organic matter, soil erosion and lowering of shallow water thus impacting on the wetland's ability to provide ecosystem services, including crop production

4.2.3 Main livelihood activities in the study area

The main source of livelihood for communities in the study area is small-scale subsistence agriculture. Households self-consume most of their production and sell the surplus in the market to raise cash income to purchase agricultural inputs and meet other expenses such as clothing, school fees etc. Agricultural production is mixed crop and livestock systems with cropping taking place under small-scale irrigation and in the wetland. There are three small-scale irrigation schemes in the area with an estimated area of 170 ha (Chiron, 2005). Approximately 160 households have access to irrigation plots, with an average irrigated area of 0.60 ha per household. Maize is the main crop grown under irrigation and in the wetland. A large proportion of the maize produced is used for home consumption while vegetables constitute the bulk of the marketed output.

More than 80% of the households in the study area are considered to be poor, earning a monthly income of less than 1000 South African Rands⁴ (R). The main sources of income are agriculture, government social grants, pensions and remittances. Households receive social grants of R200 per month for children under the age of 14 years and adults aged over 64 years receive R800 per month. Approximately 35% of households depend on pensions while 30% of the households depend on off-farm activities for income (Ferrand, 2004). Those engaged in off-farm activities are mostly middle-aged males working in mines, large-scale commercial farms and other industries located in nearby towns. Part of their income is remitted to family members

⁴ One United States dollar (\$) was approximately equal to 7.5 SAR in 2009.

in rural areas. Some households hire labourers to ease labour shortages during peak farming periods (Ferrand, 2004). The average wage rate in the local labour market is R8 per hour (Adekola, 2007).

4.3 Data and data collection methods

A combination of participatory rural appraisals (focus group discussions and key informant interviews) and formal methods (household surveys) were used. The former was used to gain a baseline understanding on the main livelihood strategies, the uses of the wetland and the types of users who make use of these resources as well as guide the design of the subsequent household survey. Two complimentary face-to-face household surveys, using structured household questionnaires, were carried out in the study area in October, 2006. In both surveys a stratified random sampling strategy was used to select households for interviews. The stratification of the population was based on access to a wetland plot or not. The first survey was done in two rounds: the first was conducted in May, 2006; and the second in October, 2006. A total of 102 households were interviewed in the two phases using a structured questionnaire administered by local trained enumerators in the local language. The household questionnaire collected data on: household demographics; access to different types of assets (physical, financial or natural); use of wetland resources; description of crop production activities (area under cultivation, production levels, input use including labour, prices of inputs and output); sources of food and food security; and sources of income (Appendix A3).

The second complimentary survey was conducted in October 2006 and was aimed at generating information to assess the economic value of the provisioning services of the Ga-Mampa wetland (Adekola, 2007). In this survey a total of 66 households (thirty-three wetland cultivators and the same number of non-wetland cultivators) were interviewed and some of these households were part of the first survey. The household questionnaire used in this survey was aimed at collecting detailed quantitative information on: the harvesting of wetland products; wetland cropping; input use in wetland activities (including labour use); and prices. The questionnaire had three main sections: the demographic and socio-economic characteristics of respondents; general information on access and use of the wetland; and detailed

quantitative information on wetland products (i.e. quantity of product harvested, labour use and prices) (Appendix A4). Input-output information was also asked on crop production. Where market prices of wetland products could not be ascertained through the household survey and group discussions, information acquired during a visit to the local market in Ga-Mampa and Mafefe was used. Also prices of substitutes were also used as surrogates for market prices for wetland products where market prices could not be easily ascertained.

The data from the two surveys were pooled resulting in a sample size of one hundred and forty-three households. These households account for thirty-six percent of the total number of households residing in five villages around the wetland. Table 4.2 shows the distribution of the sampled households in the five villages. The sample fraction selected from each village (column 5) is proportional to the percentage of the village population in the area's total population (column 3).

Table 4.2: Sample distribution of interviewed households

Village	Estimated total number of households in village*	Number of households in village as percentage of total population in study area	Number of sampled households	Sampled households as percentage of total sampled households (%)
Mapagane	215	55	71	49.7
Ga-Moila	60	15	24	16.8
Manthlane	43	11	20	14.0
Mashushu	41	10	19	13.3
Marulatshiping	35	9	9	6.2
Total	394	100	143	100

*Figures are based on estimates by Adekola (2007) compiled through field data.

As detailed, quantitative data on wetland products collected and labour time used while collecting were missing for households interviewed in the first survey, which were not part of the sample in the second survey⁵ (although information on whether a

⁵ As households in the study area do not keep records of the quantities collected and the time used it was difficult to collect reliable data on these for all 143 households. However, the second survey collected more reliable data, because the survey was followed up with focus group discussions to validate information collected from the survey.

household harvests wetland products or not was available for these households). Mean values calculated from the second survey were used for the missing values.

Also it was not possible to collect reliable quantitative information on labour time used in off-farm activities, although the survey collected information on whether a household had members engaged in off-farm work. We therefore resorted to using a coefficient (or ratio) calculated using off-farm to on-farm mean labour shares presented in the work of Fisher *et al.* (2005) to calculate off-farm labour time by weighting farm labour time with the off-farm to farm labour share ratio for the households engaged in off-farm work.

4.4 The survey of wetland uses

In the survey, households were asked about their use of wetland products. Table 4.3 shows the number of households using the wetland for different uses and the estimated economic values per household for each service. Of the 143 households interviewed, 92% of them use the wetland in one way or another. The main provisioning services for households in the study area that are derived from the wetland are: edible plant collection; livestock grazing; crop production; domestic water extraction; reeds collection (*Phragmites mauritanus* and *Phragmites australis*); and sedge collection (*Cyperus latifolius* and *Cyperus sexangularis*). Using a direct market pricing approach, Adekola (2007) showed that the annual net financial value of these services is \$211 (USD) per household (excluding livestock grazing value) with crop production contributing the highest to the total financial value of the wetland with an estimated value per household of \$1072 (USD) per annum. The same study showed that the wetland contributes a cash income of \$35 (USD) per household per annum, with sedge harvesting contributing the most to the household cash income compared to all the other services.

The intensity of use varies throughout the year. The uses are discussed in detail below.

Table 4.3: Number of households using wetlands for different uses and estimated values per household

Wetland use	Number of households in sample (n=143)	Net financial value of service per user household (US\$/household/annum)	Cash income per user household (US\$/household/annum)
Edible plants collection	80 (56%)	84	2
Livestock grazing*	66 (46%)	192	0
Crop production	60 (42%)	1072	10
Domestic water abstraction	37 (26%)	9	0
Reed collection	34 (24%)	93	4
Sedge collection	33 (23%)	88	20
Firewood collection	2 (1.4%)	667	0
Fishing	5 (3.5%)	12	0
No use	11 (8%)	-	-

* Values for livestock grazing are unreliable as data used was unreliable
Source: Household survey data & Adekola (2007)

4.4.1 Edible plants collection

The studied wetland system provides a wide range of edible plants which play an important role in the diversification of people's diet. The plants grow across the wetland in both the cultivated and wetland areas. Of the 143 households interviewed, 56% collect edible plants from the wetland. Collection of edible plants takes place all year round with most of the collection taking place between November and March. Some households collect excess plants in the wet season and sundry them for use in the dry season when they are no longer obtainable.

4.4.2 Crop production

Wetland agriculture contributes significantly to food security and incomes of households residing in the vicinity of the wetland. Adekola (2007) found that crop production contributes the highest to the total financial value of the wetland with an

estimated value per household of \$1072 (USD) per annum. The wetland is a key agricultural resource because of its fertile peat soils and ability to store water during the dry season, which enables dry season crop production. However, the conversion of the wetland to agriculture is quite recent and partly due to the collapse of irrigation schemes, which used to account for the bulk of agricultural production in the last 10 to 15 years. Recurring droughts, which were experienced in the area since 2000, also contributed to the increasing trend in the conversion of the wetland to croplands. Sarron (2005) estimated that between 1996 and 2004 half the wetland had been converted to agriculture with a corresponding decrease in the wetland area (Figure 4.4). By 2006, 66 ha of the wetland had been converted to agriculture (Adekola, 2007).

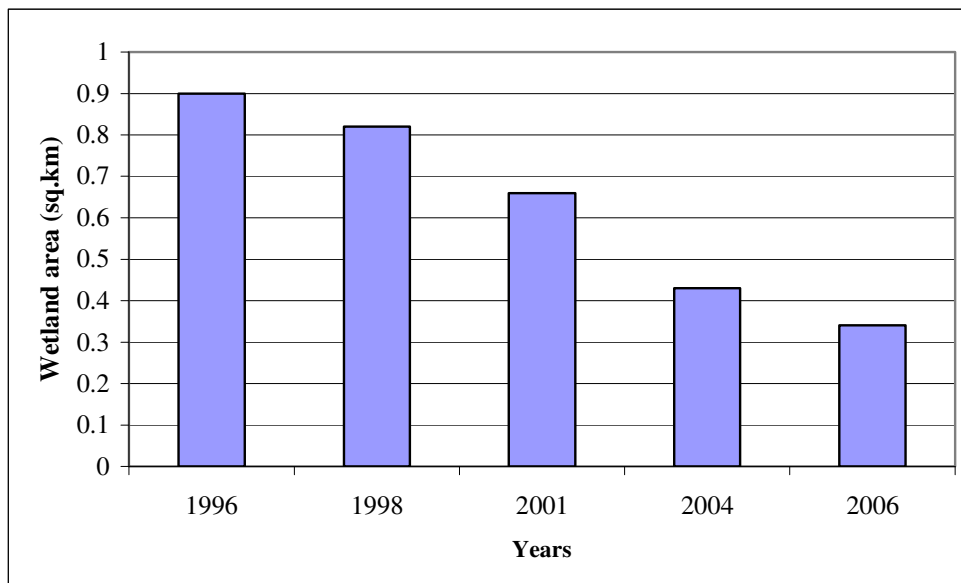


Figure 4.4: Trend in wetland area in the Ga-Mampa wetland (Sarron, 2005)

Of the households who were interviewed, 42% reported that they use the wetland for crop production although 25% of all households in the study area cultivate in the wetland. An average wetland plot size per wetland-cultivating household is 5.3 *bambas*⁶ (0.66 ha). Most of them (82%) reported that the reasons why they cultivate

⁶ *Bamba* is the local unit for measuring a land area. 12 *bambas* = 1 hectare.

in the wetland are because of recurrence of droughts, its fertile soils and its all year round soil moisture.

Maize is the main crop that is produced during the rainy season (October to April) and is often intercropped with vegetables and groundnuts. Coriander and beans are the main dry season crops. Few farmers grow vegetables (tomatoes, onions, spinach, cabbages, etc.).

4.4.3 Livestock grazing

Livestock grazing is another important service provided by the wetland. Livestock generally graze in the adjacent uplands during the wet season. However, during the dry season the wetland is the main source of dry season grazing and watering, because the wetland is more accessible to animals during this period as levels of soil moisture are lower and crop production is limited. During this period livestock also feed on crop residues from the preceding wet season's wetland crops. The crop-livestock interaction is important, but the two systems do compete for space. Grazing in the wetland is mostly uncontrolled and, in some instances, livestock trespass into the crop fields as the cropped area is not fenced.

4.4.4 Reeds and sedge harvesting

Reeds and sedges are harvested by some households in the study area, but in relatively small quantities compared to other wetland areas, mainly due to the availability of preferred substitutes for their uses as well as the scarcity of these resources in the wetland system. Approximately 24% of the interviewed households harvest reeds and sedges from the wetland. Reeds are used in fencing courtyards and for construction purposes (as roofing material). Sedges are used in making art and craft materials. Approximately 19% of the harvested reeds are sold on the local market (Adekola, 2007). Unlike reeds, sedges are rarely used in raw form, they are processed into different art and craft items such as baskets and floor mats, the bulk of which is sold in the local market. Sedge harvesting contributes the most to the households' cash income compared to all the other provisioning services and is estimated to contribute a cash income of \$20 (USD) per household per year.

Based on information collected through focus group discussions, the quantities of reeds and sedge harvested from the wetland have declined over the past five years due to the decrease in their availability. A decrease in the accessibility of these resources is as a result of the expansion of wetland agriculture, which demonstrates the existence of trade-offs between crop production and collection of natural products (Kotze, 2005; Sarron, 2005). Also, the harvesting of reeds has declined due to “modernisation” as people now prefer modern roofing materials such as zinc.

The reeds and sedge are harvested at a certain time; this is regulated by the local leaders (the headman). Harvesting of these wetland products is restricted to the winter period (June and July) to allow for the regeneration of the products. Those who violate this restriction are summoned by the village head for a disciplinary hearing. However, most of these hearings just end up with the violators being cautioned and in very rare cases fined. This is done so as to maintain harmony in the community.

4.4.5 Domestic water abstraction

Water is abstracted from the wetland for a variety of purposes, including: drinking, washing, bathing; and building among others (Darradi *et al.*, 2006). Of the interviewed households, 26% abstract water for domestic purposes. Most of the households that abstract water from the wetland are from one of the villages which have a limited water supply. In addition, some households from the other villages use wetland water for drinking and bathing while engaging in crop production or edible plant collection. Domestic water abstraction is highest during the wet season due to its complementarity to wetland cropping.

Based on the household survey and previous studies carried out in the study area (Adekola, 2007) it was shown that some households engage in a combination of uses and there are complementarities between wetland uses for some households. For instance, it was noted that there are some complementarities between wetland cropping, edible plants collection, domestic water abstraction and reeds and sedge collection.

4.5 The empirical model

From the solution of the first order optimality conditions presented in the previous chapter, a set of reduced form equations can be derived showing the endogenous variables as functions of all the exogenous variables. As done in other similar studies, these equations form the basis for empirical estimation (Heltberg *et al.*, 2000; Fisher *et al.*, 2005; Chen *et al.*, 2006). As shown earlier, the household model comprises of 21 endogenous variables and therefore we have 21 reduced form equations. However, it is not necessary to estimate the full system of equations (Sadoulet and De Janvry, 1995).

Given that our primary interest is to examine the factors that influence household labour use in each of the livelihood activities (grain production, livestock production, off-farm work and collection of wetland products) and the supply of grain and wetland products, we focus our empirical analysis on the following endogenous variables: household labour time used in each of the productive activities (L_o, L_H, L_V, L_G); the quantity of grain supplied (G_q); and the wetland product harvested by households (X_H^H). The reduced form functions for G_q and X_H^H will give rise to household supply functions for grain and wetland products, respectively. These are specified as:

$$G_q = G_q(L_T, E, \Omega, P_j, W_o, \beta, \alpha, \theta, \omega, \mu_G) \quad (4.1)$$

$$X_H^H = X_H^H(L_T, E, \Omega, P_j, W_o, \beta, \alpha, \theta, \omega, \mu_H)$$

Where μ_G and μ_H are error terms and P_j denotes market prices for wetland products, grain, livestock, agricultural inputs, livestock inputs and other market goods.

The main crop grown in the study area is maize and hence represents grain in this case. Livestock labour use and products supply functions are not included in the empirical analysis as livestock data (labour time spent and products) were not reliable in part because livestock grazing is mainly uncontrolled with minimum labour use and livestock is mainly used for draft power and less for meat and milk. The reduced form

equation for household labour time used in each of the livelihood activities is given by:

$$L_i = L(L_T, E, \Omega, P_j, W_o, \beta, \alpha, \theta, \omega, \mu_i) \quad (4.2)$$

Where subscript i represents wetland product collection, grain production and off-farm work while μ_i is the error term.

4.5.1 Model variables and expected direction of relationships

The dependent variables in this study's empirical model are the amount of labour time used in each of the productive activities; and quantities of grain and wetland products supplied. The selection of explanatory variables for the empirical model was based on the analytical framework developed earlier. The explanatory variables in the labour use equations and the grain and wetland products supply functions include: exogenous variables, such as household demographic and endowment characteristics; products and inputs prices; household exogenous income and off-farm wage rates based on this study's analytical framework.

The selection of explanatory variables pertaining household demographic and endowment characteristics is informed by theoretical and empirical literature and data availability. Table 4.4 presents definitions of variables used in the empirical analysis.

Various studies have shown that household demographic characteristics such as gender, the size of the household, the age of the head of the household and a household's education level influences rural household labour supply decisions for different livelihood activities, including natural resource activities (Reardon and Vosti, 1995; Fafchamps and Quisumbing, 1998; Jolliffe, 2004; Matshe and Young, 2004). A household's size is used as a proxy for household labour time endowment (L_T). It is expected that a household's size is positively related to the labour that is allocated to grain production, collection of wetland products and off-farm work, because of the availability of surplus labour. Accordingly, it is expected that a

household's size should be positively related to grain and wetland product supply due to the availability of labour to use in the production of these products.

Matshe and Young (2004) showed that gender influences labour allocation decisions of rural households and found, like Fafchamps and Quisumbing (1998) that because of their time commitment to activities within the household, females are less likely to participate in off-farm activities than males. In most subsistence farming communities in Africa women tend to do much of the agricultural work and interact with the environment more often than their male counterparts. Therefore, one can expect female-headed households to allocate more time to grain production and collection of wetland products and less time to off-farm work. One can also therefore expect female-headed households to supply more grain and wetland products than their male-headed counterparts.

It can be expected that the head of the household's age is positively related to labour used in grain production and collection of wetland products, but negatively related to labour time allocated to off-farm work. This is based on the expectation that older heads have more experience in farming and collection of wetland products. Their experience creates inertia and results in them being interested in their traditional sources of livelihood (farming and natural product collection). The position of older heads in the social network might also give them better access to natural resources including wetland products (land for cropping in the wetland and natural products). Accordingly, it is expected that the age of a household head has a positive effect on grain and wetland product supply.

Many empirical studies have shown that education increases potential employment opportunities in off-farm work, but negatively affects the labour time allocated to the collection of natural products and farm work (Fafchamps and Quisumbing, 1998; Abdulai and Regmi, 2000; Jolliffe, 2004; Matshe and Young, 2004; Fisher *et al.*, 2005; Chen *et al.*, 2006). Therefore, it is hypothesised that the education level of the head of the household is negatively related to labour allocated to grain production and the collection of wetland products, but positively related to time worked off-farm. It is also expected that the education level of a household's head to be negatively related to supply of wetland products and grain.

Table 4.4 Definition of variables used in the econometric analysis

Variable	Definition of variable	Value/measure
<i>Dependent variables</i>		
L_i	Labour time used in grain production, wetland products collection or off-farm activities	Hours per year
X_H^H	Quantity of wetland products supplied (sum of harvested reeds and sedges)	Quantity (in kilograms) per year
G_q	Quantity of maize supplied	Kilograms per year
<i>Explanatory variables</i>		
L_T	Household labour time endowment. Household size is used as a proxy	Number of household members
E	Household exogenous income (includes income from social transfers and pensions)	Rands per month
P_G	Price of agricultural grain ¹	Rands per kilogram
P_H	Price of wetland products (average price of reeds, sedge and edible plants was used)	Rands per kilogram
P_M	Price of market goods. Expenditure on basic food items per capita is used as proxy	Rands per capita per year
P_Y	Price of agricultural inputs. Price of maize seed is used as a proxy.	Rands per kilogram
W_o	Off-farm wage rate	Rands per hour
Houseduc	Education level of household head	Number of years of schooling
Head gender	Gender of household head	1=male 0=female
Head age	Age of household head	Number of years
Wealthind	Household wealth status. An index capturing household assets (land, livestock, farm assets) is constructed	Index

¹For P_G , P_H , P_M and P_Y a village's average prices are used as there was less variation in these prices for households in the same village. Similarly, a village's average wage rate was used.

A household's exogenous income is another explanatory variable in the labour and wetland product and grain supply equations with social grants, pensions and

remittances representing its main forms in the study area. According to Fafchamps and Quisumbing (1998) and Chen *et al.* (2006) a household's exogenous income decreases labour time allocated to crop production and off-farm work and induces higher consumption of leisure. Following this, it is expected that a household's exogenous income to be negatively related to labour time used in off-farm work, grain production and the collection of wetland products.

With regards to the impact of exogenous income on grain supply, Collier and Lal (1986) found that non-farm income is positively related to crop output and hence, supply of crop output due to a better ability to hire labour and purchase agricultural inputs. In contrast, Holden *et al.* (2004) found that better access to non-farm income (exogenous or off-farm work income) reduces incentives to do farming, which leads to lower agricultural production (i.e. households become net buyers of food). Therefore, the impact of exogenous income on supply of grain could be positive or negative. We expect a household's exogenous income to be negatively related to labour time used in wetland products harvesting since it relaxes the household cash constraint inducing higher consumption of leisure thereby reducing labour time used in wetland products harvesting. Similarly, wetland products supply is expected to be negatively related to a household's exogenous income as it reduces the incentive to seek additional income from wetland activities.

One expects that the price of wetland products to be positively related to labour used in collecting wetland products and the supply of the product. Similarly, one can expect the price of grain to be positively related to labour used in grain production and grain supply. Both the price of wetland products and grain are expected to negatively impact on labour used in off-farm work.

An increase in the price of agricultural inputs reduces returns to agriculture and is therefore expected to result in the shifting of household labour resources away from grain production towards off-farm work and wetland product collection. As a result, the supply of wetland products is expected to increase and that of grain reduced. The price of market goods is expected to be positively related to labour time used in the grain production, off-farm work and collection of wetland products since an increase in the price of market goods reduces household real income, inducing the household

to forego leisure. Accordingly, the supply of wetland products is expected to be positively related to the price of market goods, but a negative relationship with grain supply is expected since a high price of market goods reduces the affordability of agricultural inputs.

The off-farm wage rate is expected to be positively related to labour used in off-farm work but negatively related to labour used in grain production and in the collection of wetland products. Therefore, a negative relationship between off-farm wage rates and supply of grain and wetland products is expected.

Many studies have shown that wealth status influences labour allocation decisions of rural households. Although wealthier households are more likely to participate in off-farm work than the poor, they spend less time in the activity (Matshe and Young, 2004). Several studies have found that the poor spend more time on the collection of natural products and collect more quantities than the non-poor (Turpie *et al.*, 1999; Campbell *et al.*, 2002; Chen *et al.*, 2006; Kipkemboi *et al.*, 2007). But the effects of wealth on the collection of wetland products and the supply of these could also be positive in situations where wealthier households have better access to the wetland products, as was demonstrated by Turpie *et al.* (1999) for some wetland sites in the Zambezi basin.

Thus, the relationship between wealth status and labour use and the supply of wetland products could be positive or negative. The relationship between a household's wealth status and the supply of grain is expected to be positive as wealthier households are expected to have more farm assets to enhance farm productivity. However, one may expect wealthier households to allocate less of their time to grain production given that they can hire labour and also can use machinery for some of the activities which are done manually by poor households.

In developing the wealth index, the author followed the approach of Campbell *et al.* (2002) and Démurger and Fournier (2006) in developing a composite wealth index computed as a linear combination of household assets using a principal component

analysis (PCA)⁷. The key household asset variables used for constructing the wealth index are based on household assets identified by Tinguery (2006) through participatory wealth ranking conducted in the study area⁸. In constructing the household wealth index, physical assets were first categorised into three main variables: farm assets (hoe, shovel, plough etc.); domestic assets (radio, television, telephone etc.); and transport equipment (bicycle, motorcycle etc.). A PCA was then done using 6 variables namely: housing type; farm assets; domestic assets; transport equipment; number of livestock (expressed in Tropical Livestock Units); and land area. The index was computed by multiplying the standardised value of each of the 6 variables by the first factorial coordinate of the variable in the PCA and then summed across all 6 variables. A wealth index computed in this way is much more encompassing and better reflects the wealth status of a household than the use of a single proxy variable, as done in most studies.

4.5.2 Econometric estimation procedures

Reduced form models 4.1 and 4.2 constitute the system of equations, which we estimate econometrically. As the error terms across the equations in the system are potentially correlated due to the fact that the same explanatory variables and unobserved characteristics may influence the different equations, estimating the individual equations using ordinary least-squares yields biased and inconsistent estimates as it ignores error correlations across equations (Woodridge, 2002). Seemingly unrelated regression (SUR) models proposed by Zellner (1962), are the most appropriate econometric techniques to account for the cross equation correlations. The merit of the SUR model is that it allows the estimation of the system of equations simultaneously, thereby controlling correlation across the error terms (residuals) in the different equations. This yields unbiased and efficient estimates (Bartels and Fiebig, 1991).

This study accordingly used the SUR procedure to jointly estimate models 4.1 and 4.2 as a system. It should be noted that if the regressors in each equation are the same as

⁷ This technique involves combining several original variables into few derived variables or principal components (factors). In this case the single derived variable is a wealth index.

⁸ A detailed discussion on the construction of the wealth index is given in Jogo *et al.* (2008)

is in this study's case, then the parameters of each independent variable obtained by a SUR model are identical to those obtained through equation-by-equation ordinary least-squares estimation (Greene, 2003). However, it is important to know that even when this is the case, there is still a good reason to estimate the equations jointly using a SUR model (Woodridge, 2002). One reason for this is that one may be interested in testing joint hypotheses involving parameters in different equations.

The Breusch-Pagan test was employed to test the null hypothesis that the error terms of the equations in the system are independent. The results of the test showed that $\chi^2(6) = 47.17$; $p < 0.001$ and therefore the null hypothesis of independence of errors across the equations is rejected and hence the use of the SUR model to jointly estimate the equations is justified.

4.6 Empirical results and discussion

4.6.1 Summary statistics of variables used in the econometric analysis

Table 4.5 presents descriptive statistics of the variables used in the econometric analysis. The statistics show that of the 143 households interviewed, 53% were female-headed. The average age of household heads is 55.5 years. Household size ranges from 2 to 18, with an average of 7.3 persons per household. Education levels in the study area are quite low; the average number of years of education of a household head is 5.5 years, which corresponds to primary level education. This mirrors the picture at the district level where a large proportion of the population attained up to primary level education (Statistics South Africa, 2004). Only 28% of the interviewed households had a member with secondary level education. The low education attainment in the area could be attributed to poor access to basic educational facilities, which characterises most rural areas in South Africa due to the segregationist policies implemented during the apartheid era.

More than 60% of the households in the study area depend on exogenous income sources in the form of social grants, remittances and pensions. Household monthly exogenous income varies widely across households due to differences in demographic

structure of households, especially in terms of age composition⁹. Of the households in the sample, 23% had a household member engaged in off-farm work. Segmentation in the labour market prohibits some people from engaging in off-farm wage employment possibly due to lack of required education level, skills and capacity. Opportunities for off-farm work are limited to jobs in mines, temporary road works, working in nearby large-scale farms and government jobs in health and education departments.

Prices of agricultural output, agricultural inputs, wetland products and market goods and off-farm wage rates are almost the same for all households living in the same village and therefore village average prices and wage rates were used.

Table 4.5: Descriptive statistics of variables used in the econometric analysis

Variable	Mean (n=143)
<i>Dependent variables</i>	
Labour used in grain production(hours/household/year)	285 (126)
Labour used in off-farm work (hours/household/year)	40 (14)
Labour used in collection of wetland products (hours/household/year)	66 (112)
Grain supply (kgs/household/year)	843 (581)
Wetland products supply (kgs/household/year)	246 (357)
<i>Explanatory variables¹</i>	
Household size	7.3 (3.2)
Head of household's age (years)	55.5 (12.9)
Household head's education (years)	5.5 (3.7)
Head of household's gender (% male-headed)	46.9
Household exogenous income (Rands/month)	1000 (757)
Price of grain (Rands/kg)	1.58 (5.46)
Price of agricultural inputs (Rands/ kg)	5.29 (3.60)
Price of wetland product (Rands/kg)	2 (4.44)
Price of market goods (Rands)	342 (548)
Wage rate (Rands/hour)	8 (10.2)

Figures in parenthesis are standard deviations

¹Wealth index is not reported as it is an index ranging from -4.3 to 4.3 with a mean of 0.

⁹ The amount of exogenous income depends on the age structure of the household. Households receive social grants for children under the age of 14 years at the rate of R200 per month and old people aged over 64 years receive R800 per month.

Table 4.5 also shows the average household labour time used in different livelihood activities¹⁰. The figure for labour time allocated to off-farm work compares reasonably well with that from a study on smallholder agricultural households in Zimbabwe by Matshe and Young (2004) although it's higher presumably due to the fact that there are more off-farm opportunities in the study area than those in Zimbabwe.

Households spend most of their time on farm activities presumably due to the high priority given to food security through own production. Low levels of education and skills reduce the productivity and returns from off-farm work, which reflect the opportunity cost of farm labour time. Therefore households rationally allocate more time to farm work and collection of wetland products than off-farm work. This finding is consistent with that of Laszlo (2008) and Jolliffe (2004) that on average rural households particularly those with lower levels of education allocate more labour time to farm activities than to off-farm activities despite the fact that the returns to labour time are lower in farm activities than in off-farm work. This can also be attributed to the overriding importance of farm activities in enhancing food security among rural households in developing countries.

4.6.2 Econometric results

Table 4.6 presents results of the SUR model for labour allocation and supply decisions for grain and wetland products. The results indicate that household size is positively related to the amount of labour time used in grain production, collection of wetland products and off-farm work. This result can be attributed to the fact that larger families have surplus labour to allocate to these livelihood activities. The positive relationship between household size and labour allocated to off-farm work is consistent with income diversification strategies for risk smoothing. As the household size increases the household diversifies its income base and diverts part of its labour force into off-farm activities to generate more income in order to meet the increased consumption demands (Fafchamps and Quisumbing, 1998). This hypothesis is

¹⁰ Labour hours worked per year were calculated from respondent estimates of how many hours are worked per week and the number of weeks worked per year for each activity.

supported by the findings from our survey data which shows that 55% of the households engaged in off-farm activities are large (above average) families.

The positive relationship between household size and the supply of grain and wetland products can also be explained by availability of labour resources to use in grain production and the collection of wetland products.

As expected, results indicate that female-headed households spend more time in grain production and collection of wetland products and accordingly supply more grain and wetland products than their male-headed counterparts. This could be explained by the fact that in most rural smallholder farming communities in South Africa women do most of the agricultural work and have more farming experience than men. In addition, this result could be attributed to the fact that female-headed households have limited access to off-farm income opportunities (this study's household survey data shows that the proportion of households with access to income from off-farm activities is 27% and 20% for male and female-headed households, respectively) and have surplus labour to engage in harvesting of wetland products (average household size for female headed households is 7.8 and that for male-headed households is 6.7). This result corroborates with that of Kipkemboi *et al.* (2007) who found that female-headed households collect more quantities of wetland products than their male-headed counter-parts.

As expected, the education level of the head of the household has a positive effect on labour time allocated to off-farm work and a negative effect on labour used in grain production and the collection of wetland products. The significant positive effect of education on labour time spend in off-farm work can be explained by the fact that education increases one's potential productivity in off- farm work (because, for example, educated household heads are more knowledgeable of employment opportunities and more adaptable in a range of tasks that they are able to perform) and therefore increases the opportunity for lucrative off-farm work. Households with better-educated heads spend less time collecting wetland products, because the opportunity cost of spending their time collecting wetland products (in terms of off-farm income foregone) is very high. Accordingly, household education is negatively related to the supply of wetland products. Other studies by Fisher *et al.* (2005); Chen

et al. (2006) and Narain *et al.* (2008) also found a negative relationship between education and the quantity of natural products collected.

While education has a negative effect on labour input in grain production, it has a positive effect on grain supply. Hence, households with more educated heads are more efficient in grain production. This could be because education enhances opportunities for off-farm work and therefore leads to less labour allocated to on farm work but the resultant increased income from off-farm activities provides the necessary financial resources required to purchase agricultural inputs, which has a positive effect on grain supply.

Household exogenous income has a significant negative impact on labour used in grain production, collection of wetland products and off-farm work. By relaxing the household income constraint, exogenous income reduces the need to undertake on-farm, off-farm and natural products collection activities and induces higher consumption of leisure. Findings consistent with ours are reported by Matshe and Young (2004), who found exogenous income to be negatively related to hours worked off-farm and Chen *et al.* (2006) who found a negative relationship between exogenous income and labour input in fuelwood collection.

In line with the negative relationship between labour input in the collection of wetland products and exogenous income, the supply of wetland products is negatively related to household exogenous income. Although a household's exogenous income reduces labour input in grain production as highlighted above, it increases the supply of grain. A possible explanation for this result is that exogenous income relaxes household liquidity constraints thereby enhancing the ability to purchase productivity-enhancing inputs. Although this result contradicts that of Holden *et al.* (2004), who found a negative relationship between non-farm income and production and supply of agricultural output, it is in line with that of Collier and Lal (1986) that non-farm income is positively related to crop output and supply.

Though statistically insignificant the signs of the coefficients for price of wetland products and that of grain show the expected negative cross-price effects on labour allocation, which shows that the livelihood activities compete for labour resources.

This is also confirmed by the negative cross-price effects of supply of grain and wetland products. With regards to own price effects on supply, the results show a positive supply response of grain and wetland products to price, which is consistent with the microeconomics foundations of an upward sloping supply curve. The insignificance of prices could imply that markets for wetland products are too thin such that labour allocation and supply decisions are influenced more by subsistence considerations in which case a possible extension of this work would be to use endogenously determined household-specific shadow prices.

The results show that the price of agricultural inputs is positively related to labour allocated to off-farm work and wetland products harvesting, but negatively related to labour input in grain production and the supply of grain. A possible explanation for this result is that increased agricultural input prices increase input costs and reduce returns to production to which households respond by using less labour and shift some of their labour resources towards off-farm work and wetland product harvesting thereby reducing grain supply. The other possible explanation is that as price of maize seed increases farmers switch to using traditional seed varieties with a low productivity potential with a negative impact on supply and use less labour because of the expected low returns to labour investment.

Off-farm wage rates were found to be negatively related to labour input in grain production and the collection of wetland products, but positively related to labour supply to off-farm work. As labour returns to grain production and wetland biomass harvesting are quite low (Adekola [2007] estimated that the returns to labour in reeds and sedge harvesting to be approximately R15 and R9 per hour, respectively), a higher off-farm wage rate increases the opportunity cost of labour used in grain production and the collection of wetland biomass products and therefore results in labour resources being shifted away from these activities towards off-farm work. Accordingly, the supply of wetland products significantly decreases. The positive relationship between off-farm wage rates and labour used in off-farm work conforms with the upward sloping labour supply curve, which shows that as the wage rate increases leisure becomes relatively more expensive (the opportunity cost of leisure increases) causing households to substitute away from leisure to more work.

Table 4.6: Seemingly unrelated regression results for labour use in productive activities and supply of grain and wetland products.

Independent variables	Dependent variables				
	Labour used in grain production	Labour used in off-farm work	Labour used in collection of wetland products	Grain supply	Wetland products supply
Household size	0.71* (1.93)	0.37* (2.34)	2.09 (0.73)	0.47* (3.21)	12.13* (2.15)
Age of household head	0.24 (0.50)	-0.66 (1.03)	0.43 (0.14)	0.27 (0.98)	3.83 (0.18)
Gender of household head	-0.19** (1.37)	0.45 (0.78)	-0.73 (0.01)	-0.18 (1.12)	-0.62 (0.95)
Education level of household head	-0.26(1.56)	0.07 ** (4.17)	-0.72** (3.15)	0.95(0.15)	-0.75 (1.23)
Household exogenous income	-0.016** (2.06)	-0.74* (2.57)	-0.02* (1.53)	0.01* (1.08)	-0.09** (4.57)
Price of market goods	-0.001 (0.96)	0.93 (1.07)	-0.12 (1.37)	-0.08 (0.13)	-0.37 (0.89)
Price of agricultural input	-0.01 (0.12)	0.64 (1.12)	0.34 (1.24)	-0.08** (3.16)	0.11 (1.67)
Price of grain	0.054 (0.12)	-0.12 (1.67)	-0.45 (0.15)	0.058** (0.37)	-0.13 (0.78)
Price of wetland products	-0.01(1.20)	-0.01 (0.01)	0.02 (0.45)	-0.01 (0.13)	0.01 (0.220)
Wage rate	-0.039** (6.32)	0.014* (3.24)	-0.086* (1.47)	-0.013 (0.03)	-0.036** (3.07)
Wealth index	-0.07 (0.20)	-0.12* (3.27)	-0.17* (1.84)	0.24** (3.91)	-2.17* (2.89)
Constant	4.63 (2.97)	-9.69 (0.11)	2.13 (0.23)	-2.19 (1.19)	-1.62 (0.50)
Breusch-Pagan test for independence of residuals (χ^2)	47.17				

Absolute values of z-statistics in parenthesis; **denotes significance at 5% and * at 10% level of significance.

Household wealth status has a significant negative effect on labour input in wetland products collection and the supply of these products. This implies that poor households spend more time collecting wetland products and accordingly supply more of these products than the wealthier households. This could be attributed to the fact

that unlike the wealthier households, poor households have limited access to assets and other sources of income (non-resource based off-farm income sources) that can buffer them against negative income and food shortfalls and they also cannot afford alternatives to wetland products. The results of the author's survey show that of the 23% of the surveyed households who have access to off-farm income only 27% belong to the poor category. This result is in line with the evidence found in other studies in rural South Africa that more well-off households often substitute collected goods with purchased alternatives (e.g. Dovie, 2001). This result also supports findings by studies that show that poorer households are more reliant on environmental resources than wealthier households (Barrett *et al.*, 2001; Fisher, 2004; Shackleton and Shackleton, 2006). With regards to wetland products, a study by Turpie *et al.* (1999) also found that poor households collect greater quantities of wetland products than the wealthier households in the Barotse floodplain wetlands (western Zambia) and in the Lower Shire floodplain wetlands (Malawi and Mozambique) although other wetlands in the same study showed an opposite result demonstrating the mixed nature of the findings on the relationship between wealth and natural resource use. .

This study's results also indicate that a household's wealth status has a negative effect on labour time allocated to grain production and off-farm work. Asset-poor households put more labour input into food production and spend more time with off-farm work due to their low marginal productivity of farm labour and the need to meet household food requirements. Wealthier households do less on-farm and off-farm work compared to the poor. This result is similar to that of Matshe and Young (2004) and Fafchamps and Quisumbing (1998) who also found that wealthier households spend less time working off-farm.

Although households who are better-off allocate less time to grain production than their poorer counterparts, they supply more grain presumably due to their better access to productive assets (livestock, farm implements, land), which enhance agricultural productivity.

4.7 Concluding Summary

This chapter analysed the factors that influence household labour allocation and supply decisions by rural households for grain production, off-farm work and wetland products. Reduced form labour use and grain and wetland product supply equations derived from an agricultural household model were estimated jointly using a SUR approach to analyse the determinants of household labour allocation and product supply decisions.

The results presented in this chapter indicated that large families have more workers available to diversify their income base by allocating more labour time to on-farm and off-farm activities than smaller families. The positive and significant effect of household size on grain supply shows that it is critical to alleviate labour bottlenecks (perhaps through adoption of labour saving technologies) in order to improve the supply of the staple crop and enhance food security among rural households.

Our results showed that education is positively related to labour time allocated to off-farm activities, which implies that investment in education and skills development of the rural population is important for the rural population to benefit from growth in the non-farm sector. Since women have relatively limited access to off-farm employment opportunities, gender mainstreaming in rural education programmes is important to improve education opportunities for women to enhance their potential for employment in the off-farm sector.

The positive effect of exogenous income on grain supply and its negative effect on the supply of wetland products shows that policy measures, which reduce household liquidity constraints (e.g. improved access to credit and off-farm income opportunities), can improve food security among rural households and at the same time provide incentives for rural households to conserve wetland resources.

The responsiveness of grain supply to prices (of input and grain) shows that government intervention in agricultural markets can have significant impacts on farm supply. Government regulations, which artificially suppress producer prices and

increase input prices, can create a disincentive for farmers to produce. Therefore, the government, in close partnership with the private sector, should strongly support and strengthen reforms in the input and output markets to ensure that input and output prices provide incentives for farmers to invest in agriculture.

The finding that poor households spend more time on the collection of wetland products and supply more of these products has two implications: first, there is need to integrate wetland management and poverty reduction to provide incentives for the poor to conserve wetland resources; and second, environmental protection policies limiting access to the wetland resources increase inequality among rural populations and deepen poverty, because poorer households suffer more intensively from deprivation of the resource.