Applied and Computational Mathematics
2014; 3(4): 177-185
Published online August 30, 2014 (http://www.sciencepublishinggroup.com/j/acm)
doi: 10.11648/j.acm.20140304.19
ISSN: 2328-5605 (Print); ISSN: 2328-5613 (Online)

Analysis of the irrigation water price in rice production Tanzania

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To cite this article:
Amos Michael, Dmitry Kuznetsov, Silas Mirau. Analysis of the Irrigation Water Price in Rice Production Tanzania. *Applied and Computational Mathematics*. Vol. 3, No. 4, 2014, pp. 177-185. doi: 10.11648/j.acm.20140304.19

Abstract: Over the past 50 years, cross-sectoral water utilization in Tanzania has grown considerably due to the increase of human populations which increasing food demands and growing of economic activities that require water in production. The agriculture sector is one of the major users of water resource for irrigation activities. The purpose of this paper was to analyse the irrigation water price in rice production in Tanzania. The secondary data were collected from the Ministry of Agriculture, Food Security and Cooperatives in Statistics Unit and zonal irrigation units. Elasticities were estimated using ordinary least squares technique with the help of STATA 11. Factor analysis technique was also applied. The estimated water price coefficient was found to be -0.03 and the average water price was estimated to be 5.50 Tshs/m^3. However the water productivity was 0.3kg/m^3, whereas the production was estimated to be 2.5ton/ha.

Keywords: Water Demand Function, Panel Data, Irrigation, Water Price, Water Productivity, Factor Analysis

1. Introduction

Irrigation water demand in rice production is still increasing due to the area being irrigated continues to expand while the amount of water for irrigation is decreasing. Over the last 30 years irrigated areas have increased rapidly, helping to increase agricultural output and feed a growing population. Amin et al, [1] and Rosegrant [2]

Tanzania is an agricultural country and its economy mostly depends on agricultural sector. Therefore Agriculture plays an important role in the Tanzanian economy and rice is among of crops which are primarily staple food as well as essential cash crops for farmers in Tanzania. Despite the fact that water is crucial in rice cultivation, but the fee paid by the farmers it claimed to be very low than the actual value of water. Appropriate water price in relation to its value helps a suitable allocation of water resource in different agricultural activities. Planners in different areas face problems on water allocation in agriculture sector because of poor water management caused by poor infrastructure resulted from low payment of irrigation water fee Sahibzada, A.S, [3]

Many developing countries not only face inefficient allocation of water resources in this sector, but also poor water management against sustainability principles as well as poor alternative practices for irrigation systems in rice production. Inefficient water management also causes the low water productivity Saima, *et al*, [4] and Sadeghi, [5].

Since the agricultural sector is the back bone to development in Tanzania, and a major factor in poverty reduction, there is a need of analyzing water price and determine its productivity in rice production in Tanzania.

2. Literature Review

The need to achieve efficient, equitable and sustainable use of water resources to meet water demands of different sectors is urgent, particularly in areas where water resources are decreasing. Along with this, a good understanding of the general analysis of the water price, specifically in rice cultivation is very important. The pricing of irrigation water has significant influence on the volume of water used by farmers. If more water is being used, the farmers have to pay more. However, the water rates in most African countries are based on the cultivated area rather than on the volumetric consumption. This does not provide any incentives for the farmers to conserve water and hence leads to lower water productivity. Cornish [6].

The production function that relates crop production to the use of water and other inputs is very crucial element for the estimation of the demand for and value of water in the agriculture sector. Production functions depict the relationship between the uses of water and crop output. McKinney *et al*, [7]

Estimates of the demand function for irrigation water and its price elasticity have commonly been based on the use of mathematical programming, especially linear programming. A mathematical programming framework involves the optimization of an objective function, subject to the underlying production technology and constraints on water and other resources. The linear programming approach has the advantage that it can be implemented with a minimum of data for those problems in which the fixed proportion input assumption and linear constraints are reasonable approximations of reality. Saima *et al*, [4].

Several studies have been done on agricultural production using the production function model. The Cobb-Douglas functions are among the best known production functions utilized in applied production analysis. Cobb-Douglas production function is a particular functional form of the production function, commonly used to represent the technological relationship between the amounts of two or more inputs and the amount of output that can be produced by those inputs. The Cobb-Douglas production function is still today the most famous form in theoretical and empirical analyses of growth and productivity. Felipe, [8]

Cobb-Douglas functional form is very popular in agricultural production studies because of its simplicity in interpretation and computational. Many studies in agricultural sector have used Cobb-Douglas production function, mostly because of the easiest interpretation of the resulted coefficients which are elasticities of production with respect to inputs. In top of that, the coefficients indicate the relative importance of each input with respect to output.

Sahibzada [3] used an initial Cobb-Douglas production function to estimate the relationship between total aggregated farm output, fertilizer use, labor supply, tractor use, and irrigation water input. A single equation Cobb Douglas production function was specified and then the Cobb Douglas parameter estimates was used to derive an input demand function for irrigation water. Along with that, the sensitivity of the irrigation water demand to a change in alternative water prices was tested. The main conclusion drawn was irrigation water shortages are the result of the inflexibility of the present irrigation water supply system for agricultural. Additionally, the results from water price simulations indicated that demand for irrigation water is less sensitive to changes in alternative irrigation water prices.

Sadeghi *et al.* [9] conducted a study which based on the use of Cobb-Douglas production function. The study discovered that water has very low price elasticity of demand for barley. They also assert that the water price of barley is not efficient, because elasticity is near to zero. On the other side they found that the quantity of crops significantly influences water consumption.

Sadeghi [10] in the study of the impact of pricing policy on the demand for water in Iran agricultural sector, again used the Cobb-Douglas production function to estimate the relationship between total aggregated output, fertilizer, labour, tractor and machinery services, animal fertilizer, irrigated area, seed, pesticide, consumed (demanded) water, and input prices, in different crops. *All coefficients of water price in different crops were found to be negative nearly to zero. Also Sadeghi et al. [11] conducted a study on the determination of* economic value of the irrigation water in production of wheat in Iran using Cobb-Douglas function, and their study revealed that water price was inefficient.

Michael et al. [12] carried out a study on estimation of irrigation water demand in rice production in Tanzania. The Cobb-Douglas production function was used and their study revealed that the quantity of rice significantly influences water consumption.

Sadeghi *et al.* [5] conducted a study on estimation of irrigation water demand function for tomato in Iran. The functional form used to estimate water demand was linear-logarithm. They found that, water has a very low price elasticity of demand for tomato in Iran. The estimated coefficient for output quantity is significant at 1% level. The estimated parameter coefficient shows that the elasticity of water use, given changes in output quantity, is 0.81, means one percentage increase in output (tomato) quantity leads to a 0.81 percent change in the use of water.

Karina *et al.* [13] conducted a study on panel estimation of agricultural water demand based on an episode of rate reform. They used a unique panel data set of water use at a disaggregated level. The parameters of an agricultural water demand function were estimated and the estimation results indicate that, the own-price elasticity of water use is in the range [-0.415, -0.275], which shows that water price is negatively related to the water demanded.

Many studies in irrigation water demand rely on simulated data. Bontemps and Couture [14] used a dynamic framework to estimate irrigation water demand in southwestern France. They simulated water demand data and analyzed demand for a single crop. Their study revealed that water demand is inelastic in arid regions, and as the quantity of water increases, water demand becomes more elastic.

Clayton and Noel [15] used a cross-section of farms in the western U.S. to estimate agricultural water demand. Their study revealed that the estimated price elasticities lie in the range of [-0.26, -0.07]. This showing that, the water price is very low and in certain time and place became totally inelastic depending on factors in a particular time and place.

Results of a simulation by Hooker and Alexander [16] discovered that, demand is inelastic across a large range of prices, but becomes elastic beyond some threshold level. Their analysis used parameter estimates based on water use in the San Joaquin Valley.

Karina *et al*. [17] conducted a study on panel estimation of an agricultural water demand function in California's San Joaquin Valley. Their study developed and estimated a model of agricultural water demand based on the role of water in the farm production function. Unique panel data set were used to estimate the parameters of the model. One objective of their analysis was to measure the price elasticity of farm water use. They revealed that under moderate prices, agricultural water demand is more elastic as elasticity was -0.79, but in low prices water demand was inelastic.

Naveen *et al*. [18] applied a multi-output production model in their study on estimation of irrigation water demand, a case study for the Texas High Plains. The model used to demonstrate the optimal allocation of fixed inputs in multi-output production. The results revealed that, water demand in the region is more sensitive to water price than to crop price.

Values of elasticity of demand are normally negative, as demand falls when price increases. Higher absolute values of elasticity point out that the percentage change in amount demanded is large compared with the percentage change in price. Price elasticity estimates from a study in OECD countries vary greatly, from -17.7 to -0.05, Cornish, [6]. Elasticity depends on various factors, among them are; Initial price of water, the lower the price, the less responsive farmers are to price increases. Another factor is production costs, the high production costs lead to low elasticity.

Water demand is inelastic only up to a given price level. Above this price level, water demand may be very price responsive. The relationship between price elasticity of demand and price has an inverted U shape, where demand is inelastic with low and high prices but more elastic with moderate prices. The level of this price depends on the economic productivity of water, price of water compared to overall production costs and the irrigation technologies in place, Cornish,[6].

The study conducted by Kadigi [19] revealed that the average water productivity in Usangu basin in Tanzania was 0.18kg/m^3, whereas water consumption per hectare closed to 9500m^3. Several studies have indicated that irrigated rice can be easily cultivated using 8000 to 10000m^3/ha. Water productivity in Sub-Saharan Africa ranges from 0.10 to 0.25 kg/m^3. But in the developed world water productivity is high as it is at an average of 0.47kg/m^3, compared to the developing world as it is 0.39kg/m^3, Kadigi [19].

Musamba *et al*. [20], conducted a study on economics on rice and non-rice crops at Kilombero, Tanzania. The results of their study revealed that, the average water productivity in rice is estimated at 0.85 kg/m^3 of consumed water.

3. Materials and Methods

The secondary data were collected from the Ministry of Agriculture, Food Security and Cooperatives in Statistics Unit, and relevant institutions such as Pangani, Rufiji and Ruaha basin authorities. Also some of information were obtained from zonal irrigation units and published documents.

A panel data of 16 regions of Tanzania in the period from 2007 to 2012 corresponding to a total number of 96 observations were used. The variables for estimation of water demand function were the input prices which are seed, water, wage, machinery rent cost, land rent cost, fertilizer cost and rice production and for dependent variable, quantities of water required for rice was used.

Regression analysis technique was used to estimate the values of parameters of the models, and ordinary least square was applied. The parameters of demand functions were estimated using the econometric method on panel data, where EXCEL and STATA 11 were used in the study.

3.1. Econometric Model Specification

The econometric model normally used to determine the relationship between the various inputs and output in agriculture is the production function model. In agriculture, the production inputs consist of land, labor and capital are the basic factors of production. Mpawenimana,[21].

The production model for rice production was adopted in this study as specified by the Cobb-Douglas functional form. Production function described physical relationship between input and output through the equation of

$$Dw = f(Wp, F, L, S, w, Q, M).$$

The general mathematical form of the Cobb-Douglas production function is given by:

$$Q = A \prod_{i=1}^{n} X_i^{\beta_i} \tag{1}$$

Where Q and X_i denote output and each bundle of inputs respectively. A and β_i are Parameters. Then from equation (1), by introducing the variables and parameters of this study, one can write the Cobb-Douglas production function as;

$$Dw = \beta_0 Wp^{\beta_1} F^{\beta_2} L^{\beta_3} S^{\beta_4} w^{\beta_5} Q^{\beta_6} M^{\beta_7} e^{\varepsilon} \tag{2}$$

Where
Dw = Amount of water demanded,
Wp= Price of water,
F = Price of fertilizer,
L= Land rental cost,
S =Price of seeds,
w = Wage cost,
Q = Output quantity and
M = Machinery cost
β_0 = Constant (intercept)
ε = Error (remains),
$\beta_1, \beta_2, \beta_3, \beta_4, \beta_5, \beta_6,$ *and* β_7 =Production factor regression coefficient of Wp, F, L, S, w, Q, M. Michael *et al*, [12]

The paper utilized the Cobb-Douglas production function model which is used widely in theoretical and applied research. The Cobb-Douglas production function was used with the reason that, the solution could easily transferred into linear and resulting to regression coefficient which is the elasticity quantity. Also the Cobb-Douglas production function provides a simpler model structure, is easier to estimate, and is less likely to violate the classical regression assumptions. Michael [22].

3.2. Empirical Model

In the econometric analysis of the water demand function, the assumption under taken was, demand function is a function of crop quantity and the prices of the seven inputs namely, water price, fertilizer price, land rent cost, seed price, wage cost, output quantity and machinery rent cost.

From equation (2), by taking natural logarithm on both sides, then can be rewritten as

$$\ln Dw = \beta_0 + \beta_1 \ln Wp + \beta_2 \ln F + \beta_3 \ln L + \beta_4 \ln S + \beta_5 \ln w + \beta_6 \ln Q + \beta_7 \ln M + \varepsilon \quad (3)$$

Thus, from the above, the following was the suggested production function in linear logarithms from the Cobb Douglas production function as developed by Michael *et al* [12].

$$\ln Dw_{i,t} = \beta_0 + \beta_1 \ln Wp_{i,t} + \beta_2 \ln F_{i,t} + \beta_3 \ln L_{i,t} + \beta_4 \ln S_{i,t} + \beta_5 \ln w_{i,t} + \beta_6 \ln Q_{i,t} + \beta_7 \ln M_{i,t} + \varepsilon_{i,t}$$

Where

$Dw_{i,t}$ is the amount of water demanded in i^{th} region in year t (Cubic Meter), $Wp_{i,t}$ is the vector of the water price used in rice production in i^{th} region in year t (cubic meter/Tshs) ,$F_{i,t}$ is the vector of fertilizer prices used in rice production in i^{th} region in year t (kg/Tshs), $L_{i,t}$ is land rent (square meter/Tshs), $Ps_{i,t}$ is the vector of seed prices used in rice production in i^{th} region in year t (kg/Tshs), $w_{i,t}$ is wage and pesticide price (man day/Tshs), $Q_{i,t}$ is the irrigated production (kg), $M_{i,t}$ is the vector of machinery rent cost ($Tshs/m^2$), and $\varepsilon_{i,t}$ represents the effects of the omitted variables that are peculiar to both the individual region and time periods.

β_0 is the total factor efficiency parameter for composite primary factor inputs in region i; the parameters β_1, β_2, β_3, β_4, β_5, β_6, $and\ \beta_7$, are production elasticity.

The equation is log-linear because both the dependent variable and the independent variables have been log-transformed. The coefficients in log-linear equations are elasticities. From the empirical model, i denotes the regions of Tanzania $(i = 1,2,\ldots,16)$ and t indicates year $(t = 2007, 2008, \ldots, 2012)$.

4. Results and Discussion

4.1. Results

4.1.1. Descriptive Statistical Analysis from 2011 to 2012

Table 4.1. *Statistical Analysis of the Study Variables 2011 to 2012*

Descriptive statistics 2011-2012					
Variable	**Obs**	**Mean**	**Std dev**	**Min**	**Max**
Water demand (m^3)	32	4.41e+08	4.20e+08	1.29e+7	2.10e+09
Water cost(Tshs/ha)	32	32 250	13 970	20 000	60 000
Water price (Tshs/m^3)	32	4.5	1.7	2.5	7.5
Wage cost(Tshs/ha)	32	320 468	27 602	260 000	380 000
Fertilizer (Tshs/ha)	32	230 625	22 134	200 000	270 000
Seed cost(Tshs/ha)	32	56641	20575	32 000	87500
Machinery cost(Tshs/ha)	32	175 938	37 404	100 000	250 000
Land cost(Tshs/ha)	32	355844	83178	150 000	462 000
Production (ton)	32	119 391	103 844	3 461	403084
Area (ha)	32	55 104	52 486	1 607	262 005
Ton/ha	32	2.1	0.5	1.2	3.2
Water productivity	32	0.3	0.1	0.2	0.4
Sells/100kg bag	32	113 281	41 150	64 000	175 000
Amount received (Tshs/ha)	32	2 354 771	1 080 691	984 614	5 261 544
Total cost(Tshs/ha)	32	1 175 766	149254	807 000	1 477 500
Profit(Tshs/ha)	32	1 179 005	1 002 956	-87 386	3 784 044

The results for 2011 to 2012 showed that, the irrigated output was at an average of 2.1ton/ha where the average cultivated area for rice was 55 104 ha. The average cost of water was 320 468Tshs/ha and the water price was estimated at an average of 4.5Tshs/m^3 whereas the water productivity was at an average of 0.3kg/m^3. On the other side, the average profit in rice production was averaged at 1 179 005Tshs/ha.

4.1.2. Correlation Results

Table 4.2. *Correlation results*

	year	**Water price**	**Production**	**Profit**	**Revenue**	**Total cost**
year	1.00					
Water price	-0.20	1.00				
production	-0.17	0.24	1.00			
profit	0.27	0.16	0.82	1.00		
Revenue	0.33	0.17	0.78	1.00	1.00	
Total cost	0.70	0.12	-0.02	0.34	0.43	1.00

From the correlation table above, the total amount of money received after selling the product has strongly correlated to the profit received in the whole process of production as shown the coefficient is almost 1.0. In addition to that the average product was also strongly correlated to the profit as its coefficient was 0.82. Furthermore the total cost has weakly correlated to the profit and revenue as it has indicated their coefficients are 0.34 and 0.43 respectively. Production and revenue has good correlation as indicated its coefficient is 0.78. However water price has no correlation to profit or any of the variable as its absolute value of coefficient is less than 0.3 to each of the variable.

But, total cost has strongly correlated to time (year), that is, total cost depends on time and the rest variables do not depend on time

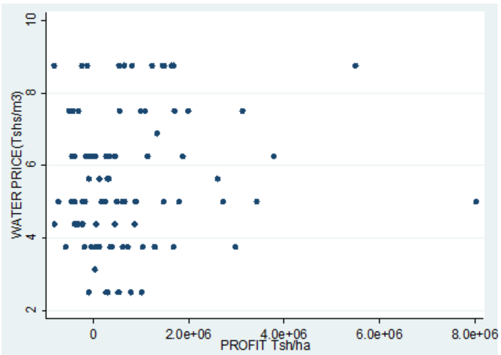

Figure 4.1. *Correlation on water price and profit*

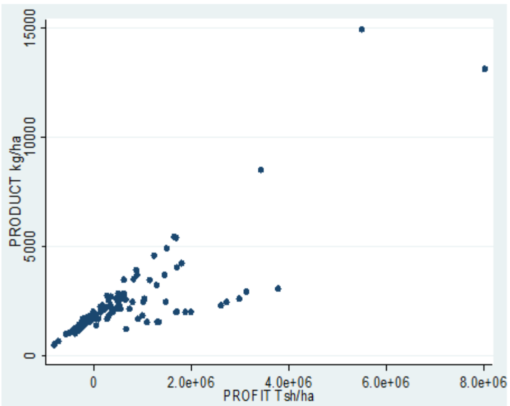

Figure 4.2. *Correlation on production and profit*

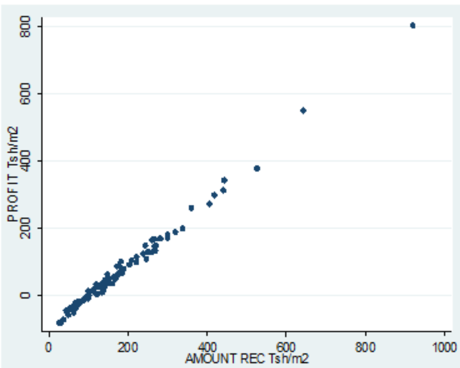

Figure 4.3. *Correlation of amount received and profit*

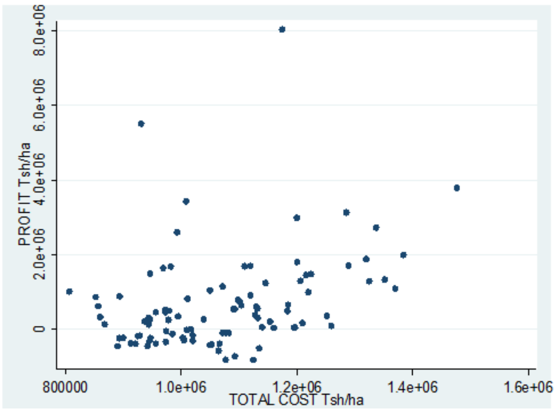

Figure 4.4. *Correlation on profit and total cost*

4.1.3. Regression Results

The equation of water demand, as a function of the price of water, fertilizer and seed prices, wage, land rent, machinery and the output quantity, was estimated using the panel data method comprising of 96 observations from 16 rice producer regions for the period of 2007 to 2012. The fixed effect and random effect were compared in the Hausman's specification test by using STATA 11. The comparison found that the irrigation water demand function of rice could be best derived using the random effect approach. The regression results are as follows

Model results

Table 4.3. *Regression results of the variables*

Random effect GLS regression: Group variable: region				
Dependent Variable: LN DW				
Independent variable	**Coefficient**	**Std. Error**	**z-Statistic**	**Prob >|z|.**
β_0	17.21*	7.91	2.18	0.030
LN w	-2.03*	1.27	-1.60	0.109
LN Wp	-0.03*	0.31	-0.08	0.935
LN M	1.21*	0.58	2.09	0.037
LN Q	0.60*	0.08	7.80	0.000
LN L	-0.35*	0.60	-0.58	0.561
LN S	-0.70*	0.41	-1.71	0.087
LN F	0.16*	0.76	0.21	0.833
Cross-section fixed (dummy variables)				
	within		0.0006	
R-squared	between		0.8966	
	overall		0.4878	
Wald Ch2(7)	83.79			
Prob(F-statistic)	0.000			

* Statistically significant at the 1% level

The natural logarithm of variables estimated using ordinary least squares as specified previously in the model. From the results, adjusted $R^2 = 0.49$, indicating that the variables in the model have explained by 49%, that is to say 49% of the model is perfectly fit.

Research findings revealed that, the estimated elasticity coefficient of water price is very close to zero, as it was -0.03. The implication of this value is, as water price increasing by 100%, the water demand in rice production will decrease by 3%. This is significant at 1%, 5% and 10% levels. Also since the p-value of water price is greater than 0.05, then this showing that water price has no significant influence on water demand. This confirms what Karina [14], Clayton and Noel [15] and Cornish [6] said in their literature, the expected relationship between water demand and water price is that, the lesser the water price the higher the water demanded.

As it has been shown, the estimated coefficient of water price is very close to zero. This implies that the demand for water has low elasticity, thus farmers are not sensitive enough to the changes in water price Michael *et al*. [12]. Hence the price of water is not efficient. In addition to that, despite of low response of farmers to the price of water, again farmers tend to reduce the use of water as price becomes higher although in small amount.

Regression Analysis on Profit, water price, total cost and income

Table 4.4. *Regression results on profit, water price, cost and amount received*

Dependent Variable: Profit				
Independent variable	**Coefficient**	**Std. Error**	**t-statistic**	**Prob >|t|.**
Water price	-0.0001	0.0002	-0.60	0.549
Amount received	1.0000	2.5e-06	3.9e+05	0.000
Total cost	-1.0000	0.0003	-4.0e+04	0.000
Constant	0.0030	0.0027	1.12	0.266
R-squared	1.00	Adj R-squared	1.00	
Wald Ch2(7)	83.79	Root MSE	0.003	
Prob(F-statistic)	0.000	Number of obs	96	

* Statistically significant at the 5% level

From the results, R^2 and adjusted R^2 all are equal to 1.0, showing that all variable have explained by 100% by the model, that is the model is perfectly fitted. The coefficient of amount received is positive in relation to profit as it is 1.0, which implies that as amount received increases by 1%, also profit will increase in 1%. This gives a note that, farmers will get more profit when the price of rice in the market is high. However, the results also have been shown that the coefficient of water price is negative and very close to zero in relation to profit as it is -0.0001. This indicates that as water price increases by 1%, profit to the farmer will decrease by 0.0001%. This value showing that, the increment of 1% of water price does not affect the profit. Thus farmers are not sensitive to the increment on water price as they are paying low rice irrigation fee compared to its real value. In addition to that, the p-value and t-value in water price is 0.549 and -0.6 respectively, showing that, water price is not significant to profit, that is to say, it does not affect the profit. In parallel to that, coefficient of total costs is also negative in relation to profit as it is -1.0. This shows that as total costs increases by 1%, the net profit will decrease by 1% as it was expected.

4.1.4. Factor Analysis

Factor analysis is a method for investigating whether a number of variables of interest are linearly related to a smaller number of unobservable factors. The researcher carried out the Kaiser-Meyer-Olkin measure of sampling adequacy (KMO) test using STATA 11 to see whether the factor analysis is possible. The KMO tests whether the partial correlations among variables are small or not. A small value of KMO statistic indicates that, the correlations between pairs of variables cannot be explained by other variables and factor analysis may not be appropriate. The KMO values range from 0 to 1. From the results, KMO value found to be 0.79, which suggests that the factor analysis is appropriate as KMO meets the minimum criteria. Amy *et al*, [23].

Determination of number of factors to be retained depends on two criteria;

1) Eigenvalues: retain all factors with Eigenvalues greater than one (Kaiser Criterion)
2) Scree plot: retain all factors "before the elbow"

The number of retained factors is usually somewhere between the number of variables divided by three and the number of variables divided by five, Rencher [24]. The following were the results of factor analysis after running STATA 11.

Table 4.5. *Kaiser-Meyer-Olkin measure of sampling adequacy*

Variable	KMO
Year	0.7991
Ln F	0.8530
Ln S	0.8452
Ln L	0.8435
Ln Q	0.4539
Ln M	0.8413
Ln Wp	0.7234
Ln w	0.8500
Ln Dw	0.5127
overall	0.7906

Table 4.6. *Factor analysis correlation*

Factor Analysis/Correlation: Method: Principal factors: Unrotated				
Factor	**Eigenvalue**	**Difference**	**Proportion**	**Cumulative**
Factor 1	3.88756	2.73612	0.7694	0.7694
Factor 2	1.15145	0.79712	0.2279	0.9972
Factor 3	0.35432	0.21290	0.0701	1.0674
Factor 4	0.14143	0.05280	0.0280	1.0933
Factor 5	0.08862	0.15709	0.0175	1.1129
Factor 6	-0.06847	0.04036	-0.0136	1.0993
Factor 7	-0.10883	0.07084	-0.0215	1.0773
Factor 8	-0.17967	0.03379	0.0356	1.0422
Factor 9	-0.21343	-	-0.0422	1.0000

LR test: independent vs saturated: Chi2(36)=480.66: Prob > chi2=0.0000

Table 4.7. *Rotated factor loadings using nine variables*

Rotated factor loadings (pattern matrix) and unique variances			
Variable	**Factor 1**	**Factor 2**	**Uniqueness**
Year	-0.9144		0.1633
Ln F	-0.6618		0.5619
Ln S	0.8542		0.2690
Ln L	0.8826		0.2036
Ln Q		0.7405	0.4449
Ln M	0.7516		0.4249
Ln Wp			0.9251
Ln w	0.6525		0.5590
Ln Dw		0.7528	0.4093

Blanks represent abs(loading)<0.3

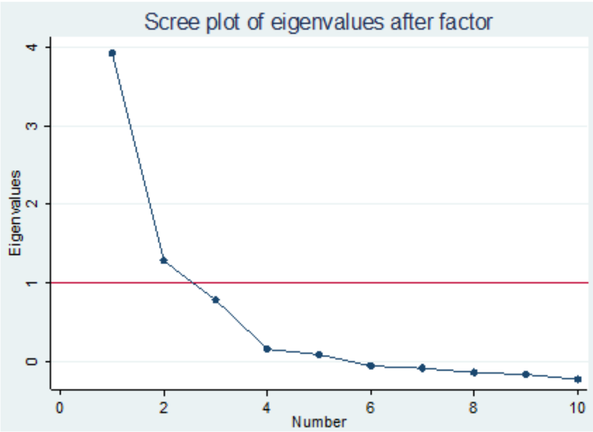

Figure 4.5. *Scree plot*

Scree Plot

From the scree plot on figure 4.5, it has been shown that only two factors were retained which of those their eigenvalues are greater than 1. The rotated factor loadings (pattern matrix) and unique variance shows that factor 1 is strongly correlated to amount received, profit and production while factor 2 is strongly correlated to total cost and year. However water price has no correlation to any of the two factors as its coefficients is even less than 0.3. In addition to that all the variables have explained well by the two factors except water price as its uniqueness is 0.94 while uniqueness of other variables is less than 0.3.

4.1.5. Factor Analysis on Profit, Water Price, Cost and Income

Table 4.8. *Factor analysis correlation on profit, water price, cost and income*

Factor Analysis/Correlation: Method: Principal factors: unrotated				
Factor	**Eigenvalue**	**Difference**	**Proportion**	**Cumulative**
Factor 1	2.93860	1.41676	0.6228	0.6228
Factor 2	1.52184	1.15260	0.3225	0.9453
Factor 3	0.36925	0.36925	0.0783	1.0236
Factor 4	0.00000	0.01283	0.0000	1.0236
Factor 5	-0.01283	0.08549	-0.0027	1.0208
Factor 6	-0.09832	-	-0.0208	1.0000

LR test: independent vs saturated: Chi2(15)= 3538.41: Prob > chi2=0.0000

Table 4.9. *Rotated factor loadings using nine variables*

Rotated factor loadings (pattern matrix) and unique variances			
Variable	**Factor 1**	**Factor 2**	**Uniqueness**
Amount received	0.9529	0.3003	0.0017
Profit	0.9715	0.2146	0.0102
Production	0.8919	-0.2373	0.1482
Water price	0.2283	-0.0866	0.9404
Total cost	0.1933	0.9298	0.0980
Year	0.0599	0.8096	0.3410

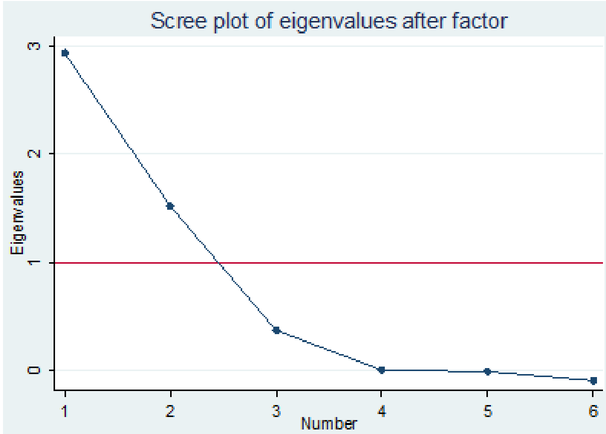

Figure 4.6. *Scree plot*

From table 4.9 and figure 4.6, it has been shown that only two factors were retained which of those their eigenvalues are greater than 1. The rotated factor loadings (pattern matrix) and unique variance shows that factor 1 is strongly correlated to amount received, profit and production while factor 2 is strongly correlated to total cost and year. However water price has no correlation to any of the two factors as its coefficients is even less than 0.3. In addition to that all the variables have explained well by the two factors except water price as its uniqueness is 0.94 while uniqueness of other variables is less than 0.3.

4.2. Discussion

From the findings, it has already observed that rice farmers pay very low price for irrigation water than the actual value of water as it was estimated to be 0.013% of total cost of water. This statement also supported by the coefficient value of water price in regression analysis as it was -0.03. Additionally, results from factor analysis method also show that water price has no correlation to any of the two factors as its coefficients is very small, even less than 0.3. In parallel to that all variables have completely explained by the two factors as their uniqueness is less than 0.3, except water price as its uniqueness is 0.94. Notice that, the higher the uniqueness, the lower the relevance of the variable in the factor model, Rencher [24].

The low irrigation fee in rice production affect water allocation and make it difficult and complicated because of poor infrastructures. The payment for water helps to cover the costs of providing services, including operation and maintenance costs and improving accountability of the water board authorities to users.

Despite of the fact that, farmers are not sensitive enough to the price of water, but would respond very little to a policy that aims at increasing the price of water, as its price elasticity was -0.03, which implies that what rice farmers are paying for water is very little compared either to other expenses or to what they receive in the whole process of rice production. However, the analysis shows that, rice farmers can decrease the water demand within a reasonable limit when water price increases. Thus water price can be used by authorities as a tool to control water use in irrigation systems. Nevertheless the estimated average water productivity and water price was 0.3kg/m^3 and 5.5Tshs/m^3 respectively.

5. Conclusions and Recommendations

5.1. Conclusions

In this study the general structure of water price in rice farms in Tanzania was investigated and estimated by using data related to 16 regions of Tanzania from 2007 to 2012. The major results of the analysis are including that, the irrigation water has very low price elasticity of demand for rice in Tanzania. The low elasticity of water price caused by many factors, but one of them is number of substitutes. In rice production it is fact that, irrigation water has no substitute. One of the factors affecting price elasticity of demand is the number of close substitutes, the more the close substitutes there are in the market the more elastic is demand, because consumers find it easy to switch. Additionally, each good or factor is totally inelastic as its price is very low, this again evidently observed in water price, Kate *et al*. [25].

Furthermore, water productivity is not efficient in rice cultivation in Tanzania, as a result of using a lot of water which is not equivalent to output quantity. The results presented in this study indicate that, the water productivity is 0.3kg/m^3, compares with figures reported in Ruaha basin rice production, which vary between 0.17kg/m^3 and 0.62kg/m^3, in Kapunga rice farm project the average water productivity ranges from 0.126 to 0.265 kg/m^3 , whereas in Sub-Saharan Africa water productivity ranges from 0.10 to 0.25 kg/m^3. However in the world, figures of up to 0.6 kg/m3 are found but with good and appropriate strategies and management.

On the other hand, the quantity of rice significantly influences water consumption. This relationship could be used to determine the impact of rice production on water use and reformulation of policies on water use.

5.2. Recommendations

Based on the above findings, it is recommended that, the water authorities should reformulate policy for water pricing so as at least water price should be relevant to its costs. This will help them to improve infrastructures and good water allocation.

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