Editorial

We take this opportunity to welcome our readers to the second issue of our sixth volume of the Gezira Journal of Economic and Social Sciences. It gives the editorial board of the journal great satisfaction to continue with its policy of presenting the readers with a variety of papers covering a wide range of its fields of specialization including this time, the fields of management, economics and applied statistics and demography.

This issue of the journal brings to you four articles which are equally divided between the English and the Arabic sections of the journal. In the English section; the first article attempts to establish a price for Sorghum irrigation water compared to gravity, spate and rain-fed irrigation in Sudan. The second paper tested a linear possibility model for ordered categorical data as a similar way of analysis to regression analysis.

The Arabic section of the journal, on the other hand, carries two articles; The first article looks into the reasons for the shift from the direct distribution policy to sales through agents in Kenana Sugar Company Limited, Sudan, whereas the second article attempts to establish the most important socio-economic and demographic factors affecting the total fertility rate in the group of Islamic countries.

Thank you

Editorial Board

Pricing of Sorghum Irrigation Water: A Comparison between Gravity, Spate and Rain-fed Irrigations in Sudan

Eltigani E. B. Abdelgalil[1], Mohamed E. Gali[2]

1. (Corresponding Author) Water Management and Irrigation Institute, University of Gezira, P.O box 20, Wad Medani, Sudan; eltigani9@hotmail.com

2. Faculty of Agriculture, Department of Agricultural Economics, University of Gezira, P.O 43, Wad Medani, Sudan

Abstract:

There is global consensus to use scientific approaches to value all natural resources including water resources. Valuation of water is one way of making users more aware of its value. The aims of this paper is to determine the value of water used in agriculture under gravity system in Gezira Scheme and spate irrigation systems in Gash Delta Agricultural Corporation in Sudan. CROPWAT model was used to determine the volume of water supplied for irrigation. Net revenue was calculated to determine the output from agriculture. The main results show that the net values of water are \$0.005/m^3 and \$ 0.001/m^3 under gravity and spate irrigation systems respectively. The value of water used in gravity irrigation system is greater than water used in spate irrigation system. These findings will help into setting real value and cost of water in agriculture as the major consumptive sector and hence will help policy makers in developing decisions on agricultural water.

Key words: Economic value, water, agriculture, irrigation systems, Sudan

قيمة المياه المستخدمة لري الذرة: مقارنة بين الري بالراحة و الري الفيضي و الزراعة المطرية في السودان

ملخص الدراسة

هناك إجماع عالمي على إتباع الطرق العلمية لإيجاد قيمة كل الموارد الطبيعية بما فيها المياه. حساب قيمة للمياه يعتبر أحد الطرق لتعرف المستخدمين بقيمتها. الهدف من هذه الورقة هو حساب قيمة المياه المستخدمة في الزراعة بنظامي الري بالراحة والري الفيضي في السودان. تم استخدام نظام CROPWAT الحاسوبي لحساب كمية المياه المستخدمة في ري محصول الذرة في كل من الري بالراحة في الجزيرة والري الفيضي في القاش. تم حساب صافي العائد لتقدير المخرج من استخدام المياه. أوضحت النتائج أن قيمة المياه المستخدمة في الري هي 0.005 دولاراً للمتر المكعب في نظام الري بالراحة، و 0.001 دولاراً للمتر المكعب في نظام الري الفيضي. قيمة المياه المستخدمة في الري بالراحة أعلى من قيمة المياه المستخدمة في الري الفيضي. هذه النتائج تساعد في وضع القيمة الحقيقية للمياه المستخدمة في الزراعة كأكبر مستهلك للمياه وكذلك تفيد متخذي القرار في صياغة القرارات المتعلقة بالمياه المستخدمة في الزراعة.

كلمات مفتاحيه: القيمة الاقتصادية" المياه" الزراعة" نظم الري" السودان

Introduction

There is an international consensus that water should be managed in means of enhancing the sustainability of water resources. This cannot be achieved without integrating economics into utilization of water particularly in agricultural sector. Incorporate value of water into water management decisions is crucial for economic benefits and allocation of water resources. Rational decisions supporting water resource development, allocation, and use require measuring the value of water in alternative uses (Frank and Ari 2002). The United Nations Conference on Environment and Development held in Rio de Janeiro in 1992, the World Summit on Sustainable Development held in Johannesburg in 2002 and freshwater resources forum, documented that water should be treated as an economic good. Peter and Savenije (2006) stated that water should have a value in order to achieve two objectives, namely recovering the cost of providing the particular water service and giving a clear signal to the users that water is indeed a scarce and should be used wisely. Creedy et al. (1998), and Duke et al. (2002) published good materials on value and cost of water focusing on domestic use while (Frank 2007) stated that economically efficient decisions supporting water resource development, allocation, conservation and protection may require measuring the value of water in alternative uses. Decision-makers, needs to know the exact value used in any water sectors (domestic use, agriculture and industrial) to make the correct allocation decision.

Irrigation has long been described as a wasteful and low value water use (Chris Perry et al., 2009), therefore policy makers seek to maximize the productivity in terms of output per cubic meter of water. It is claimed that the charges made for irrigation water is far below the operation and maintenance cost of irrigated schemes. This is because of economic problems and practical difficulties in measuring and monitoring water use and the dominant perception that water is a free good. Under low water fee, adverse impact on the irrigation systems and water use are occurring nowadays in Sudan. Water, has often been provided at subsidized prices or for free in many situations. Irrigated agriculture now occupies 18% of the total arable land in the world and produces more than 33% of its total agricultural production (Robert et al,. 2002).

In Sudan, agriculture provides 90% of the raw materials for local industries, accounts 30% to 40% of export earning, and provides income and employment for major group of the population (Abdeen 2013). Estimating real value of water used in agriculture will help policy makers to estimate real cost instead of only operation and maintenance costs. Sudan water policy of 1999 recognizes economic value of water (Abdeen 2013) however; this is not strictly applied because value of agricultural water did not previously estimated. For farmers to make enough income from agriculture, (Robinson, 2002 and Smith, 2004) suggested providing enough water for irrigated agriculture at a low price. However, real recovery fees according to economic value of water, will leads to sustainability of water use particularly in agriculture as major water consumptive sector. There are many technical Operation and Maintenance (O&M) programs adopted in irrigation schemes in Sudan with no significant progress in the output because recovery of operation and maintenance cost and other irrigation services costs are very low. This resulted in huge losses of water, cut-out of growing areas annually, accumulation of silt in canals, reduction in productivity and spread of water associated diseases. The problem of water services charges and recovery are common in irrigated agriculture in Sudan. The Ministry of Water Resources in the past did not received sufficient payments for its services and therefore, the system inadequately maintained which results in poor quality of water supply services. Now the collapsed irrigation system creating water shortage problems. Setting real value and real cost of water used in agriculture is an important instrument to break the vicious circle in irrigated schemes.

Scientists used different methods to estimate the value of water. Gibbons (1986) used net return of water approach for assessing the value of water used for agriculture; he calculated value of water by subtracting variable production costs from gross revenues per hectare. Bruce et al; (2010) used productivity approach to estimate value of water in agriculture; he focused in cost/input-response functions. Bonnie (1989) used total revenues generated by irrigated crop production minus all production costs. In this work we mixed technical (CROPWAT) and economic (net return) concepts to value the agricultural water.

The objective

The overall objective of this research is to determine the value of water used in agriculture under gravity system in Gezira Scheme and spate irrigation systems in Gash Delta Agricultural Corporation in Sudan.

Organization

This paper is organized in six sections. Section one (foregoing) includes the introduction and the objectives. The study area, which represents the location of Gezira and Gash schemes, is detailed in Section two. Section three deals with the methodology used in this paper. The results are presented in section four. Results are discussed in section five and section six provides the conclusion and recommendations.

Study area

The study area includes three areas. These are: Gezira scheme which irrigated by gravity system and Gash Delta Agricultural Scheme (GDAS) which depends on flood irrigation and *Gedarif* area which fully rainfall dependent system. All schemes lies in the dry zone and in the central clay plain in Sudan.

The Gezira scheme has an area of 0.88 million hectares. The scheme is supplied with irrigation water from the Sennar and Roseires Dams on the Blue Nile. It annually, consumes one-third ($6*10^9$ m^3) of the Sudan share from the Nile Waters Agreement of 1959. Topographically the land has a gentle slope from south to north at 15 cm per km and drops faster in the east-west direction toward the Blue Nile or the White Nile. The soil of Gezira scheme is clay soil, with clay content of 56% in depth between (0 to 65 cm) and field capacity of 43% (Elias et al. 2001). The irrigation system is by gravity from Sennar Dam through a huge network of canalization system carrying water from the dam to the fields. Gezira main canal continues northward with several branches form Managil main canal. The distribution system then forms branches, majors, and minor canals down to field ditches carrying water to the fields (Barnett 1977, Gaitskell 1959, Fakki et al., 1982 and Plusquellec 1990). The crops grown are sorghum, groundnuts, cotton, wheat and vegetables. There are about 130 000 farmers in the Scheme

Gash Delta Agricultural Scheme is located in Kassala state, east of the Republic of the Sudan between latitudes between latitudes 15 30 31 and 16 04 06 N and longitude 36 05 26 and 36 05 20 E (Abualgasim et al., 2011). The Delta stretches to about 110 km. North-East of Kassala town (Kamal e al., 2003). The average annual rainfall ranges from 260 mm in the southeast to less than 100 mm in the northwest (IFAD, 2003b). Gash River (GR) dissipates in the terminal fan some 100 km north of Kassala town where it provides moisture for natural forests, pasture and seasonal wetlands for crop production. Downstream from Kassala town, some of its flood water is diverted into canals which divert water into Messga. Gedarif area located in Eastern Sudan between Gezira and Kassala states and fully rain system dependent.

Methodology:

This paper, combines CROPWAT model to determine the volume of water supplied for agriculture with economic concepts to determine the value of water used in agriculture and at the same time compared between the values of water used in various irrigation systems. Historical meteorological data from the study areas in Sudan (*Gezira, Kassala and Gedarif*) was utilized by CROPWAT model to estimate the volume of water supplied for irrigation. Recorded data for season (2012/2013) on sorghum crop including crop type, sowing dates, productivity, cost of cultivation and value and cost of production were collected. Sorghum crop was chosen because it grown in all study area under different irrigation systems. For data accuracy, primary data on the crop was collected directly from farmers in the field. Gross revenues for sorghum crop was calculated, cost of cultivation was subtracted and then the net revenue was obtained. The net return of water was divided by the volume of water diverted for irrigation. The rain fed system was taken as pure rain fully dependent without any irrigation to accurately value the water supplied for irrigation. Values are listed in Sudanese pounds and then converting to USD (U.S. dollars) to enable readers to make direct comparison between value of water across the globe. All currency conversions were applied after adjusting values for inflation, using exchange rates from Central Bank of Sudan *(USD 1 equivalent to SDG 5.8)* at the time of the study.

Mathematically the following equation was used to determine the value of water in agriculture

$$VWA = \frac{NVWI - NVWtI}{VWDI}$$

Where

VWA is the value of water in agriculture

NVWI is the net value of output with irrigation

NVW_tI is the net value of output without irrigation

And VWDI is the volume of water diverted for irrigation, the volume of water in the denominator refers to the irrigation requirements and not to crop water requirements. Rainfall is not included in the volume of water in the denominator, but it is accounted for when net value of output without irrigation is quantified. The net value of output was calculated using the following equation

$$NVA = GVA - CC$$

Where

NVA is the Net Value of Output

GVA is the gross value of output

CC is the cost of cultivation (cost of sorghum production).

Results

The volume of water diverted for irrigation

The volume of water diverted for irrigation was calculated using CROPWAT model, version 8.0 (table 1). The results show that, the volume of water supplied for irrigation is 4374 m^3/ha/year in Gezira gravity system and 3752 m^3/ha/year in GDAS spate system.

The net value of water

It has been found that the gross values of output in irrigated systems is $358.6 and $210.0 per hectare (ha) in gravity system and spate irrigation system respectively. while the gross value of output in rain fed system (without irrigation) is only $193.8/ha. Thus, irrigation enables the farmer to increase the gross value of output by $164.8/ha and $16.2/ha in gravity and spate system respectively. Hence the volume of water diverted for the crop is 4374 m^3/ha per year in gravity system and 3752 m^3/ha per year in spate system (Table 1), irrigation makes addition in net value of output by $ 20.6 in gravity system and $ 5.4 in spate system (Table 2).

Therefore, the results gives value of water of $ 0.005/m^3/ha in gravity system and $ 0.001/m^3/ha in spate system (table 2).

It has been found that irrigation increases the net value of agricultural output by 11.8% in gravity irrigation system and by 3.4% in spate irrigation system. Also irrigation increases the cost by 78% and 21% in gravity and spate irrigation systems respectively.

Discussion

Sudan is presently utilizing 16.5 x 10^9 m^3 annually from its share in irrigated agriculture sub-sector (FAO 2010). Currently, sorghum is widely cultivated in all agriculture sub-systems (gravity, spate and rain fed). The total area cropped with sorghum constitutes 30% of the total area. The irrigation requirement for the crop is high because rain fall in arid region of Sudan is low (250-450 mm/year) and evapotranspiration is high (150 – 200 mm/year).

The values of water obtained are below the global range of $0.01/$m^3$ to $2.0/$m^3$. This is because of low productivity and relatively high cost of cultivation. Irrigation increases the net value of agriculture and at the same time increases the cost of cultivation particularly in gravity irrigation systems. This is because gravity irrigation system requires annual maintenance and operation to secure water supply while these activities not always necessarily needed in spate system. The result obtained is of vital importance because it will influence both decision makers and water users. The calculated values can be used to reset irrigation water fees in irrigated sector to reflect the real value. These values will contribute a lot in solving the historical problems of operation and maintenance cost in irrigated sector in Sudan, as World Bank (2000) reported that there is deterioration in irrigation infrastructure, inefficiency in water distribution, water losses, and low recovery in irrigation water services costs in the Gezira Scheme. With these results, this paper will support the massage for the farmers that water have value and should be managed properly as stated by (Peter and Savenije 2006). Attitudes and behavior of users and particularly farmers need to be redirected because they feel that water is a free good. The result obtained can be used to evaluate changes in policies that would alter current farm water supplies or water use patterns as confirmed by (Frank, and Ari, 2002). Exact and real water value is an effective tool for achieving efficiency in water used and financial sustainability of water supply agencies.

There is no policy for selling water in Sudan (Sudan Water Policy 1999) but the farmers bear the irrigation services cost. The management fees are used to cover the management of the schemes conducted by irrigated schemes managers.

The irrigation fees used to cover the cost of water services to the Ministry of Finance and Economic Planning against the services provided by Ministry of Water Resources and Electricity, and schemes boards. Part of the cost goes to cover the cost of maintenance of canals. However, water fees is combined by administrative fees and collected together. This makes value of water unclear. According to the values of water estimated in this paper, new set of water fees should be structured in irrigated subsector. One of the irrigation management problems in Sudan is that, the value and recovery rates of irrigation services are very low because of lack of scientific approaches in determining these values. This work will path the way for real value of water which could significantly increase water use efficiency by releasing water for more effective irrigation, and allowing expansion of food production.

Conclusion and recommendations

Value of water used in agriculture is relatively low. Low productivity and high cost are behind the low value of water in agricultural sector. Valuation of water used in agriculture as the major consumptive sector will help into setting real value and cost of water and hence correct decisions on agricultural water.

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Table 1. CROPWAT output (supplied water for irrigation)

Scheme	Type of Irrigation	Sorghum water requirements (m^3/h)	Total effective rainfall (m^3/h)	Irrigation required (Supplied water) (m^3/h)
Gezira Scheme	Gravity Irrigation	6126	1958	4347
GDAS	Spate irrigation	5259	1604	3752
Gedarif	Rain fed	4951	3922	0

Table 2. Net value of water used in gravity and spate irrigation systems ($\$/m^3$)

	Gravity irrigation system	Spate irrigation system	Without irrigation (Rain fed)	Additional value because of Gravity irrigation	Additional value because of spate irrigation	% addition in value/cost because of Gravity Irrigation	% addition in value/cost because of Spate irrigation
Gross value of output $/ha/year	358.6	210	193.8	164.8	16.2	46.0	7.7
Cost of cultivation $/ha/year	184.7	51.3	40.5	144.2	10.8	78.1	21.1
Net value of output $/ha/year	173.9	158.7	153.3	20.6	5.4	11.8	3.4
irrigation water input m^3/ha/year	4347	3752	0	4347	3752		
net value of output per unit of water ($\$/m^3$)				0.005	0.001		