WATER USE IN SMALL–SCALE PUMP IRRIGATION IN DONGA FLOODPLAINS, TARABA STATE, NIGERIA

D. U. Sangari

Department of Geography, Nasarawa State University, PMB 1022, Keffi, Nigeria

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Abstract

The aim of the paper is to examine the relationship between water and topography under the small scale modern pump irrigation system, using the concept of ecosystem. The ecosystem theory is based on the recognition that agricultural systems depend on the physical environment and its conditions, whether beneficial or harmful. The Donga River Basin in Taraba State of Nigeria is used as the case study, and the area has a long history of irrigation practices, with water resources development forming an important aspect of the agricultural development. Data for the paper was sourced primarily from fieldwork and this involved the physical elements of the small scale modern pump irrigation system. The statistical techniques of regression analysis and t–test were used to show the relationships between the different variables of irrigation practice. The paper shows that irrigated plots were mainly located on the lowlying sites to take advantage of soil moisture and water resources. It was found that the implication of the dependence of the system on the mechanical water pump is the threat it poses to sustainable irrigation due to frequent pump breakdown. The water management practices in use are adhoc, which are unreliable and unsustainable. The paper concludes that small scale modern water pump irrigation system is crucial to provide greater farming opportunities to the peasant communities and so the system's identified bottlenecks need to be addressed institutionally.

Keywords: *Irrigation, water, ecology, pumps.*

INTRODUCTION

Irrigation involves the control of excess soil moisture through drainage and the adoption of cropping practices and farming systems to optimize water use. Modern irrigation farming has come to be viewed as part of the technological improvement that is capable of radically altering agricultural production systems. Modern irrigation is centrally planned, controlled and coordinated, and has been tied to a bundle of external inputs ranging from the technical advice and guidance of experts to the structural installation of modern engineering works and pumping stations. The provision of essential factors of irrigation production is through the assistance of specialized government agencies, such as the Federal Ministries of Agriculture and Water Resources and the States' Agricultural Development Programmes (ADPs). In Nigeria there are numerous hectares of land under the modern irrigation, a practice that started around 1918 along the Sokoto–Rima Valley (Sangari, 1996). Generally speaking, in agriculture it is difficult to tell which direction farmers are moving because agricultural activities and practices are essentially evolutionary. In some cases, both the traditional and modern agriculture make use of the same production resources (for instance, water and chemical fertilizers, among others). The ecosystem approach, which is basic in agricultural geography, is adopted for the paper. This is because the distinguishing feature of agricultural domains, defined by their natural aptitude for certain farming operations and their ineptitude for others, is an indispensable basis for agricultural productivity. The ecosystem concept has been successfully employed as a method of approach to the analysis of land use patterns and agricultural systems in particular. The conceptual basis of the ecosystem theory is that resource use patterns of agricultural systems depend on the physical environment and its conditions, whether beneficial or harmful, that define the physical potential of the farming system (Richards, 1985; Barrow, 1987; and Sangari, 2008a).

Furthermore, the scale of farming operation may be determined by the relative disposition of the land and the water resources. The aim is to find water resources closer to the land. Farmers' water management strategies, for example, are designed to take care of contingencies. Two techniques are of paramount importance here. The first is to move up and down slopes exploiting sites with different drainage, soil moisture and fertility characteristics (Holmes, 1986). The fact of being on the move up and down a slope as a regular feature of the cultivation strategy permits some degree of rolling adjustments–dwelling longer or moving out of any given site as farmers see how the season is progressing (Richards,1988).

The concept of ecosystem can be used to evaluate relationships that exist in real places and thus to bring out the ecological background to the use of biological resources (Singh & Dhillon, 2005). Moss (1972) specifically used the concept to show the character of plant soil systems. Morgan (1972) also used the ecosystems concept to show the relationship between peasant agriculture and productivity. Although the approach was used by Morgan (1972); Moss (1972); Singh & Dhillon (2005) to show relationships between use of biological resources and the environment, taking a whole ecological zone, it could also be used to show the ecological background to the use of resources in different land facets within an ecological zone. Turner (1984) and Adams (1987), for example, have used this approach to demonstrate how some sites can be used during the first part of the dry season and how some sites are too wet at the beginning of the dry season, and can only be used when the surface water has dried out. In the context of this study, topography of specific sites shall be used to mean the total environmental factor in evaluating land and water use in irrigation, rather than a whole distinctive ecological zone. This is because of the influence of topography on other geographical elements, such as micro –climate and soils, among others. Again, farmers select and maintain a suite of crop varieties well adapted to this process of rolling adjustments (Grove, 1989; Richards, 1988). Typically, farmers will pay attention to where a crop variety does better on the topographic profile, and whether its duration or other growth characteristics (ability to withstand drought , weeds and neglect) are suited to its purpose within the system as a whole (Richards,1988).

The aim of this paper is to examine the relationship between water use and topography under the small–scale modern pump irrigation system in the Donga flood plains of Taraba State, Nigeria.

MATERIALS AND METHODS

Study Area

The Donga River Basin offers both resource opportunities and problems that affect the development of irrigated agriculture. The understanding of the physical characteristics of the area is crucial to the understanding of the need for irrigation. The area, located within the Guinea savanna zone of Nigeria, has rainfall for about five months in a year. The short rainy season constrains cultivation to one cropping season each year. Therefore, the use of water for irrigation forms an important aspect of the agricultural practice in the area. Irrigation practice is further helped by the presence of many favourable conditions created by the existence of numerous terraces and fadama lands, which are of great agricultural importance both for rainfed and irrigated crops. The area is considered as a low rainfall area and the agricultural growing season for rainfed cultivation is confined to the rainy months; beginning in April extending until October (Sangari, 2008b).

The total and the duration of the rains affect the level of water available in the Donga, Suntai and other tributary rivers and in the fadama land for irrigation. Variability of both the annual and monthly distribution of rainfall is a serious limitation to agricultural development in the area. Water resources development for irrigation forms a crucial aspect of agricultural development in the area. The elements of water resources of prime significance to the area are the consequence of its availability, development, utilization and management on agricultural development. The River Donga, which floods the Donga valley fadamas and terraces, receives the bulk of its water supply from the Mambilla Plateau.

Agriculture is the principal livelihood of the people in the area. It is an important agricultural region with many hectares being developed through the modern system of irrigation on the Donga and Suntai fadamas. The land resource potentials of the basin attract people from near and far places to cultivate available land.

Methods of Research

Data for the paper was sourced primarily from fieldwork that covered eight modern irrigation locations that are scattered throughout the study area. Farmers practising modern pump irrigation system were interviewed and data generated on socioeconomic parameters of the pump irrigation practice. Similarly, the physical elements of the small scale modern pump irrigation practice were also investigated. These physical elements include site location of farms, water sources, distance between plots and water sources, size of farms and sources of petrol to power the water pumps, among others. The statistical techniques of t–test and regression analysis were used to test the relationships between the different variables of small scale modern pump irrigation practice.

RESULTS AND DISCUSSION

The results of the study showed that the irrigated plots were predominantly located on the low–lying sites to take advantage of soil moisture resources and their closeness to water sources (Table 1). The important sources of water for irrigation in the area are the free flowing Donga and Suntai Rivers, which were mostly utilized by the farmers using the small –scale modern water pump. The sloping up of the raised lowland sites

prevented the retention of adequate soil moisture due to the short period of flood. Thus, most farms on the raised lowland sites depended on the river channels for water supply to irrigate their crops. The

dependence on the rivers as the main sources of water for irrigation in the area was sequel to the lack of suitable natural depressions. Thus, little use was made of ground water resources and access to it for irrigation purposes was normally by the hand dug pits, used by 0.68 per cent of the water pump users (Table 1). Pits were only dug by the farmers whose plots were located on sites without stream and river channels.

Similarly, shallow excavations were dug in the dried river and stream beds to supply irrigation water in times of water recession. The implication of dependence on rivers as the main sources of water for irrigation by the water pump users is the threat it poses to sustainable irrigation, especially in times of drought and river water recession. The operational bottlenecks associated with frequent water pump breakdown pose constraints to irrigation water use. Table 2 shows that two –thirds of the pumps broke down once every week while 0.3 per cent of them broke down thrice every week due to old age and lack of maintenance. The problems of breakdown were further compounded by the difficulties in obtaining original spare parts and service personnel. More often than not minor repairs of engine pumps take several days to be effected and sometimes pumps are taken to locations, far from the irrigation production areas, thereby leaving crops for days without water. For these farmers, it was difficult to water manually because of the long familiarity with the pump irrigation. Furthermore fuel scarcity was an operational problem to the pump in irrigation practice. Pumps stopped during watering due to tack of fuel and farmers travelled long distances to obtain it. The problem of petrol was serious since pump users relied only on road side petrol sales in the absence of petrol filling stations in the actual irrigation production areas. The nearest petrol filling stations were at Gindin Dorowa, about 8 km away from Bantaje, which has the highest concentration of irrigation locations and at Wukari, 32 km from Donga, with the second highest concentration of irrigation locations in the area. The effects of the operational problems associated with the pumps are reflected in the average hours farmers spent in drawing or lifting water to irrigate the crops. The observed variations in the average daily hours of water application on farms on different typographical sites under the pump irrigation are not statistically significant (Table 3). In the small–scale modern pump irrigation farmers who spent an average of 7.95 hours in daily water application on the raised lowland sites were the users of the relatively new water pumps.

Table 1: Site Location of farms and irrigation water sources

Site	Sources of water					
	River channel		Natural depressions		Dug pit	
	farms No of	%	farms No of	%	farms No of	%
Low–lying	124	83.78	2	1.35	3	2.03
Raised lowland	17	11.49	1	0.68	1	0.68

Table 2: Frequency of water pump breakdown per week

Frequency	No. of pump breakdown	+ Percentage
No. breakdown	242	66.5
3/week	1	0.3
2/week	41	11.3
1/week	80	22.0

Table 3: Results of t–test for site location of farms and average hours of irrigation

	Low lying	Site	Raised lowland
Mean	7.83		7.95
Std Error	0.29		0.86
T Value		–014	
Probability		089	

Not significant at the 0.05 %

Effects of site on conditions for water application

Water application, on the average, was done once, twice and thrice per week. Farmers who cultivated the low–lying sites applied irrigation water thrice weekly in order to keep the soils at field capacity and to sustain crop growth. The frequencies of water application, in addition to site location, depended on factors such as appearance of cultivated crops, nature of soils and the farmers' inclination for watering (Table 4). It was found that farmers, whose water application was guided by both the physiological appearance of crops and soil, cultivated the low–lying sites (Table 4).

Table 4: Site Location of farms and conditions for water application

	Appearance of Crops		**Appearance of Soils**		**Any day**		**Appearance of Crops and Soil**	
Site	**No of farms**	**%**	**No of farms**	**%**	**No of farms**	**%**	**No of farms**	**%**
Low–lying	2	1.35	21	14.19	9	6.08	97	65.54
Raised lowland	2	1.35	1	0.68	–	–	16	10.81

Table 5: Results of t–test for site location of farms and average width of water intake channels (m)

	Low lying	**Site**	**Raised lowland**
Mean	32.08		36.68
Std Error	0.62		1.14
T Value		–2.16	
Probability		0.03	

Significant at the 0.05% level

The width of the intake channels on the raised lowland sites was wider than those found on the low–lying sites (Table 5). The variations in the sizes of water intake channels between farmers cultivating the raised lowland sites and the low–lying sites are statistically significant. The reason for having such wide water intake channels was to transport easily available irrigation water in large volumes to irrigated plots. Sometimes, the width of water intake channels was widened as a result of collapse of intake channel walls. The loss and collapse of intake channel walls were mainly the results of the predominant sandy nature of soils of the low–lying sites. The problem of loss and collapse of intake channel walls was accentuated further by the powerful flow of pump irrigation water from the river channel.

Factors of irrigation water application

As would be expected the length of time and rate of irrigation water application influenced the average volume of irrigation water applied and this varied from one location to another. The average volume of irrigation water applied under the small–scale modern pump irrigation was 127.76 $m^{3/ha-1}$. The results of the t–test, which t–value is given as 2.02 and statistically significant at the 0.05 per cent level show that the average volumes of water applied vary significantly between the pump users cultivating the low–lying and raised low–land sites

(Table 6). In pump irrigation, water availability, coupled with the infiltration of soils of the low–lying sites created the tendency for the pump users to apply higher volumes.

Table 6: Results of t–test for site location of farms and average volume of water applied (m^3/ha^{-1})

	Low lying	Site	Raised lowland
Mean	136.46		68.68
Std Error	$1.2E^6$		$1.6E^6$
T Value		2.02	
Probability		2.02	

Not Significant at the 0.05 % level

Relationship between water use and farm sites

The simple regression analysis was employed to further show the relationship between water use and site location of farms. Water use was measured in litres per hectare while site location, was defined as a dummy variable. The regression model of the functional relationship between water use and site location of farms in pump irrigation is of the form:

$Y = 6.8E^6 + 6.7E^6 X_1$, where Y is the water input (X_6) and X_1 is the site location of farms.

The results of the regression statistics give the F value as 4.09 and is significant at the 0.05 % level (Table 7). Based on the statistical results above, we can therefore say that water use in pump irrigation is affected by the site location of farms. The pump users located their farms on sites that ensured available water supply for irrigation. Where farms were located far away from water sources, farmers intensified their water utilization efforts by pumping water to higher and far away sites.

Table 7: Regression results of water use and site location of farms

Independent Variable	b Coefficient	Std. Error of Mean	F	Probability
Site location (X_1)	$6.7E^6$	$3.3E^6$	4.09	0.05

Intercept = $6.8E^6$; Significant at the 0.05 % level

Effects of site on water management

The observed water management strategies of the farmers using the water pump for irrigation were embarked upon only when problems of water utilization were manifested. The major problem of water use is lack of powerful engine pumps, which have higher capacity than the observed old engine pumps in use. The distance between water sources and plots, coupled with water fluctuation, left pumping points far away and this made it difficult to get sufficient water to the farms.

One of the ad hoc strategies to the problem of irrigation water use was the maintenance of water sources. Water sources were maintained in order to make them recharge more water for irrigation. Channel maintenance was often done to coincide with the time farmers were in the farms for other operations, such as water application and weeding. This was done to save labour, rather than going to the farms on separate days for channel maintenance only. The users of water pumps did not practice water use in rotation because the pumps are individually acquired and the pits dug personally while the river channel is a common property. It is entirely; therefore, the sole responsibility of each pump user to maintain the points at which he pumps irrigation water to the farms.

On the first day of irrigation, farmers start from the top–end and on the next irrigation day, they begin from the bottom–end. This principle of alternate water application is based on the understanding that the part that is first irrigated does not immediately need water. In this manner the problem of drainage is controlled. Excess water is drained off by creating an out let in the last basin. The implication of such disposal of excess irrigation water is that it would flow into the adjacent farm and which may not be needed especially when farmers on such bottom end farms had already applied irrigation water. The ecosystem approach was adopted to analyse the effects of topography on water use, using the modern water management technique. The simple regression statistical technique is used to investigate whether functional relationship exists between topography and water use.

CONCLUSION

The paper concludes that in small scale modern pump irrigation practices, the influence of site location on land use tends to vary. Irrigated plots are located on sites that ensure available water resources for crop sustenance, irrespective of topography of the land. The physical location of irrigated plots has influence on the size of land that was brought under irrigation regime. Irrigated plots, on the average, were found to be small to accommodate the available resources, especially water.

Irrigation is generally needed to provide greater opportunities to the peasant communities especially in areas where water deficiency is a limiting factor for plant growth. The opportunities are limited, as seen in terms of the size of land brought under irrigation, caused by lack of extended water resources. For farmers to be able to bring more land under irrigation production, greater effort must be made to provide water facilities beyond what is currently possible. The observed water management strategies need to be changed and replaced with more carefully planned ones that can tackle water supply and use problems even before they are manifested.

REFERENCES

Adams, W. M. (1987). Approaches to water resources development, Sokoto Valley, Nigeria. The problem of Sustainability in Conservation in Africa, People, Policies and Practice. Anderson, A. and Grove, R. (eds.). Cambridge University Press, Cambridge. 307–323.

Barrow, C. (1987). Water Resources and Agricultural Development in the tropics. Longman development studies. New York. John Wiley and Sons.

Grove, A. T. (1989). The Change Geography of Africa. Oxford University Press, United Kingdom.

Holmes, R. C. (1986). Irrigation in Southern Peru: The Chili Basin. Department of Geography, the University of Chicago, Research paper no. 212.

Morgan, W. B. (1972). Peasant agriculture in tropical Africa in Environment and land use in Africa. Thomas, M. F. and Whittington, G. W. (eds.) Methuen and Co. 241–272. United Kingdom.

Morgan, W. B. & Munton, R. J. C. (1971). Agricultural Geography, Methuen and Co., United Kingdom.

Moss, R. P. (1972). The ecological background to land use studies in tropical Africa, with special reference to the west. In Environment and Land use in Africa. Thomas, M. F. and Whittington, G. W.(eds.). Methuen and Co, 193–338. United Kingdom.

Richards, P. (1985). Indigenous agricultural evolution. Ecology and food production in West Africa, London.

Richards, P. (1988). The versatility of the poor: indigenous wetland management systems in Sierra–leone, University College, London.

Sangari, D. U. (1996). Historical trends in irrigation development in Savanna Region of Nigeria. Studies in Humanities, 1(1): 67–88.

Sangari, D. U. (2008a). Manual irrigation in Donga Valley, Taraba State, Nigeria. Nigerian Journal of Tropical Geography, 2(1): 40–47.

Sangari D. U. (2008b). The management of bucket irrigation in Bantaje floodplain, Taraba State, Nigeria. Journal of Environmental Research and Policies, 3(4): 88–92.

Singh, J. & Dhillon, S. S. (2005). Agricultural Geography. Third Edition. Tata McGraw–Hill Publishing Company Limited, New Delhi.

Turner, B. (1984). The changing land use Patterns in the fadamas of Northern Nigeria. In: Life before the drought. Scott, E. (ed.). Allen and Unwin, London, 149–170.