DETERMINANTS OF RURAL HOUSEHOLD LABOUR ALLOCATION FOR WETLAND AND OTHER LIVELIHOOD ACTIVITIES: THE CASE OF THE LIMPOPO WETLAND IN SOUTHERN AFRICA

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ABSTRACT

Wetland ecosystems provide a wide range of services supporting the livelihood of many rural communities in southern Africa. This study analyses factors influencing rural household labour allocation and supply decisions for competing livelihood activities, including wetland activities. The analyses employ the agricultural household framework, which takes into account that rural households are both producers and consumers. Results show that poor households are more dependent on wetland products and have less capacity to participate in off-farm opportunities, and hence allocate most of their labour time to farm and wetland activities. Better access to education is critical for enhancing employment potential in the non-farm sector, reducing pressure on wetland resources. Government policies that enhance access to education enable the poor to diversify into non-farm livelihood sources and provide necessary incentives for conserving wetland habitat. This has to be linked with broader rural development programmes such as improving access to markets, micro-credit and other small-scale income-generating activities.

Keywords: Agricultural household model, wetlands, labour allocation, Southern Africa

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1 INTRODUCTION AND BACKGROUND

It is now widely recognised that communities with livelihood strategies that combine subsistence agriculture with utilisation of wetland resources constitute a significant proportion of the population in developing countries (Silvius, Oneka and Verhagen 2000). In southern Africa, there is mounting evidence that wetlands play a significant role in the livelihoods of communities living in semi-arid areas (Biggs *et al*. 2004, Breen, Quinn and Mander 1997, Frenken and Mharapara 2002, Taylor, Howard and Begg 1995, Turpie, Smith, Emerton and Barnes 1999). Wetlands are important agricultural resources because they act as sponges, which store water during the wet season and release it during the dry season, thereby

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providing farmers with the opportunity to grow crops all year round, enhancing food security and household incomes.

Besides crop production, wetlands provide other ecosystem services that directly support human welfare, such as livestock grazing and watering, water supply, fishing and natural products (reeds, papyrus, fuel wood, edible plants and wild animals) (Matiza and Chabwela 1992). Wetlands also provide regulating services, as well as cultural and supporting services (soil formation and nutrient cycling).

In spite of their role in supporting human welfare, wetlands in southern Africa are being increasingly degraded and lost, mainly through conversion to agriculture and the harvesting of natural products (Biggs *et al*. 2004 Breen *et al*. 1997, Matiza and Chabwela 1992). Given their importance in supporting livelihoods, it is essential that they are managed in a sustainable manner, so that they may continue to provide support in future.

One of the major constraints to sustainable management of wetlands in Africa and southern Africa in particular is the lack of understanding of the factors that influence people's access to and use of wetland resources. To date, most of the studies on wetlands in southern Africa have largely focused on economic valuation of wetland services (Mmopelwa 2006, Turpie *et al*. 1999). Very little work has been done on assessing the factors that influence people's decisions on the use of wetland resources. The few studies that have attempted to do so used econometric approaches that are not based on any structural model of rural household decision-making behaviour (e.g., Chiputwa, Morardet and Mano 2006). This study attempts to assess factors influencing rural household decisions on using wetland products through formal modelling of household labour allocation decisions, taking into account that rural households engage in multiple livelihood activities, which compete for their limited labour resources.

The following section describes the case study site and the data and survey design, and gives a summary of the main livelihood activities and wetland uses in the study area. Section 3 presents the analytical model, derives the optimality conditions and discusses the analytical results. The empirical model for implementing the analytical framework is presented in section 4, where hypotheses about the direction of relationships and applied econometric estimation procedures are discussed. Section 5 presents and discusses empirical results. Conclusions and policy implications are presented in section 6.

2 MAIN LIVELIHOOD AND WETLAND ACTIVITIES IN THE STUDY AREA

2.1 The study area and main livelihood activities

This study was carried out in the Ga-Mampa wetland, which lies in the Mohlapitsi river catchment, a tributary of the Olifants River in the Limpopo river basin in South Africa. The study area is located in the former homeland[1] area of Lebowa in the Capricorn district of the Limpopo province. In 2006, it was estimated that 2 800 people (394 households) resided in the villages around the wetland (Adekola 2007).

The main livelihood activity for communities in the study area is small-scale subsistence agriculture. Agricultural production is mixed crop and livestock systems with cropping taking place under small-scale irrigation and in the wetland. Approximately 160 households have access to irrigation plots. 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 marketed agricultural output.

The main sources of income are agriculture, government social grants, pensions and remittances. Households receive social grants for children under the age of 14 years at the rate of ZAR160 per month, and people aged over 64 years receive ZAR900 per month. Approximately 35 per cent and 30 per cent of the households depend on pensions and off-farm activities, respectively, for income (Ferrand 2004).

2.2 The survey of wetland uses

A household survey was conducted in the study area to understand household livelihood strategies and dependence on wetland products. One hundred and forty-three households were randomly selected for interviews. A structured household questionnaire was used to elicit data on demographics, asset endowments, main livelihood activities (farm, off-farm and main wetland uses) and their contribution to the household economy, and other household socio-economic characteristics. In addition, the survey solicited quantitative information on time spent on different livelihood activities, production, consumption and marketing of grains and wetland products and prices.

Major uses of the wetland in the area were found to be the collection of edible plants, livestock grazing, crop production, domestic water abstraction and the collection of reeds (*Phragmites mauritianus*) and sedge (*Cyperus latifolis* and *Cyperus sexangularis*).

3 THE ANALYTICAL FRAMEWORK

The neoclassical model of a farm household (agricultural household model) described by Singh, Squire and Strauss (1986) has been the main analytical approach used for analysing the 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 both producers and consumers. The households can separate production and consumption decisions by first maximising profit from food production and then using the profits from production to maximise utility from consumption.

We drew upon the neoclassical model of the farm household presented in Singh *et al*. (1986) and applied in other empirical studies in developing countries (Chen, Heerink and Van den Berg 2006, Heltberg, Arndt and Sekhar 2000) to develop our model for analysing the factors influencing household labour allocation decisions for competing livelihood activities and supply decisions including wetland activities. The model presented below captures the situation of a farm household engaged in crop production, livestock production, off-farm work and the collection of wetland products.

The model assumes that a representative household maximises its utility function, which is dependent on consumption of a composite wetland product (X_H), agricultural grain (X_G), livestock product (X_N), market goods (X_M) and leisure time (L_Z). Household utility is assumed to vary with 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 market goods, X_M , are purchased from the market.

Thus, the household utility maximisation problem is defined as:

$$\text{Max } \Omega = U(X_H, X_G, X_M, X_N, L_Z; \grave{U}) \tag{1}$$

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

$$X_H = X_H^H + X_H^P - X_H^S \tag{2}$$

The production constraint of wetland products describes harvesting of wetland products 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 the education level of the household, and a vector of production technology parameters (β):

$$X_H^H = X_H^H \, (L_H, \beta; \Omega) \tag{3}$$

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, hoes) (ω), a composite input capturing all the inputs used in grain production that are purchased from the market, such as fertiliser and seeds (Y_G), and the production technology parameter (α).

$$G_q = G_q \, (\alpha \, , L_G, Y_G; \omega) \tag{4}$$

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

$$X_G = G_q + G_q^p - G_q^s \tag{5}$$

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 a production function parameter (Θ).

$$V_N = V_N \, (L_V, N, \Theta) \tag{6}$$

As is the case with agricultural grain, livestock products can be bought and sold on 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 on the market (V_N^S):

$$X_N = V_N + V_N^P - V_N^S \tag{7}$$

Household cash expenditures are constrained by income from selling agricultural grain, livestock products and wetland products, as well as off-farm labour income and exogenous income (E). Exogenous income includes income in the form of pensions, social grants and remittances. The household can spend income on purchasing wetland products, livestock products, agricultural grain and market goods and on purchasing agricultural inputs used in grain production. Farm inputs (Y_G) are bought but not sold. We assume that all market prices are exogenous and cash expenditures cannot exceed total cash income.

Thus the household budget constraint is given by the following formula:

$$P_H X_H^S + P_G G_q^S + P_V V_N^S + L_o W_o + E \geq P_M X_M + P_H X_H^P + P_g G_q^p + P_V V_N^P + P_Y Y_G + P_N N \quad (8)$$

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

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

$$L_T = L_H + L_o + L_G + L_V + L_Z \quad (9)$$

The decision problem for the subsistence farm household is to maximise utility function (1) subject to production, budget and time constraints specified in (2) to (9) above. The Lagrangian function for an internal solution to this problem is as follows:

$$\ell = U\{X_M, X_H, X_G, X_N, L_Z; \Omega\} - \lambda_1 (X_H^H - X_H^H(L_H, \beta; \Omega)) - \lambda_2 (G_q - G_q(\alpha, L_G\ Y_G; \omega)) - \lambda_3 (V_N - V_N(L_V, N, \theta)) - \lambda_4 (P_M X_M + P_H X_H^P + P_G G_q^p + P_V V_N^P + P_Y Y_G + P_N N - P_H X_H^S - P_G G_q^S - P_V V_N^S - L_o W_o - E) - \lambda_5 (L_H + L_o + L_G + L_V + L_Z - L_T) \quad (10)$$

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

L_o, L_H, L_V, L_G, 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^S, V_N^P, λ_1, λ_2, λ_3, λ_4, λ_5

Therefore, one needs 21 equations to solve for 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 to A21 in Appendix A, gives the complete set of 21 equations needed to solve for 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, ω.

4 THE EMPIRICAL FRAMEWORK

From the solution of the first order optimality conditions presented in the previous section, a set of reduced form equations can be derived, showing the endogenous variables as functions of all exogenous variables. As in other similar studies, these equations form the basis for empirical estimation (Chen *et al*. 2006, Fisher, Shively and Buccola 2005, Heltberg *et al*. 2000). As shown earlier, our household model comprises 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 influencing household labour use in competing productive activities (grain production, livestock production, off-farm work and collection of wetland products) and supply of grain and wetland products, we focus our empirical analysis on the following endogenous variables: labour time used in each of the productive activities (L_o, L_H, L_V, L_G); G_q and X_H^H. The reduced form equations for G_q and X_H^H will give rise to supply functions for grain and wetland products, respectively.

These are specified as follows:

$$G_q = G_q\,(L_T, E, \Omega, P_j, W_o, \beta, \alpha, \Theta, \omega, \mu_G) \qquad (11)$$

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

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. The production function for livestock products is not included in the empirical analysis as livestock are mainly used for draft power and less often for meat and milk. Similarly, labour use in livestock activities and the price of livestock inputs are not included in the empirical analysis since labour use for livestock activities in the study area is minimal as livestock grazing is mainly uncontrolled.

The reduced form equation for labour time used in each of the livelihood activities is given by the following:

$$L_i = L\,(L_T, E, \Omega\,, P_j, W_o, \beta, \alpha, \Theta, \omega, \mu_i) \qquad (12)$$

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

4.1 Model variables and expected direction of relationships

The dependent variables in our empirical model are the amount of labour time used in each of the livelihood activities and the quantities of grain and wetland products supplied. 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 grain and wetland product supply functions include exogenous variables, such as household demographic and endowment characteristics, product and input prices, household exogenous income, and off-farm wage rate based on our analytical framework.

The selection of explanatory variables pertaining to household demographic and endowment characteristics was informed by theoretical and empirical literature and data availability. Table 1 presents the definitions of variables used in the empirical analysis.

Various studies have shown that household demographic characteristics, such as household size, age of household head, education level of household and gender, influence rural household labour supply and supply decisions for different livelihood activities including natural resource activities (Fafchamps and Quisumbing 1998, Jolliffe 2004, Matshe and Young 2004, Reardon and Vosti 1995). Household size is used as a proxy for household labour time endowment (L_T).

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.

Education increases potential employment opportunities in off-farm work, but negatively affects labour time allocated to the collection of natural products and on-farm work (Abdulai and Regmi 2000, Chen *et al*. 2006, Fafchamps and Quisumbing 1998, Fisher *et al*. 2005, Jolliffe 2004, Matshe and Young 2004). Accordingly, we expect household education to be negatively related to labour time allocated to grain production and the collection of wetland products and the supply decisions made for wetland products and grain.

Table 1: Definition of variables used in the econometric analysis

Variable	Definition of variable	Value/measure
Dependent variables		
L_i	Labour time used in grain production, wetland product collection or off-farm activities	Hours per year
X_H^H	Quantity of wetland products supplied	Quantity (in bundles/ kilograms) per year
G_q	Quantity of grain supplied	Kilograms per year
Explanatory variables		
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, 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 good. Expenditure on basic food items is used as proxy	Rands
P_Y	Price of agricultural input. This is set equal to price of maize seed as seeds are the main input cost for maize in the study area	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

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

Labour supply and supply of wetland products and agricultural grain are functions of prices of wetland products, market goods, agricultural grain and agricultural inputs and off-farm wage rates as these induce several substitution and income effects on household production and consumption choices.

Many studies have shown that wealth status influences labour allocation decisions of rural households. While wealthier households were found to be more likely to participate in off-farm activities than the poor (Matshe and Young 2004), poor households have a stronger incentive to diversify into off-farm activities (Bagamba 2007) but lack of skills and capacity make them less responsive to off-farm employment opportunities. Several studies found that the poor spend more time on collection of natural products and supply more quantities than the non-poor (Campbell *et al*. 2002, Chen *et al*. 2006, Kipkemboi *et al*. 2007, Turpie *et al*. 1999).

We follow the approach of Campbell *et al*. (2002) and Démurger and Fournier (2006) to develop a composite wealth index computed as a linear combination of household assets using principal component analysis (PCA). The key household asset variables used for constructing the wealth index are based on household assets identified by Tinguery (2006) through participatory wealth ranking. Variables used are: housing type, farm assets, domestic assets, transport equipment, livestock number and land area. 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 used in most studies.

Household exogenous income is another explanatory variable included with social grants, pensions and remittances representing its main forms in the study area. Fafchamps and Quisumbing (1998) and Chen *et al*. (2006) found that household exogenous income decreases labour time allocated to crop production and off-farm work and results in more time allocated to leisure. However, Collier and Lal (1986) found that non-farm income is positively related to crop output due to a better ability to hire labour and purchase agricultural inputs. In contrast, Holden, Shiferaw and Pender (2004) found that better access to non-farm income reduces incentives to do farming, which leads to lower agricultural production (i.e. households become net buyers of food).

4.2 Econometric estimation procedures

The reduced form equations (11) and (12) constitute the system of equations that 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 the error correlations across equations (Woodridge 2002). Seemingly unrelated regression (SUR) models, proposed by Zellner (1962), are the most appropriate econometric techniques to account for cross-equation error correlations. The merit of the SUR model is that it allows estimation of the system of equations simultaneously, thereby controlling for correlations across error terms (residuals) in the different equations. This yields unbiased and efficient estimates (Bartels and Fiebig 1991). In addition, fewer observations are required to obtain reliable estimates than when the equations are estimated separately (Smith and Kohn 2000).

This study accordingly used the SUR procedure to jointly estimate models (11) and (12) as a system. It should be noted that if the regressors in each equation are the same as is in our 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 we 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 across 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.

5 RESULTS AND DISCUSSIONS

5.1 Summary statistics of variables used in the econometric analysis

Table 2 presents descriptive statistics of 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 was 55.5 years. Household size ranged from 2 to 18, with an average of 7.3 persons per household.

Table 2: Descriptive statistics of variables used in the econometric analysis

Variable	Mean (n=143)
Dependent variables	
Labour used in grain production(hours/household/year)	285 (126)
Labour used in off-farm work (hours/household/week)	40 (14)
Labour used in collection of wetland products	66 (112)
Grain supply (kg/household/year)	843 (581)
Wetland products supply (kg/household/year)	246 (357)
Explanatory variables[1]	
Household size	7.3 (3.2)
Head age (years)	55.5 (12.9)
Household head education (years)	5.5 (3.7)
Head 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/month)	342 (548)
Wage rate (Rands/hour)	8 (10.2)

Figures in parenthesis are standard deviations. 1 Wealth index is not reported as it is an index ranging from -4.3 to 4.3.

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 per cent 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 the demographic structure of the households especially in terms of age composition[2]. Of the households in the sample, 23 % had a household member engaged in off-farm work.

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

Table 2 also shows the average household labour time used in the different livelihood activities[3]. Households spend most of their time on farm activities, presumably due to the high priority given to food security through their own production. Low levels of education and skills reduce the productivity and labour returns to off-farm work and, therefore, households rationally allocate more time to farm work and collection of wetland products than to off-farm work. This finding is consistent with that of Laszlo (2008) and Jolliffe (2004) who found 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.

5.2 Econometric results

Tables 3 and 4 present the 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, the 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 increased consumption demand (Fafchamps and Quisumbing 1998).

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

The results indicate that female-headed households spend more time on grain production and the 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 much of the agricultural work and have more farming experience than men. Men spend more time in off-farm work. This result supports that of Kipkemboi *et al*. (2007) who found that female-headed households collect greater quantities of wetland products than their male-headed counterparts.

Table 3: Seemingly unrelated regression results for labour use in alternative livelihood activities

	Dependent variables		
Independent variables	Labour used in grain production	Labour used in off-farm work	Labour used in collection of wetland products
Household size	0.71* (1.93)	0.37* (2.34)	2.09 (0.73)
Age of household head	0.24 (0.50)	-0.66 (1.03)	0.43 (0.14)
Gender of household head	-0.19** (1.37)	0.45 (0.78)	-0.73 (0.01)
Education level of household head	-0.26(1.56)	0.07 **(4.17)	-0.72** (3.15)
Household exogenous income	-0.02** (2.06)	-0.74* (2.57)	-0.02* (1.53)
Price of market goods	0.001 (0.96)	0.93 (1.07)	0.12 (1.37)
Price of agricultural input	-0.01 (0.12)	-0.64 (1.12)	0.34 (1.24)
Price of grain	0.05 (0.12)	-0.12 (1.67)	0.45 (0.15)
Price of wetland products	-0.01(1.20)	0.01 (0.01)	0.02 (0.45)
Wage rate	-0.04** (6.32)	0.01* (3.24)	-0.09* (1.47)
Wealth index	-0.07 (0.20)	-0.12* (3.27)	-0.17* (1.84)
Constant	4.63 (2.97)	-9.69 (0.11)	2.13 (0.23)
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.

Table 4: Seemingly unrelated regression results for supply of grain and wetland products.

Independent variables	Grain supply	Wetland products supply
Household size	0.47* (3.21)	12.13* (2.15)
Age of household head	0.27 (0.98)	3.83 (0.18)
Gender of household head	-0.18 (1.12)	-0.62 (0.95)
Education level of household head	0.95(0.15)	-0.75 (1.23)
Household exogenous income	0.01* (1.08)	-0.09** (4.57)
Price of market goods	-0.08 (0.13)	0.37 (0.89)
Price of agricultural input	-0.08** (3.16)	0.11 (1.67)
Price of grain	0.06** (0.37)	-0.13 (0.78)
Price of wetland products	0.01 (0.13)	0.01 (0.22)
Wage rate	0.01 (0.03)	-0.04** (3.07)
Wealth index	0.24** (3.91)	-2.17* (2.89)
Constant	-2.19 (1.19)	-1.62 (0.50)

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

As expected, the education level of a household head 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 spent on off-farm work can be explained by the fact that education increases one's potential productivity in off-farm work (e.g., because educated households are more knowledgeable of employment opportunities and more adapted to the range of tasks that they are able to perform) and, therefore, increases the opportunity for lucrative off-farm work. Households with more educated household 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, Gupta and Klaas (2008) also found a negative relationship between education and collection of natural products.

While education has a negative effect on labour input in grain production, it has a positive effect on grain supply, implying that households with more educated heads are more efficient in grain production.

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 results in more time spent on leisure activities. Findings consistent with ours are reported by Matshe and Young (2004), who found that exogenous income is negatively related to hours worked off-farm, and Chen *et al*. (2006), who found a negative relationship between exogenous income and labour input in firewood collection.

In line with the negative relationship between labour input in collection of wetland products and exogenous income, the supply of wetland products is negatively related to household exogenous income. Although household 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 Collier and Lal's (1986) finding that non-farm income is positively related to crop output and supply.

Our results show that the price of agricultural inputs is negatively related to labour input in grain production and the supply of grain. This could be attributed to the fact that increased agricultural input prices increase input costs and reduce returns to agricultural production, to which households respond by reducing land under cultivation and using less labour and other inputs, thereby reducing grain supply. The supply of grain shows a positive response to its price, which is consistent with the upward sloping supply curve.

Off-farm wage rate was found to be negatively related to labour input in grain production and collection of wetland products, but positively related to labour supply to off-farm work. This is due to the fact that a higher off-farm wage rate increases the opportunity cost of labour used in grain production and collection of wetland products and, therefore, results in labour resources being shifted away from these activities towards off-farm work. Accordingly, the supply of wetland products decreases significantly. The positive relationship between off-farm wage rate and labour used in off-farm work conforms to the upward sloping labour supply curve, which shows that as wage rate increases, leisure becomes relatively more expensive, causing people to substitute for leisure with more work.

Household wealth status has a significant negative effect on labour input in wetland products collection and 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 income sources) that can buffer them against negative income and food shortfalls, and also cannot afford substitutes for wetland products. This result is in line with the finding by studies on income diversification in Africa, which show that asset poverty compels diversification into environmental resource activities (Barrett, Reardon and Webb 2001, Fisher 2004). A study by Turpie *et al.* (1999) also found that poor households collect greater quantities of wetland products than wealthier households in the Barotse floodplain wetlands (western Zambia) and in the Lower Shire floodplain wetlands (Malawi and Mozambique).

Our results also indicate that household 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 working off-farm, due to their low marginal productivity of farm labour and the need to meet household food requirements. Wealthier households work less on-farm and off-farm compared to the poor. This result is similar to those of Matshe and Young (2004) and Fafchamps and Quisumbing (1998), who also found that wealthier households spend less time working off-farm.

Although the better-off households 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.

6 CONCLUSION AND POLICY IMPLICATIONS

This paper analysed the factors influencing labour allocation decisions of rural households among grain production, off-farm work and the collection of 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 supply decisions.

The results presented in this paper indicate that large families have more person power 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 in order to improve 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 a significant impact on farm supply. Government regulations, which artificially suppress producer prices and increase input prices, can create a disincentive for farmers to produce. Therefore, 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 collection of wetland products and supply more of these products suggests that there is need to integrate wetland conservation and poverty reduction to provide incentives for the poor to conserve wetland resources. This can be achieved through enhancing non-farm livelihood options for the rural poor, whose livelihoods depend primarily on agriculture and natural products.

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NOTES

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

2 The amount of exogenous income depends on age structure of the household. Households receive social grants for children under the age of 14 years at the rate of ZAR160 per month, and old people aged over 64 years receive ZAR900 per month.

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

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APPENDIX A

First order conditions for the household optimisation model

$$\partial\ell/\partial L_H = \lambda_1 \, \partial X_H^H/\partial L_H - \lambda_5 = 0 \tag{A1}$$

$$\partial\ell/\partial L_G = \lambda_2 \, \partial G_q/\partial L_G - \lambda_5 = 0 \tag{A2}$$

$$\partial\ell/\partial L_V = \lambda_3 \, \partial V_N/\partial L_V - \lambda_5 = 0 \tag{A3}$$

$$\partial\ell/\partial L_o = \lambda_4 W_o - \lambda_5 = 0 \tag{A4}$$

$$\partial\ell/\partial Y_G = \lambda_2 \, \partial G_q/\partial Y_G - \lambda_4 P_Y = 0 \tag{A5}$$

$$\partial\ell/\partial N = \lambda_3 \, \partial V_N/\partial N - \lambda_4 P_N = 0 \tag{A6}$$

$$\partial\ell/\partial X_M = \partial U/\partial X_M - \lambda_4 P_M = 0 \tag{A7}$$

$$\partial\ell/\partial X_H^H = \partial U/\partial X_H \, \partial X_H/\partial X_H^H - \lambda_1 = 0 \tag{A8}$$

$$\partial\ell/\partial X_H^S = \partial U/\partial X_H \, \partial X_H/\partial X_H^S + \lambda_4 P_H = 0 \tag{A9}$$

$$\partial\ell/\partial X_H^P = \partial U/\partial X_H \, \partial X_H/\partial X_H^P - \lambda_4 P_H = 0 \tag{A10}$$

$$\partial\ell/\partial G_q = \partial U/\partial X_G \, \partial X_G/\partial G_q - \lambda_2 = 0 \tag{A11}$$

$$\partial\ell/\partial V_N = \partial U/\partial X_N \, \partial X_N/\partial V_N - \lambda_3 = 0 \tag{A12}$$

$$\partial\ell/\partial G_q^P = \partial U/\partial X_G \, \partial X_G/\partial G_q^P - \lambda_4 P_G = 0 \tag{A13}$$

$$\partial \ell / \partial G_q^S = \partial U / \partial X_G \; \partial X_G / \partial G_q^S + \lambda_4 P_G = 0 \quad \text{(A14)}$$

$$\partial \ell / \partial V_N^P = \partial U / \partial X_N \; \partial X_N / \partial V_N^P - \lambda_4 P_V = 0 \quad \text{(A15)}$$

$$\partial \ell / \partial V_N^S = \partial U / \partial X_N \; \partial X_N / \partial V_N^S + \lambda_4 P_V = 0 \quad \text{(A16)}$$

$$\partial \ell / \partial \lambda_1 = X_H^H (L_H, \beta; \Omega) - X_H^H = 0 \quad \text{(A17)}$$

$$\partial \ell / \partial \lambda_2 = G_q (L_G, K_G, Y_G, \alpha) - G_q = 0 \quad \text{(A18)}$$

$$\partial \ell / \partial \lambda_3 = V_N (L_V, N, \theta) - V_N = 0 \quad \text{(A19)}$$

$$\partial \ell / \partial \lambda_4 = P_H X_H^S + P_G G_q^S + P_V V_N^S + L_o W_o + E - P_M X_M - P_H X_H^P - P_G G_q^p$$
$$- P_V V_N^P - P_Y Y_G - P_N N = 0 \quad \text{(A20)}$$

$$\partial \ell / \partial \lambda_5 = L_T - L_H - L_o - L_G - L_V - L_Z \quad \text{(A21)}$$