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The Economics Analysis of Small Scale Vegetable Production in North Central Namibia

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Abstract In this paper, we attempted to identify determinants of farmers' participation in Green Scheme project and determinants of profits once farmers are in the project. Furthermore, we have attempted to investigate whether there is any difference in profitability between project farmers and other farmers operating own horticultural enterprises within the vicinity of the project. This paper has focused primarily on Etunda Green Scheme Project and other farmers in the Olushandja area. We used the Heckman's Sample Selection Model to address the issue of farmers' self-selection into the project. The study found that owning a car (proxy for wealth) and the project plot size are the most significant determinants of farmers' participation in the project. The study also found that the level of education and ability to hire labor are critical determinants of profitability for project farmers.

Keywords Small-Scale Irrigation, Participation, Green Scheme Income

1. Introduction

The agricultural sector is the mainstay for many households in Namibia. It employs over 70 per cent of the working population and accounted for around 5 per cent of gross domestic product (GDP) each year between 2000 to 2010 [1]. Scarcity of productive arable soil, low input use, dependence on highly variable natural rainfall and low output are salient features of Namibian agriculture. This is in agreement with Staatz and Eicher[2] who argued that the majority of the poor in most developing countries (third word) live in rural areas and because food prices are a major determinant of the real income of both the rural and urban poor the low productivity of developing countries agriculture was seen as a major cause of poverty. Thus, agriculture production and the use of natural resources are important for rural household income and food self-sufficient in Namibia. For instance with respect to crops in the north central Namibia farm households traditionally depend on rain-fed agriculture, and *mahangu* (pearl millet) is the principal staple crop grown on the same field with much smaller quantities of sorghum and maize. These cereals are supplemented by legumes (beans, cowpeas, bambaranuts, and groundnuts) vegetables (melons). According to Mendelsohn et al [3] crop commercialization in the northern communal areas is only possible for farmers with the resources to provide high cost of inputs such as irrigation, fertilizer and labor to produce surpluses which can be sold for cash incomes.

Moreover, the government of the Republic of Namibia sees significant potential for the production of horticultural fresh produce through irrigation farming in northern communal areas, home to almost half of the country's population. This means that the focus is on utilization of water for irrigation along the perennial transnational rivers (Kunene, Okavango and Zambezi). In addition small-scale irrigation farming in northern Namibia is considered an adaptation strategy for coping with rainfall variations [4]. In northern Namibia farmers are vulnerable to recurring droughts and occasional flooding over the years. The interruption of rains within growing season and the adverse effects of drought upon soil conditions render crop failure for most farming households in rural areas [5]. Similarly during floods across much of the northern Namibia throughout January to March smallholder (subsistence) farmers area under cultivation is significantly reduced [6]. As a result, this has limited the country's crop productivity and food security. Collier and Dercon [7] argue that if African agriculture is to be successful despite overall deteriorating agro-climatic conditions, new crops or varieties will need to be grown, using different appropriate technologies.

In an effort to boost food production, the Namibian government has endeavored to enhance agricultural production and unleash the potential of agricultural production and exploit opportunities that agriculture has to offer through irrigated farming. This initiative is known as Green Scheme which was born out of the World Food Summit held in 2002 in Rome where countries especially African countries decided to expand irrigation by investing in irrigation infrastructure in order to boost agricultural production [8]. It is estimated that potentially about 43500 hectares [9] of the underdeveloped land in Namibia could be irrigated by water obtained from the perennial rivers (Orange, Okavango and Zambezi rivers) that border the country, as well as from excess underground water that is available countrywide. As a result the Green Scheme policy was finalized and adopted by the government of the Republic of Namibia, through the Ministry of Agriculture, Water and Forestry (MAWF) in 2003 [8]. The purpose of the Green Scheme is to increase productivity and social development, increasing agricultural production, promoting investment in food and agro-industry and promoting food security. According to FAO[10] the initiative of irrigation boosts agricultural production as it helps producers to overcome rainfall and water constraints, thus increasing income and food security in poor communities.

Thus, small-scale irrigation farmers in northern Namibia utilized mainly micro-irrigation technologies [4], drip and sprinkler based systems which according to Shah and Keller [11] was first perfected in Israel during the 1960's have spread to many other parts of the world, especially United States of America. Although it is expected that farmers stand to benefit from their participation in the green scheme, it remains unclear whether scheme farmers realize significantly more income than those farmers that are operating on their own. Researchers like Singh[12], Little and Watts[13], Havnevik et al[14] questioned whether agriculture schemes do generate sustainable benefits for participants. Little[15] argues that income from agriculture scheme may increase but in most cases, it is not enough to rely on and hence some farmers derive income from other non-farm activities. However, it is important to note that missing agricultural markets for some factor inputs or outputs have created complex sets of incentives for small-scale producers who are faced with a need to gain high agricultural incomes or migrate out of agriculture altogether [16]. This study therefore seek to address the following objectives: 1) identify determinants of project participation 2) identify determinants for profitability for project farmers 3) investigate if there is profitability differences between project farmers and non-project farmers and 4) determine if there is selection bias.

2. Methodology

2.1. Description of Study Area

The Etunda irrigation project is located in the Omusati region in north-central Namibia about 40 km north-west of Outapi, the administrative town in the region. The project was first started in 1994 as a government initiative to introduce and develop horticultural crops in the region and hence increase agricultural sector contribution to the country's GDP through the development of irrigation infrastructures. The project initially was managed by government owned institution, the Namibian Development Cooperation (NDC). Today the project is tendered to a private company which engages in high value crops production and runs day to day operations as a service provider to small-scale producers. The Etunda irrigation project covers an area of 1200 hectares of land. Currently, 600 ha are undeveloped; the commercial production occupies 300 ha using a centre pivot irrigation system and is managed by a service provider. The remaining 300 ha are for small-scale production with each small-scale farmer occupies a minimum of 3 ha and uses the sprinkler irrigation method in their production. Presently, the project has 85 small-scale producers with farming experiences ranging from 1 to 20 years. The main crops grown at the project are maize, cabbages, tomatoes, groundnuts, butternuts, sweet potatoes, green peppers, watermelons and carrots.

Moreover, soil in the project area is predominantly comprised of (deep) Kalahari sands with low water retention and to a lesser extent loams and silts. Generally organic matter in the topsoil is low about (1 to 5%) with nutrient deficiency, low fertility and susceptible to salinity. The climate in the region can be described as semi-arid with an average annual erratic rainfall ranging from 350 to 500 mm per annum. The water for irrigation in the study area is pumped from the nearby Kunene River across the border in Angola. Summers are hot with maximum temperatures between 30°C and 35°C during the hottest months, and the coldest winter temperatures are around 2 to 6°C [17].

2.2. Data Collection and Sample Size

Due to small number of participating farmers in horticultural production in the region this study sampling procedure was to purposefully sample all small scale farmers in Etunda irrigation project and individual small-scale irrigation farmers in the vicinity of the project area (around the Olushandja dam). Fifty nine (59) and 26 small scale farmers were interviewed in Etunda project (as project participants) and around Olushandja dam (non-participants) respectively. Primary data was collected using a structured, pretested questionnaire which was administered to the head of the household through face to face interviews. The questionnaire solicited information on household demographics (gender, age and education), land size, training, household production assets and technology, household expenses and income. The study was undertaken between June and July 2012. In addition to primary data, secondary data were collected from Ministry of Agriculture, Water and Forestry Offices, Etunda Irrigation project offices, Olushandja Horticulture Producers Association Office and the Namibian Agronomic Board. Heckman's two stage estimation models which are discussed next were used to analyze the collected data.

2.3. Analytic Methods

Evaluating the effect of a program, in this case participation in an irrigation project, on the outcome variable (income) using standard techniques such as Ordinary Least Square and Logit or Probit yield inaccurate estimate as some include variable and some omit variable that affect both selection and the subsequent outcome of interest [18]. These techniques can thus lead to biased estimates if the underlying process which governs selection into the institution or a program is not incorporated in the empirical framework [19]. Farmers participating in Etunda project were selected according to pre-determined criteria which may create selection bias in our analysis. In addition, there may be other salient factors that influence the selection of farmers into the project causing biasness. Therefore the Heckman's two stage model was chosen for analysis as it provide an important way of accounting for economic decision that combine discrete and continuous choice and of correcting non-random sampling [20]. The same model was used by Miyata et al[21], Aseyehegn et al[19]; Benfica [22] for similar type of studies as it controls for sample selection biasness.

Benfica[22] referred to a Standard Sample Selection Bias Model to explain and address the selection problem. Let the equations be:

The equation that determines the sample selection:

$$c_1 = \gamma z_i + e_i \quad \varepsilon(e_i \mid z) > 0 \tag{1}$$

Where:
c1 is the dummy variable for participation
γ denotes independent variables
z1 denotes a vector of variables that affect participation
e1 denotes the disturbance term
Net Income Equation:

$$y_i = \beta x_i + u_i \quad \varepsilon(u_i \mid x) = 0 \tag{2}$$

Where:
yi denotes the level of net income of Etunda farmers
β denotes the parameters representing the relationship between explanatory variables and income
zi denotes the vector of variables that affect the level of income
ui denotes the disturbance term
ui ~ N(0,σ), e1 ~ N(0,1), and corr(u1,e1)ρ is assumed by the standard sample selection bias.

We assume that x and z are always observed and x and z both exogenous which means that they both are determined by outside factors. We further assume that x is a strict subset of z i.e. some elements that are not in x are in z, fourth ei is independent of both x and z and has a standard normal distribution.

Table 1. Shows the variables that were included in the model and their expected signs

Variable Name	Variable Type	Participation Model	Income Model
Age of Household Head	Age of household head in years.	Age of household head is expected to be negatively related to participation as older farmers tend to be conservative.	Age is expected to be negatively related to income because older farmers tend to be less innovative and largely employ conservative management practices.
Gender of Household Head	Dummy = 1 if male, 0 = if female	Male farmers are expected to be more likely to participate in projects.	Male farmers tend to be more likely to derive higher income.
Total Revenues	Revenues earned in a year (N$)	Higher revenues expected to attract farmers into project.	This variable is used as an exclusive restriction, thus not included in this model.
Hired Labor	Dummy = 1 if farmer hired labor, 0 = if not.	Ability to hire labor expected to increase probability to participate.	Ability to hire labor expected to increase profits.
Trained	Dummy = 1 if farmer received relevant training, 0 = if not.	Training expected to increase farmers' managerial ability, thus positively related to participation.	Training expected to increase profits.
Household Size	Number of household members.	A bigger household size expected to increase probability for participation.	Household size expected to increase profits.
Land Size	Size of land in ha.	Large land size expected to increase probability for participation.	Land size expected to increase profits up to a point.
Profits	Difference between Total Revenue and Total cost, in a year (in N$ '000).	Higher profit expected to attract farmers into projects.	Used as a dependent variable in this model.
Car	Number of cars owned.	Owning a car as indicator of wealth can either increase probability or reduce probability for participation depending on how farmers perceive the project's enhancement to their wealth.	Owning a car expected to increase profits.
Education Level	Level of education attained. Expressed in terms of the number of years required to reach the grade.	Education level expected to positively influence participation to limited extent.	Education level expected to increase profits.

Table 2. Shows summary and descriptive statistics for Etunda project and Olushandja (non-project) Farmers

Variable	Units	Etunda			Olushandja			P>|z|
		min	Mean	Max	min	Mean	Max	
Age of household head	Years	24	45	64	27	41	59	0.0320**
Gender of household head	Dummy	0	.64	1	0	1	1	0.000***
Total Revenue	1000NAD	0	336.11	1461	50.89	226.07	931.68	0.0407**
Hired Labor	Dummy	0	.51	1	0	.69	1	0.0232*
Trained	Dummy	0	1	1	0	.54	1	0.0001***
Household Size	persons	2	2.35	14	2	4.42	15	0.0773*
Land Size	ha	3	3.46	6	2	2.69	6	0.0005***
Profit	1000NAD	-9.1	241.16	1312	25.29	156.79	855.68	0.0807*

***significant at 1%, **significant at 5% and *significant at 10%

Therefore sample selection biasness result from the correlation between ui and ei, having to consider the conditional expectation in equation 2 on z and ei, and also considering that x is a subset of z, the following arises:

$$\varepsilon(y_i \mid z_i, e_i) = \beta x_i + \varepsilon(u_i \mid z_i, e_i) = \beta x_i + \varepsilon(u_i \mid e_i) \quad (4)$$

Noting that ε(yi|zi,ei) = ε(ui|ei) because (ui,ei) are independent of z

3. Results and Discussions

3.1. Summary Statistics for the Primary Data Collected on Etunda and Olushandja Farmers

Table 2 below compares the summarized information for the primary data collected from project participants (Etunda farmers) and the control group (Olushandja farmers). On average, Olushandja farmers are slightly younger compared to Etunda farmers. As can be observed from the p-values, the two groups differ significantly in the means of variables such as; head of household, gender distribution, whether farmers received training and land size holding. The two groups also differ to some extent in terms of; the age of household, total earned revenues, ability to hire labor, household size and the amount of earned profits. All Olushandja farmers were male while respondents from Etunda comprised of 64 percent males. Etunda farmers had higher average revenues although there were some farmers that did not make any sales. Olushandja farmers tended to augment own labor with hired labor more than their Etunda counterparts. All farmers in Etunda project received training on horticultural production whereas only about half of Olushandja farmers received training. Olushandja households tended to be larger than those of Etunda farmers. Etunda farmers had larger plot size compared to their Olushandja counter parts. Etunda farmers tended to make more money than Olushandja farmers although there are some farmers in Etunda project that made negative profits.

Table 3. Shows the Heckman Selection Model Results

Variables	Coefficients	Std. Error
Participation Model	(odds)	
Age of household head	1.68*	(0.33)
Car	-5.0***	(0.42)
Own labor	0.87**	(0.14)
Land size	3.15***	(0.32)
Outcome Model		
Education Level	1.00***	(0.32)
Ability to hire labor	0.905***	(0.26)

***significant at 1%, ** significant at 5% and*significant at 10%

3.2. Participation Model

The Heckman model has a Wald $X^2(13) = 61.35$, $p<0.001$ indicating a strong predictive power. The participation model results show that owning a car and land size are the most important determinants for participation in the project. However, car ownership greatly reduces the odds of project participation. The results show that households that owned a car were five times more unlikely to participate in the green scheme project compared to the households that did not own a car. If we conceive car ownership as a proxy for wealth, then this result shows that wealthy households are highly unlikely to participate in the project. This is an important result as it suggests that farmers perceive project participation as an intervention that is worthwhile only for poor households.

The results show that land size is a critical determinant for project participation. Increasing project plot size by one hectare would increase the odds of farmers' participation by more than three times. This suggests that farmers consider the size of the allotted plots in the project before making the participation decision. Larger plot size tends to increase the likelihood for farmers' participation. This result makes sense since the potential profits that farmers will make depend on the size of land allocated to them.

The supply of own labor appears to be an important determinant for project participation. However, the results show that the size of the household does not have much impact on the likelihood for project participation. This result suggests that adding an additional member to the household diminishes the household's likelihood to participate in the project.

The age of the head of household appears to play a less important role in the decision to participate in the project. Although older farmers are 1.68 times more likely to participate in the project, this variable is not very significant. This seems to suggest that growing vegetables does not require farmers to be innovative. However, this variable may be influenced by the project selection criteria. What was clear from the study is that the government selection process of project participants is faced with increased risk of adverse selection as many potential farmers do not have the required management and entrepreneurial skills in horticultural farming.

3.3. Outcome Model

With respect to the outcome model, education level and ability to hire labor appear to be the most important factors influencing profits. The results show that increasing the farmers' education level by one grade results in N$ 1000 additional profit. The result suggests that highly educated farmers tend to realize higher profits. This result is plausible because education level is considered a proxy for managerial ability. This finding implies that horticultural production is management intensive and better educated farmers tend to be more productive.

Ability to hire labor is a critical determinant for profit. The results show that the household ability to hire an additional labor increased profit by N$ 905. This is a vital contribution to profitability. This suggests that horticultural production is labor intensive and the ability to augment own labor with hired labor is critical. This is especially true because certain crop management activities such as manual planting and harvest tend to be time sensitive and delays can significantly reduce profits. Moreover, the results for the outcome model indicate that the supply of own labor does not seem to influence profits. This is because during interviews the study found out that the number of permanent workers is minimal, ranging between 1 and 3. As a result most of the workers are employed as temporary workers during peak times such as manual weeding and harvesting period.

The results of the outcome model indicate that participation in the project does not significantly increase income. This finding implies that there is no significant difference in profits between project participants and non-participants. This result is surprising considering that project participants enjoy better service provision than non-project farmers. The study, however, found out that the horticultural farmers in the region experiences high transaction costs and production costs. Therefore, if project farmers' experiences higher transaction costs than non-participants this could explained the difference in profits but, this analysis was beyond the scope of this study.

The outcome model also shows that there is no selection bias as the mills ratio has a p-value of 0.13, $p > 0.05$ which is not statistically significant at any level. This suggests that the participation and outcome model could be estimated without the Heckman's model.

4. Conclusion and Policy Recommendations

The outcome of this research shows that car ownership and land size are the most critical factors influencing participation in the project. This implies that well to do farmers may not be interested in project participation. This also means that the size of the plots allotted to farmers in the project is important for farmers. The larger the size of the production plots, the more the likelihood that farmers will be keen to participate in the project. These suggest to policy makers that projects such as Etunda are more appealing to poor resource farmers and the size of plots are critical for farmers' participation.

Family size as a proxy for own labor and the age of household head are needs to be considered as they play an important role in the decision to participate in projects. This means that a household with a large family size will be more likely to participate in the project. Older household heads also tend to be more likely to participate in projects. Thus government targeting and selection criteria need to take cognizance of these findings if irrigation projects are to succeed.

With regards to the outcome results, education level and ability to hire labor are the most critical determinants of profits. Highly educated heads of households and the availability of hire labor, and its cost thereof, are significant factors for profitability. Policy makers should consider educational programs to improve the managerial abilities of project participants. In addition, government needs to provide incentive and stimulate the labor market within the vicinities of projects. The study does not find any difference in profits between project participants and non-participants. This means government need to improve the production conditions for project farmers in order to ensure that project farmers are more productive.

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