JOURNAL OF AGRICULTURE & SOCIAL SCIENCES
1813–2235/2006/02–4–242–248
http://www.fspublishers.org

Modelling Water Demand and Use Behaviour of Dry Season Waterleaf (*Talinum triangulare*) Cultivators in Calabar, Nigeria: A Discrete Choice Approach

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ABSTRACT

This study analysed the determinants of choice of water source and water use by dry season waterleaf cultivators in Calabar-South Local Government Area (LGA) of Cross River State, Nigeria, using both univariate and multivariate statistical techniques on primary data collected from a survey of waterleaf farmers in two major waterleaf growing fields. The women were the principal growers of waterleaf in the study area, majority of whom were married, between 31 and 40 years of age with mostly primary-level education and family sizes of between 6 and 10 persons. Particularly, farmers' income, number of plots owned, collection time for water and marital status were found to be significant determinants of farmers' choice of water source. Moreover, farmers' age and watering frequency were estimated significant predictors of quantity of water applied by the farmers per hectare per season. The relationship between the dependent variable and number of plots owned, water source and marital status conform to *a priori* expectations. The study recommends that policy actions directed at this sub-sector should consider proximity of water source, size of plots and reliability of water source. These can be achieved by allocating particular areas permanently to waterleaf cultivation and providing the required access (both physical & economic) on a sustainable basis to the source of water. Crop extension services should be provided to educate waterleaf farmers on optimal water application in waterleaf farms so that the time wasted in applying excess water on the plots can be put to other productive uses with higher opportunity costs of time.

Key Words: Discrete choice; Logits; Source characteristics; Low external inputs; Waterleaf water.

INTRODUCTION

Water is very vital in agricultural production; however, wasteful, inefficient and unsustainable agricultural use might lead to reduced access and water stress which might collaborate with other factors to exacerbate the problem of poverty, hunger and disease. The United Nations (2003) reports that the world is facing a serious water crisis and that water access and service delivery in the developing world need to be improved dramatically and urgently if gains are to be made in the fight against poverty, hunger and disease, which is one of the Millennium Development Goals of the United Nations for 2015. It has been observed by the International Food Policy Research Institute that inadequate growth in food production occasioned by increasingly scarce water pose serious constraints to future agricultural and economic development in sub-Saharan Africa. This is probably why the World Bank (1996) notes that in agriculture low-income producers can increase food production significantly by having reliable access to water and through improved water harvesting techniques and water and soil conservation practices.

In Nigeria (one of the countries in sub-Saharan Africa characterised by low-income agricultural producers) vegetable production is a major source of income and livelihood for low external input farming population especially, vegetable producers. The production of these vegetables (particularly in the dry season) depends mostly on irrigation water, which is not mostly supplied by complex conventional government irrigation schemes. The cultivators use water from different sources including rivers, streams, wells, etc., to water their farms, often spending a lot of time in collection of water by trekking long distances and sometimes not applying the right quantities of water required by the plant.

Dry season waterleaf production in Calabar is one of the major sources of income and food for low-income agricultural producers in Cross River State and it is entirely dependent on irrigation water. The dry season production, usually spanning an average of four months is the more profitable to the growers since it gives higher yields and hence, incomes.

Waterleaf (*Talinum triangulare*) belongs to the botanical family of Portulacaceae and has a lot of economic importance, which include provision of food, income, employment and herbal medicine to the population (Opabode & Adebooye, 2005), as well as being a weed in some other instances. It is mainly used as a leafy vegetable for human consumption and its culinary use is most popular in local delicacies of Southern Nigeria (for example, in the well-known *Afang*, *Edikang-ikong* soups in Calabar) and some other parts of the country. Waterleaf has also been used as a palatability improver in pasture. Beyond these, the plant is renowned for its high medicinal value, especially in the treatment of diuretic and stomach problems (Ayodele, 2003).

Grubben (1977) observed that the average nutritive value per 100 g of edible portion of waterleaf is higher than that of lettuce. In specific terms, waterleaf is richer in proteins, calcium, iron, carbohydrates and vitamin C than lettuce, but lower in same than pumpkin.

Empirical studies on waterleaf production are few and far between (Josiah, 1990; Udoh, 1993; Ukut, 1997; Idiong *et al*., 2002), while studies on water use and determinants of demand for alternative sources of water in waterleaf production systems in Nigeria are rare and in view of the importance of waterleaf, as a vegetable and the importance of water in its cultivation, this study sets out to practically analyse water use and demand for alternative sources of water in waterleaf production systems in Calabar-South L.G.A, Cross River State.

Specifically, the study seeks to:

i. Describe the socioeconomic characteristics of dry season waterleaf cultivators in Calabar

ii. Determine the adequacy of water use for waterleaf production during the dry season in Calabar

iii. Determine the factors that influence the choice of alternative sources of water for waterleaf production in Calabar

iv. Determine the factors that affect the quantity of water used per hectare per season in waterleaf production in the area.

The remainder of the study is structured as follows: section 2 discusses the conceptual framework and literature review. Section 3 presents the methodology comprising the analytical structure and the data. Section 4 discusses the results of the empirical exercise, while the last section concludes with policy implications.

Conceptual framework and literature review. In this study, the framework alluded to in conceptualising the factors, which drive farmers' demand (choice) for alternative water sources for waterleaf production is the utility function approach. The major assumption in this model is that the farmers choose from a set of jointly exclusive alternatives. It postulates that the utility a farmer derives from a water source is a function of at least two sets of explanatory variables, namely:

i. Source characteristics, which affects farmers utility

ii. Farmers' socioeconomic qualities, which affect differences in tastes and preferences among farmers (Whittington *et al*., 1990; Akin *et al*., 1995; Alaba & Alaba, 2004).

Following Alaba and Alaba (2004), if X is a vector of source characteristics and Z is a vector of farmers' characteristics, the conditional indirect utility function of the farmer f can be written as:

$$Max.\ U_{if} = U_{if}\,(X_{if}, Z_{if}) \quad \ldots\ldots\ldots\ldots\ldots (1)$$

$$Subject\ to \quad \sum_{i=1}^{n} w_i T_1^i + \sum_{i=1}^{n} y_i = C^1$$

Where,

i is water access by area; and

f is denotes farmers.

Since the utility U_{if} is not observable, its influence is assumed to be captured in the random term, which for operational purpose is usually assumed to be added to the observed (or systematic) component of the farmer's random utility function (Manski, 1973; Ben-Akiva & Lerman, 1985). Thus, random utility function in this sense is stated as:

$$U_{if} = V_{if} + e_{if} \quad \ldots\ldots\ldots\ldots\ldots (2)$$

Where,

V is the observed term; and

e is the random term.

Hence, let the variable y_{jf} stand for the farmer $f's$ choice decision on source j by area such that:

$$y_{jf} = 1 \text{ if } V_{jf} + e_{jf} > V_{if} + e_{if} \text{ and}$$
$$y_{jf} = 0 \text{ if } V_{if} + e_{if} > V_{jf} + e_{jf} \text{ (for } i, j = 1) \quad \ldots\ldots\ldots (3)$$

The expected utility of y_{jf} is thus:

$$E\,(y_{jf}) = P\,(y_{jf}) = 1 \ldots\ldots\ldots\ldots\ldots (4)$$
$$= P\,(U_{jf} > U_{if}) \ldots\ldots\ldots\ldots\ldots (5)$$
$$= P\,(V_{jf} + e_{jf} > V_{if} + e_{if}) \ldots\ldots\ldots\ldots\ldots (6).$$

In other words, the probability that farmer f chooses alternative source j equals the probability that the derived utility from using j is greater than that of any other alternative (McFadden, 1973).

Since the distribution of U_{if} depends on the distribution of e_{if}, different assumptions about the distribution of e_{if} will lead to different discrete choice models. Here e_{if} is assume to have an extreme-type distribution (Gumbel distribution), so that the probability of choosing a source will have a logit-type function. The standard statistical method for modelling a set or group of independent variables is the multinomial logit technique, which has been generalised in different ways by McFadden (1973 & 1976) and Maddala (1983).

The assumption of the multinomial logit model restricts the correlation between each pairing of the three errors in the model to zero. In this approach, relative probabilities of any two choices are un-affected by the addition of another choice.

Several studies have adopted and used various approaches to model water demand. Almost all of the studies model domestic water demand in urban and/or rural communities. These range from logit, probit to multinomial logit framework (for example, World Bank, 1993 & 2005; Whittington & Swarna, 1994; Nyong, 1998; Alaba & Alaba, 2004 etc.).

Alaba and Alaba (2004) made use of the multinomial logit technique to analyse the determinants of individuals' choice of utilizing a given water source. They find that income, education, quality, time and government policy were variously significant at different levels of analysis of sources and areas.

The World Bank (1993 & 2005) in their studies observe that three sets of factors jointly influence a household's (or farmer's) willingness to use or to pay for improved systems of water supply. The first is made up of a multitude of socioeconomic and demographic characteristics of the household, which include education of family members, family size, per capita water use level and income. Second, the characteristics of the existing or traditional sources of water and those of improved water supply, including the cost, time required to collect water, the quality and health implication and third, is households' attitude towards government policy.

Similarly, Nyong (1998) following the method used by Benguin *et al*. (1992) found that household size, education, water distance, water quality, sex of collector, etc., are major factors that influence water use in rural areas of Nigeria. Overall, the results of their analysis broadly support the proposition that the determinants of the demand for water in rural Nigeria are subject more to socio-cultural than economic interpretations.

While most of these studies focus on water use generally, none has critically examined the factors that condition water use in agricultural production, particularly in an urban setting with high competing demands for water.

This study models source and farmers' characteristics on the number of discrete (alternative sources) outcomes available to the farmers using a logit-type representation. Particularly a binomial logit model postulated in the following section is pursued.

METHODOLOGY

Analytical framework. Both univariate and multivariate statistical techniques were used to analyse the data. Univariate analysis involved the use of descriptive statistics to examine farmer's characteristics (namely, age, gender, educational level, marital status, household size & income) as well as water use indices (comprising, mean quantity of water applied per hectare, mean quantity of water applied per hectare per season, mean quantity of wasted water per hectare per season).

Multivariate statistics based on binomial logistic regression analysis were used to estimate the influence of farmers' and water source characteristics on choice of alternative water source, while the weighted least squares (WLS) regression was used to estimate the extent and direction of the relationship of the variables, which influence the quantity of water applied on waterleaf plots per hectare per season.

Model Specification

Determinants of farmers' choice of alternative source of water. Consider a farmer *f*, choosing from two alternative sources of water labelled for convenience, *'i'* and *'j'* and assume that there is a vector of observable source and farmer characteristics (covariates) *X*, which can be used to explain his choice (occurrence) of one source (outcome) or the other, we can specify a random utility function for the farmer following Manski (1973), Ben-Akiva and Lerman (1985), Alaba and Alaba (2004) thus:

$$U_f = \beta' X_f + e_f \quad \ldots\ldots (7)$$

If the farmer chooses source *i*, his utility would be:

$$U_{if} = \beta' X_{if} + e_{if}, \text{ or that } U_{if} > U_{jf}\ (e_{jf} - e_{if} \leq \beta' X_{if} - \beta' X_{jf}) \ldots\ldots (8).$$

However, if he chooses *j*, his utility would be:

$$U_{jf} = \beta' X_{jf} + e_{jf}, \text{ or that } U_{jf} > U_{if}\ (e_{if} - e_{jf} \leq \beta' X_{jf} - \beta' X_{if}) \ldots\ldots (9)$$

Thus, if we let:

$$e = e_{if} - e_{jf} \quad \ldots\ldots (10)$$

And

$$\beta' X_f = \beta' X_{if} - \beta' X_{jf}, \quad \ldots\ldots (11).$$

Then the binary choice model applies to the probability that the error is less than or equal to the observed systematic component, $e \leq \beta' X_f$, of the farmer's utility function in equation (7), which is a convenient way to view the choice behaviour between two outcomes.

Where,

β' is vector of parameters

X_f is a vector of source and farmer characteristics $(A_{ge}, E_{du}, I_{cm}, M_{st}, N_{pl}, C_{tm}, N_{ct})$

A_{ge} is age of the farmer

E_{du} *is* educational level of farmer

I_{cm} is yearly income of farmer

M_{st} is marital status of farmer

N_{pl} is number of waterleaf plots owned by farmer in the same field

C_{tm} is time spent in collecting water per trip

N_{ct} is number of water collectors used by the farmer

e_f is the random error term.

Determinants of quantity of water applied per hectare per season. The quantity of water applied per hectare per season is specified, following Nyong (1998), as a function of farmer's and source characteristics as well as other relevant variables hypothesised to influence the dependent variable as follows:

$$Q_{ws} = Q_{ws}\ (A_{ge}, E_{du}, M_{st}, N_{pl}, C_{tm}, W_{sc}, W_{fq}, \xi) \ldots\ldots (12)$$

Where,

Q_{ws} is quantity of water applied per hectare per season

W_{sc} is water source

W_{fq} is frequency of watering

$A_{ge}, E_{du}, M_{st}, N_{pl}, C_{tm}$, are as earlier defined

ξ is the stochastic error term.

Weighted least squares estimation technique was used, because of a possible problem of heteroscedasticity due to the variability that may exist in watering depth across different soil types, slope, etc., for different plots. It allows us to account for the effect of soil type, slope, etc., on the variability of changes in the quantity of water applied (for different soil types or gradient) in estimating the linear model.

The assumption is that in using a weighting variable the variability discussed above would be eliminated thus restoring the assumption of constant variance within the population, as in the standard linear regression model.

The data. The data for this study were collected from a cross-sectional survey of waterleaf farmers in Calabar-South Local Government Area of Cross River State. The two major waterleaf planting locations namely, the University of Calabar Waterleaf fields and the New Airport Waterleaf fields were used for the survey. A random sample of 51 respondents was drawn from the two sites and interviewed with the use of a survey instrument.

Responses on the instrument were grouped into general characteristics (socioeconomic & demographic) of respondents, waterleaf plots information and information on water use in waterleaf plots.

RESULTS AND DISCUSSION

Socioeconomic Characteristics of Waterleaf Farmers

Gender composition. Only women (100%) grow waterleaf in the area (Table I). This is in line with previous studies. For example, Idiong *et al.* (2002) found that only women grow waterleaf in Calabar and that its production is a major source of income for women farmers in the area.

Age distribution. 58.8% of the farmers fell within the age bracket of 31 and 40 years of age with an estimated average age of 40.61 years. Furthermore, as shown in the table, 88.2% of the respondents are within the age range of 20 to 50 years. These results indicate that most of the waterleaf farmers are within the active age bracket.

Marital status. Majority (80.4%) of the respondents were married, while 17.7% were widowed. This result was expected as married households produce larger families that can be useful as family labour in the fields. In addition, married women engage in waterleaf production in order to raise income to supplement subsistence income needs of the family.

Educational level. Majority (58.8%) of the farmers have attained primary education, 15.7% have no formal education, while 25.5% have attained secondary education. None of the farmers has gone beyond secondary education. Farmers' level of education has implications on how they manage their farms and their overall productivity. Thus, water use in waterleaf farms is expected to be affected by the level of education of the farmers. The extent and direction is revealed in the weighted least squares regression results.

Household size. Approximately half (58.8%) of the cultivators' households was between 6 and 10 persons. The average size of the households was estimated to be 7 persons. It has been hypothesized that families with large numbers often use them to supplement hired labour, thus reducing costs and increasing productivity. In the case of waterleaf farms, large household would have a good number of water collectors. This can reduce collection time considerably thus increasing the quantity of water use in plots.

Income distribution. Of the respondents, 60.8% fall within the income category of between N 11,000 and N 30,000 per dry season from waterleaf production, while 21.6% earn incomes between N 31,000 and N 60,000 per season. The average income earned across the respondents is N 22,745.10. Farmers with high incomes are bound to increase their productivity, because of the ease with, which production inputs can be purchased. For instance, high income waterleaf cultivators can afford personal wells, which might be closer to their plots than streams. Collection time and number of water collectors can be reduced considerably if personal wells are affordable by waterleaf farmers.

Table I. Socioeconomic characteristics of waterleaf farmers in Calabar-South L.G.A

Variables	Frequency	Percentage
Gender		
Male	0	0
Female	51	100
Total	51	100
Age bracket (years)	Frequency	Percentage
20 – 30	7	13.8
31 – 40	29	56.8
41 – 50	9	17.7
51 – 60	4	7.9
61 and above	2	4.0
Total	51	100
Marital status	Frequency	Percentage
Single	1	2.0
Married	41	80.4
Widowed	9	17.7
Total	51	100
Educational level	Frequency	Percentage
No formal education	8	15.7
Primary education	30	58.8
Secondary education	13	25.5
Tertiary	0	0
Total	51	100
Household size	Frequency	Percentage
1 – 5	19	37.3
6 – 10	30	58.8
10 and above	2	4
Total	51	100
Income levels	Frequency	Percentage
0 – 10,000	9	17.6
11,000 – 30, 000	31	60.8
31,000 – 60,000	11	21.6
61, 000 and above	0	0
Total	51	100

Source: Field Survey, 2006

Table II. Summary results of water use in waterleaf farms

		Total	Mean	Std. Deviation	Coeff. of variation (%)
Plot size		**0.2829**	**0.00555**	**0.00398**	**71.315**
Quantity/ hectare	AQ/HA	4452941	87312.56	24882.95	28.498
	OQ/HA	2770371	54321	0	0
Quantity/ season	AQ/SS	1160640	22757.64	17462.22	76.731
	OQ/SS	737862.56	14467.89	10388.29	71.80
Quantity /season/ hectare	AQ/SS/HA	220304998	4319705.84	1462972.69	33.867
	OQ/SS/HA	132977808	2607408	0	0
Quantity wasted/season		422777.432	8289.753	10718.226	129.295
Quantity wasted/season/hectare		87327189.82	1712297.84	1462973	85.439

Note: AQ = Actual Quantity; OQ = Optimal Quantity; SS = Season; HA = Hectare
Source: Field Survey, 2006

Table III. Results of binomial logistic regression analysis with two outcomes for Waterleaf farmers

Independent variables	Logit estimate (b)	Odds ratio Exp (b)	Standard error	Wald	Significance
Age	0.117	1.125	0.087	1.837	0.175
Education				1.418	0.492**
Education(1)	0.577	1.782	1.4655	0.155	0.694
Education(2)	-0.974	0.377	1.113	0.767	0.381
Income				6.335	0.042**
Income(1)	-5.732	0.003	2.286	6.289	0.012**
Income(2)	-2.078	0.125	1.515	1.882	0.170
Marital status(1)	4.399	81.333	2.332	3.557	0.059*
No. of plots	0.636	1.889	0.363	3.074	0.080*
Collection time (1)	-5.492	0.004	1.704	10.390	0.001***
No. of Collectors	-0.608	0.545	0.460	1.742	0.187
Constant	-7.316	0.001	4.500	2.643	0.104
Diagnostic statistics					
Hosmer and Lemeshow's Ratio		12.901			
Nagelkerke R^2		0.678			
Chi-square		35.051***			
-2 Log likelihood		32.300			
No. of iterations		7			

Note: Education, income, marital status and collection time entered the logistic regression as discrete explanatory variables (based on the groupings in tables (1) and not as continuous covariates, hence, the groupings appear as separate independent variables in the logit analysis

Water use in waterleaf farms. The total plots size was 0.283 ha, with mean of 0.00555 ha per farmer and a coefficient of variability of 71.3% indicating that there are wide variations in plot sizes among farmers (Table II). Although the mean plot size of the farmers was very small, most of the farmers own even smaller plots. This perhaps suggests that land for waterleaf cultivation is scarce as it was evident that most of the cultivators would prefer to own bigger plots.

Results reveal that total actual quantity of water applied per hectare was 4,452,941 L for all the plots taken together, while the optimum quantity required for the same expanse of waterleaf field is 2,770,371 L. On average, 87,312.56 L were applied per hectare based on the optimum quantity of 54,321 L per hectare per application recommended by Brodie (1990) for vegetables. The calculated coefficient of variability for the actual quantity applied per hectare across the farmers was 28.49%, which is low. This suggests that quantities applied per hectare do not vary too widely among the farmers. Besides, the test of significance of the difference between the mean actual quantity (87,312.56 L) applied per hectare and the mean optimum quantity (54,321 L) was significant at the 1% significance level based on the results of the student t-test.

Estimated total quantity of water applied for a dry season of four months for 0.2829 hectare is 1,160,640 L with a mean of 22,757.64 L and a variability of 76.73%. However, optimum quantity estimated was 737,862.56 L, with a mean of 14,467.89 L and a coefficient of variability of 71.8%. These suggest that total quantity of water wasted by the farmers per dry season is 422,777.432 L with a mean of 8,289.753 and coefficient of variability of 129.29%.

Furthermore, the actual quantity of water applied per season per hectare is 220,304,998 L, with a mean of 4,319,705.84 L and coefficient of variability of 33.86%. Meanwhile, optimum requirement for the season per hectare is 132,977,808 L with a mean of 2,607,408 L. Thus, the quantity of wasted water per hectare per season was estimated to be 87327189.82 L with a mean of 1,712,297.84 L with coefficient of variability of 85.439%.

Overall, the farmers have been using more than the optimum quantity of water that the crop requires for optimum yield. Several factors may be responsible for it. These may include proximity to water source, large number of collectors and the fact that all the farmers are full-time vegetable cultivators. Aside all these, since the farmers are not paying for the water, they are likely to use it inefficiently. Taken as a whole, these issues have implications for scheduling of irrigation schemes for waterleaf production.

Determinants of choice of specific water source by waterleaf farmers. Table III depicts the estimation results of the binomial logistic regression analysis for the determinants of demand for alternative sources of water by waterleaf farmers.

Results indicate that the model fits the data adequately well as supported by the non-significance of the Hosmer-Lemeshow's goodness of fit test at the 5% level of significance or less. The model chi-square statistic (35.051), which measures the improvement in fit made by the explanatory variables is significant at the 1% level of probability, indicating that the inclusion of independent variables significantly predicted the dependent variables in the logistic regression.

The estimated Nagelkerke's R^2 of 0.678 is fairly high and indicates that the strength of association between the dependent and the independent variables is almost 68%.

Four of the logit (effect) coefficients are significant at the 10% level of significance or less in determining the decision of the farmers to choose a specific source of water. These include income of farmers, number of plots owned by the farmers, marital status and time spent in collecting water. The other variables (age, education & number of water collectors) did not significantly contribute in

Table IV. Results of weighted least squares (WLS) regression analysis

Predictor variables	Coefficient estimate	Derived elasticity	Standard error	t-value	p-value
Age	43684.22	0.410658	18717.85	2.334	0.0243**
Education	378391.17	0.096184	247258.49	1.530	0.1333
Marital status	431361.46	0.082237	464954.79	0.928	0.3587
No. of plots	-110679.71	-0.05978	76863.83	-1.440	0.1571
Collection time	265214.24	0.085473	372960.21	0.711	0.4809
Water source	122755.20	0.010587	356617.16	0.344	0.7324
Watering freq.	798603.85	0.576374	208903.20	3.823	0.0004***
Constant	-1669340.72		1167675.60	-1.430	0.160
Diagnostic statistics					
Multiple R			0.669		
R^2			0.448		
Adjusted R^2			0.358		
Standard error			0.0001		
F-ratio			4.994***		
Log-likelihood function			-778.618		

determining the farmers' choice of their water source. From the four significant variables, three (income, marital status & collection time) are categorical, while the remainder (number of plots owned) is a continuous covariate.

The effect coefficient of income indicates that as income of the respondents earning between N 11,000 and N 30,000 increases, their choice of streams as source of water for their plots would decrease. This invariably means that controlling for other factors increase in their incomes would turn their preference to the use of wells, which definitely would be sited closer to their plots. In terms of the odds ratio, the result implies that the odds that a farmer with an income of between N 11,000 and N 30,000 chooses well as his water source is 0.003 times the odds that a farmer with an income of between N 31,000 and N 60,000 would. Put the other way round, in choosing well as the preferred water source, the odds favour farmers within the N 31,000 - N 60,000 (or higher) income category.

The logit estimate for marital status is positive and this suggests that married farmers are more likely to use stream as their preferred source. This may be due to the fact that they are likely to have children that can help with the task of collecting water from the streams, in spite of the distance and time involved. The odds ratio suggests that the odds that a married respondent uses stream as water source is 81.33 times the odds that a single respondent would choose stream.

The number of plots has a positive logit effect of 0.636, which indicates that as the number of plots increases, the preference for the use of streams also increases. This result is intuitively appealing, as it suggests that if plots are scattered, for instance, it may be difficult for the farmers to afford wells at all the locations were they have plots or use one well to serve all the plots. Again, well ownership is tied to income, while using water from streams does not require any initial costs. The interpretation of the odds for this variable is different since it is a continuous covariate. Thus, the odds ratio of 1.889, (which is approximately 2) hints that if any of the farmers adds two plots to her existing number of plots, this would increase her odds of opting for stream as water source by 0.636%, controlling for other variables in the model.

The logit parameter for water collection time for a round trip is negative. This means that as the collection time per round trip increases, the farmers are less likely to continue to use streams as their preferred source of water. Hence, the odds that a farmer that spends 10 min per trip collecting water choosing a well as source is 0.004 times the odds of a farmer spending between 11 and 30 min. This simply means that farmers spending between 11 and 30 min per trip collecting water from streams are likely to change to the use of well, controlling for all other factors in the model.

Empirical studies carried out in respect of preference for specific sources of water have indicated that cost, quality, collection time and quantity are significant variables that drive the decision of individuals in choosing their preferred sources (Alaba & Alaba, 2004; World Bank, 2005).

Determinants of quantity of water used by waterleaf farmers. Table IV presents the estimation results of the weighted least squares regression analysis of determinants of quantity of water used by the farmers per hectare per season.The data are well fitted to the model as evident in the significance of the F-ratio at the 1% level. However, only about 45% of the variations in the included independent variables explain the changes in the quantity of water used by the farmers per hectare per season.

Evidence further shows that only age and watering frequency significantly explain the quantity of water used, though with inelastic parameter estimates. Increasing watering frequency by 10% increases the quantity of water used by 5.76%, while in the case of age, an increase of 10% in the age of farmer increases water use by 4.1%.

Number of plots owned by the farmer was not significant in explaining the quantity of water used, but it carried the right sign *a priori*, which indicates that as number of plots increases, the amount of water used per hectare per season reduces.

Overall, these results can be said to be mixed as no single group of variables, whether source, farmers' or economic stands out as the major determinant of quantity of water used per hectare per season.

However, since the model is not intended to be used for forecasting purposes, the important relationship (by way of signs of the coefficients) shown by marital status, number of plots and water source, which conforms to *a priori* expectations show for example that increasing the number of plots will *ceteris paribus* reduce the quantity of water used per hectare per season.

Summary conclusions and policy implications. This study analysed the determinants of the demand for specific water source and water use by dry season waterleaf growers in Calabar-South Local Government Area of Cross River State. The results of the analysis reveal that women are the principal cultivators of waterleaf in Calabar-South L.G.A.

and that majority of them are married and between 31 and 40 years of age with basically primary-level education and with family sizes of between 6 and 10 persons.

Waterleaf farmers in the study area use only well water and water from nearby streams. They try as much as possible to locate their plots close to where they can access streams, thus their plots are very small with an averaged sized plot measuring 0.00555 hectare, (which is about 55.5 m^2). On the average, farmers applied 87,312.56 L of water per hectare as against the prescribed 54,321 L for leafy vegetables thus, wasting about 1,712,297.84 L per hectare per season per farmer.

Analysis of the determinants of their demand for specific water sources reveal that farmers' income, number of plots owned, collection time for water and marital status were the significant determinants of farmers' choice of water source. In fact, increasing farmers' incomes will make them choose sources that would significantly reduce collection time. However, the significance of marital status indicates that so long as farmers have many water collectors, they may not easily change from a source that involves longer collection time even if income increases. Furthermore, increase in number of plots, especially if they are scattered increases the chances of farmers choosing stream as their preferred source. In all, collection time was the most significant factor influencing farmers' choice of water source. As collection time increases, waterleaf farmers are likely to choose wells in watering their plots.

The examination of the determinants of quantity of water used by farmers revealed age and watering frequency to be the only significant determinants of quantity of water used by the farmers per hectare per season. Since the model is not intended to be used for forecasting purposes, the important relationship (by way of signs of the coefficients) shown by marital status, number of plots and water source, which conforms to *a priori* expectations has some implications. For example, the negative coefficient of number of plots variable clearly signals that increasing the number of plots will *ceteris paribus* reduce the quantity of water used per hectare per season.

In view of the above findings, the study recommends that policy actions directed at this sector should consider the proximity of water source, size of plots and reliability of water sources. These can be achieved by allocating particular areas permanently to waterleaf cultivation (since the current sites are temporary) and providing the required access (both physical & economic) to and reliability of water source. This would reduce collection time and distance trekked by collectors with the resultant outcome of increased productivity and efficiency.

Crop extension services should be provided to waterleaf farmers to enlighten them on optimal water application in waterleaf farms so that the time wasted in applying excess water on the plots can be put into other productive uses with higher opportunity costs of time.

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(Received 03 August 2006; Accepted 25 September 2006)