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Full Length Research Paper

Assessment of irrigation systems for dry season vegetable production in urban and peri-urban zones of Ibadan and Lagos, Southwestern Nigeria

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Dry season vegetable irrigation system plays a key role in the economics of Nigeria as a basic source of food, income, and employment generation especially in the off-season of rainfall agriculture. This diagnostic study was embarked upon to assess the different irrigation systems to better understand the characteristic problems and needs. This article reports on some general information on irrigation systems that are useful to project planners, agencies and policy makers. Results indicate that farmers are frequently faced with low stream flow, conveyance of water from source to farm site as well as sources of water drying up. Majority of the farmers whom are illiterates lacks basic knowledge of crop-water requirement, irrigation scheduling and skills in maintaining and operating irrigation systems. These affect the productivity of the systems, as the crops are either over- or under-irrigated, leading to wastages of the little available water. Recommendations are made that could enhance the farmers' productivity and increase their farm hectares in order to meet the growing demand for vegetables especially during the off season.

Key words: Irrigation systems, management practices, dry season, vegetable production, urban-peri-urban, Nigeria.

INTRODUCTION

Urban and peri-urban agriculture is growing fast around all major cities in Africa with the increase of urban population and consequent rising demand for fruits and vegetables. Irrigated agriculture will need to expand rapidly in the future in order to cope with this rising demands. However, water resources are limited and irrigation is very labour demanding because in many urban and peri-urban farming, irrigation water is carried by hand from the well, reservoir or river to the field (Van Leeuwen, 2001).

Irrigation schemes in developing countries especially in sub-Sahara Africa (SSA) suffer from very low water use efficiency, resulting in water logging and salinity problems. Most readily available water resources have been mobilized already and a large part of the expansion of the irrigated area should come from the development of small-holder farmers of small local water resources such as small reservoirs and shallow groundwater. The optimal use of these limited resources is essential. The adoption of small-scale low-cost irrigation technologies by small-holder farmers in Africa has great potential and could be one of the solutions for increasing food production, farmers' incomes and improving food security (Van Leeuwen, 2001; Hillel, 2001).

Vegetable production is done mainly during the rainy (major cropping) season in Southwestern Nigeria. During this season, vegetables are easy to grow as water is available and farmers can avoid the cost of irrigation (Olasantan, 1996). Vegetable production is one of the most important enterprises of peri-urban production systems in Nigeria because vegetables are an important component of human diet and they can be easily cultivated on small areas. Whereas, the Food and Agricultural Organization of the United Nations (FAO) and the World Health Organization (WHO) recommended a daily vegetable intake of 200 g per person, the Nigerian

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National average is below this value (Kintomo et al., 1997). This inadequate intake of fresh vegetables may further be worsened during the dry season when moisture scarcity limits the area under cultivation and quantity of vegetables that can be grown and supplied to the urban areas.

On the other hand, a previous study by Kintomo et al. (1997) in Ibadan indicated that it was more profitable to grow vegetables during the dry season when water is made available. Growing vegetables during this period also lead to higher quality products because of low disease pressures compared to vegetables grown under rain fed conditions. In that study however, 81% of farmers rated water management and/or poor drainage system as the most important abiotic constraint limiting dry season vegetable production. Ogunjimi and Adekolu (2002) advised that the problem of small-scale irrigation systems especially for vegetable production in Nigeria needs to be further studied. Hence, the objective of this work was to assess the irrigation systems within the urban and peri-urban vegetable production systems of Southwestern Nigeria in order to proffer technological improvements that will enhance the productivity of the systems.

MATERIALS AND METHODS

The study was conducted from January to March 2005 within and around Lagos and Ibadan cities. Lagos/Ibadan is located in the humid forest/moist savannah transition zone (average of 210 m above sea level, 7° 30'N, 3° 54'E). Annual rainfall pattern is bimodal, with about 120 - 128 rainy days totaling approximately 1200 – 1400 mm per annum. Rains usually begin in April and ends in November, with a mid season dry spell in July and August. November to April is the dry season. Total class A pan evaporation is 1500 – 1550 mm per annum. Mean annual maximum and minimum temperatures range between 24 - 29°C, 27 - 34°C, and 20 - 30°C for summer, autumn and winter. Mean relative humidty is 64 - 83%.

The locations studied spread across urban and peri-urban areas of Ibadan and Lagos, Southwestern Nigeria and included Molete-Bode, Lade-Ido-Abeokuta, Abanla, Ijanikin-Lagos, and Akufo farm settlements. These locations were chosen because they represent the typical urban and peri-urban dry season vegetable production systems in Southwestern, Nigeria. The study was undertaken using an approximately designed interview schedule and the participatory learning approach. Data were collected by face-to-face interview and personal questionnaire/assessment of the farms. A total of 113 farmers were interviewed. Some of the issues addressed by the questionnaire include socio-economic parameters, source of irrigation water, irrigation methods, agronomic practices, soil and water management practices, problems encountered, mode and type of assessment expected.

Economic analysis of irrigation systems was considered for lettuce production per meter squared. Labour was charged at N40 per hour and current average price of lettuce of peri-urban market was fixed at N550 per kilogram. Marginal cost of the systems and labour were considered. All other costs that do not differ across irrigation systems (e.g. costs of planting, transplanting, land purchase and preparation, etc) will be incurred regardless of the system being used. Labour was charged at N40 per labour per hour manday. Marginal revenue was calculated by subtracting the current market price from the marginal cost of lettuce.

The survey team was made up of agronomists, irrigation engineers, extension agronomists, socio-economists, extension agents on site and an expert irrigation agronomist from the United States. Through the study administered by questionnaire, general description of irrigation systems, the management, productivity and constraints facing the systems were investigated.

RESULTS

Biodata information and socio-economic factors of dry season vegetable farmers in Southwestern Nigeria

Farms studied ranged between 0.01 - 0.33 ha in size with average farm size of 0.2 ha. Farms were relatively smaller within the city (Molete-Bode and Ijanikin-Lagos) than on the outskirts (Table 1). Majority of the farmers (87%) were part time farmers who augment their primary income from off-season vegetable production (Table 2). Eighty percent of the farmers were tenants who rented their field plots annually from landowners (Table 1).

Vegetable crop calendar

Dry season vegetables in Southwestern Nigeria are finally harvested between March and April of each year. Thereafter most the farms become flooded if within the flood plain or fadama because of early rains or are left fallow during the rainy season (May to early September). Land preparation close to a fresh water source is carried out between late September and October, followed by planting operations. Plantings are either on the ridges or raised beds depending on the depth of water table and time of the year. A typical cropping calendar for the systems is as shown in Table 3. Two to three cropping cycles of a particular vegetable is common depending on growth duration, other crops in the mixture and market preferences.

Crops grown

The major crops cultivated were lettuce (*Lactuca sativa*), cucumber (*Cucumis sativus*), cabbage (*Raphanus satumus*), carrot (*Dacus carota*), radish (*Radish botinane*), amaranthus (*Amaranthus crentus*), celosia (*Celosia argentea*), chochorus (*Chrollemus oleotrium*) (Table 4).

Majority of the farmers' practices (77%) are of intercropping or the other, depending on the types of crop grown and time of the year. The dominant systems are presented in Table 4.

System management

Weeding was carried out either with hoe or by hand pulling depending on the crops grown and cropping

Table 1. Biodata information on dry season vegetable farmers in Southwestern Nigeria.

Biodata	Location				
	Molete/Bode	Lade/Abeokuta	Abanla	Akufo	Ijanikin/Lagos
No. of farmers	27	30	18	28	10
No. of farm sampled	12	10	5	8	4
Ave. farm size (ha.)	0.01	0.25	0.30	0.33	0.02
Land acquisition (%)					
Owned	x	2	33	50	x
Leased	90	93	50	17	50
Rented	10	5	17	3	50
Years spent in farming (%)					
<10 years	47	24	15	02	45
10 - 15 years	13	58	25	28	07
>15 years	40	18	60	70	48

* Indicate no response.

Table 2. Socio-economic factors information of dry season vegetable farmers in Southwestern Nigeria.

Factors	Location				
	Molete/Bode	Lade/Abeokuta	Abanla	Akufo	Ijanikin/Lagos
N*	**27**	**30**	**18**	**28**	**10**
Gender profile (%)					
* Male	85.2	50.0	66.7	75.0	70.0
* Female	14.8	50.0	33.3	25.0	30.0
Marital status (%)					
* Married	74.1	93.3	83.3	78.6	80.0
* Single	25.9	6.7	16.2	21.4	20.0
Farmers' disposition (%)					
* Part time	82.0	96.0	88.0	80.0	89.0
* Full time	18.0	4.0	12.0	20.0	11.0
Mean age (%)					
* <30 years	77.8	10.0	33.3	14.3	20.0
* 30-50 years	14.8	90.0	66.6	71.4	80.0
* >50 years	7.4	-	-	14.3	-
Mean no. of children	14.8	20.0	27.8	17.9	30.0
Education (%)					
* Primary	25.9	73.3	61.1	89.3	30.0
* Secondary	74.1	26.7	38.9	10.7	50.0
* Tertiary	-	-	-	-	20.0

N* = Number of respondents; - Indicate no response.

systems (Table 4). For instance, hand weeding is carried out when leafy vegetables are intercropped because their seeds are broadcast at high density. Pests and diseases especially leaf eating insects are controlled by the application of pesticides and natural plant products (Table 4). Majority (70 - 74.0%) of farmers that are closer to cities plant imported seeds from other countries (Table 4).

Table 3. Vegetable crop calendar during the dry season in Southwestern Nigeria.

S/No.	Period	Activities
1.	Humid (Mar – Apr)	Final harvest of irrigated vegetables.
2.	Rainy (May – early Sept.)	Fallow or submerged land (if within the Fadama or flood plain).
3.	Early dry (Late Sept. – Oct.)	Preparation of land close to a fresh water source for irrigated cropping by preparation of irrigation beds, channels and seedling nurseries.
4.	Dry (Nov. – Feb.)	Growth of 2 - 3 sequences of relay/intercropped irrigated vegetables.

Table 4. Crops grown and agronomic practices adopted by dry season vegetable farmers in Southwestern Nigeria.

Parameter	Percent respondents				
	Molete/Bode	Lade/Abeokuta	Abanla	Akufo	Ijanikin/Lagos
N*	**27**	**30**	**18**	**28**	**10**
Crops grown					
Lettuce (*Lactuca sativa*)	66.7	40.0	55.6	35.7	80.0
Cucumber (Cucumis sativus)	44.4	13.3	22.2	14.3	60.0
Cabbage (*Apium graveolense*)	74.1	13.3	44.4	21.4	90.0
Carrot (*Dacus carota*)	59.3	6.7	11.1	7.1	70.0
Radish (*Raphanus sativus*)	29.6	x	x	x	50.0
Amaranthus (*Amaranthus cruentus*)	14.8	x	22.2	17.9	60.0
Celosia (*Celosia argentea*)	7.4	x	16.7	10.7	x
Chochorus (*Chrllemus oleotrium*)	18.5	66.7	100.0	78.6	80.0
Cropping systems					
Monocrop	74.1	86.7	55.6	46.4	70.0
Mixed cropping	x	x	16.7	17.9	x
Relay cropping	25.9	13.3	16.7	28.6	30.0
Inter cropping	x	x	11.1	7.1	x
Weeding/pest control					
Hand weeding	74.1	83.3	55.6	78.6	40.0
Herbicides	x	x	11.1	7.1	20.0
Others	x	x	x	x	x
Insecticides	18.5	6.7	27.8	7.1	20.0
Traps	x	6.7	5.6	7.1	x
Fungicides	7.4	3.3	x	x	20.0
Sources of seed					
Local	22.2	20.0	66.7	05	20.0
Imported	74.1	6.7	16.7	02	70.0
Farm produce	3.7	73.3	16.7	21	10.0

*Number of respondents; x: Indicate no response.

Soil fertility management

Soil fertility was managed either by depending on nature fertility of the soil or by the application of inorganic fertilizer mainly (NPK 15-15-15), especially on plots that are cropped for up to 2 - 4 cycles before the end of the season (Table 5).

Water management

Water conservation management varied from mulching with grasses to reduce loss of water from the system to constructing drainage channels to drain off excess water from field especially at the beginning of the cropping season when the water table is high. Other methods

Table 5. Soil fertility conservation techniques for dry season vegetable production in Southwestern Nigeria.

Techniques (%)	Location				
	Molete/Bode	Lade/Abeokuta	Abanla	Akufo	Ijanikin/Lagos
N*	**27**	**30**	**18**	**28**	**10**
*Fallow	-	13.3	16.7	17.9	-
*Organic fertilizer	7.4	26.7	44.4	35.7	20.0
*Inorganic fertilizer	96.3	93.3	88.9	64.3	100.0
*Zero tillage	3.7	-	-	-	20.0
*Ridging methods	96.3	100	100	100.0	80.0

*Number of respondents; - Indicate no respondents.

Table 6. Water conservation management techniques for dry season vegetable production in Southwestern Nigeria.

Techniques (%)	Location/N*				
	Molete/Bode	Lade/Abeokuta	Abanla	Akufo	Ijanikin/Lagos
N*	**27**	**30**	**18**	**28**	**10**
*Mulching	-	43.3	66.7	67.9	80.0
*Organic manure	25.9	6.7	11.1	17.9	40.0
*Irrigation scheduling	74.1	60.0	88.9	60.7	100.0
*Dug pond	44.4	13.3	5.6	14.3	80.0
*Dredging of streams	29.6	13.3	44.4	28.6	40.0
*Boring of wells	51.9	6.7	72.2	17.9	90.0

*No of respondents; x = indicate no respondents.

include construction of raised beds, irrigation scheduling, digging of shallow wells and use of watering cans or use of portable petrol water pump during the peak of the dry season (Table 6).

Irrigation practices

Sources of irrigation water are river, well, borehole, dam and stagnant pool. Major sources of water are rivers (Table 7). Water conveyance is by watering can, drainage channels and bucket/basin. The quantity and quality of irrigation water applied are still in the rudimentary stage. Crude way of feeling the soil, observing the crop and soil, as well as farmers' experiences are major ways of determining the quantity and quality of water to be applied (Table 7).

Irrigation systems partial budgeting for lettuce production

Table 8 shows the comparison of the productivity of irrigation systems in Southwestern Nigeria. Unit cost of the sprinkler was highest compared to drip or watering can for instance. Total cost was lowest for drip irrigation system, which also had the highest gross benefit (Table 8). Comparing the systems, drip irrigation had the highest net benefit compared with all other systems (Table 8).

DISCUSSION

Irrigation management reforms are a key component of government policy in almost all countries with a significant irrigation sector. An irrigation management reform has history of more than 50 years. It has gathered momentum during the past two decades. Since the mid-1980s the centre-piece of the reforms has been the transfer of management of irrigation systems to water user associations or other non-governmental agencies, combined with the down-sizing or withdrawal of government role in operation and maintenance, fee collection, water management and conflict resolution (Merrey et al., 2001).

In general, irrigation management transfer (IMT) has worked in situations where individual stakes are high and the irrigation community has been able to take the additional burden of self management (financially and managerial). International experience in IMT suggest that small holder IMT programmes in Africa need satisfy that significant net improvement in life-situations for members; irrigation systems must be central to creating such improvement; economic and financial cost of scheme management must be an acceptable small proportion of improved income and proposed organization design must

Table 7. Irrigation practices for dry season vegetable production (% of farmers) in Southwestern Nigeria.

Techniques	Molete/Bade	Lade/Abeokuta	Abanla	Akufo	Ijanikin/Lagos
N*	**27**	**30**	**18**	**28**	**10**
*Sources (%)					
River	92.6	60.0	88.9	78.6	80.0
Well	7.4	6.7	11.1	14.3	80.0
Borehole	x	x	x	x	40.0
Dam	x	x	x	x	x
Stagnant pool	x	x	x	x	x
*Water conveyance (%)					
Watering can	85.2	60.0	88.9	82.1	90.0
Drainage channels	14.8	6.7	27.8	42.9	40.0
Motorized pump engine	44.4	x	22.2	14.3	90.0
Hand/Bucket/Basin	14.8	26.7	47.4	35.7	50.0
Others	x	x	x	x	x
*Water scheduling (%)					
Feeling the soil	7.4	6.7	11.1	7.1	20.0
Observing the crop	66.7	53.3	88.9	71.4	80.0
Experience	92.6	60.0	100.0	92.9	90.0
Calculation	x	x	x	x	x
Tensionmeter	x	x	x	x	x

*Number of respondents; x = indicate no respondents.

Table 8. Partial budget for lettuce production averaged across urban and peri-urban systems dry season of Southwestern Nigeria.

S/N	Irrigation system	Unit cost (A)	Labour cost (B)	Total cost (A+B)	Gross revenue (C)	Marginal revenue (C-A)	Net revenue (C-A-B)
1.	Drainage channels	850	400	1,250	5,000	4,150	3,750
2.	Drip/Trickle	450	200	650	6,500	6,050	5,850
3.	Sprinkler	1,200	200	1,400	6,000	4,800	4,600
4.	Watering can	250	800	1,050	5,000	4,750	3,950
5.	Bucket/basin	200	800	1,000	5,000	4,800	4,000

58 Nigerian Naira (N) = One US dollar; Lettuce = N550 kg^{-1}; One hour manday = N40 h^{-1}; 10,000 m^2 = One hectare; [1]Gross revenue = Field price/kg × average yield (kg/m^2); where field price is the market value of one kg of lettuce to the farmer. [2]Marginal revenue: This was calculated by subtracting the unit cost of the system from the gross revenue; [3]Net revenue: This was calculated by subtracting the labour cost from the gross revenue.

have low transaction cost (Merrey et al., 2001).

Water control and soil management are critical for reliable food production. In Africa, only 12 million ha, about 6% of the total cultivated land are irrigated. This could be increased considerably and irrigation could bringabout increase in yield of over 400%. However, this would require policy making which in turn relies on irrigation research (Dada, 2001).

Majority of the farmers (81.9%) are married with children and therefore would maintain a permanent residence in the area of operation and continue the practice if encouraged. Majority of the farmers (64.6%) are also young adults and would still be active in production for a long time. Majority (55.9%) are also illiterate with barely primary education, thus any technology to improve the system must be simple and easily adoptable (Table 2).

The preponderance of leafy vegetables over fruit vegetables suggests that they should be the target of research effort to improve the system. They have shorter life cycle, thereby enabling the farmers to have more (2 - 4) crop cycles before the rainy season. It also defrays costs of field establishment at the beginning of each cropping season.

Majority of the farmers in the system (77%) practice one form of inter cropping or the other, while hand

weeding was most prevalent across the different locations. We noticed with interest that farmers in the city source their seed from imports while peri-urban farmers get their seed from produce or locally suggesting that locally produced seed could be improved upon for export.

About 12% of farmers dig ponds off the stream to store water, but it was observed that dredging of stream during low flow did not adequately control seepage because pond walls were not stabilized. We recorded that 7.8% of the farmers apply organic manure which need be improved upon because Adekalu et al. (2001) have shown that soil of Southwestern Nigeria requires adequate soil water permeability during the dry season so organic manure could improve. More research is needed on the use of organic manure to improve irrigation water use efficiency.

Most farmers (29.6%) use regular intervals of irrigation and control the amount of water used based on their experience and intuition. This is probably because most of the farmers are illiterates and the few literate among them did not study agriculture. Knowledge of initial water holding capacity if lacking does not allow evaluation of water requirement and this often leads to unavailability of water supply, especially during critical periods. Improper and insufficient irrigation scheduling reduces yield and income as was evident in the partial budgeting for lettuce production in this study. The calibration of a bucket evaporator as used in the trickle irrigation system which is similar to that proposed by Torres for the majority of the crops grown by the farmers would serve a useful and simple tool for irrigation scheduling for the farmers. Farmers should be trained in the method of assessing water source to meet irrigation water request and best irrigation requirements as well as estimation of irrigation water request and best irrigation system to meet farmers' needs.

The main soil conservation practice is the application of fertilizer to improve productivity of the land. Due to high cost of fertilizer and availability in dire need, an average of 11.9% of the farmers uses organic animal manure. A few practice fallow (4.3%). It was noted that none of the farmers' practice *in-situ* live mulch that could control weed and add nitrogen to soil, for instance the use of soyabeans and *sorphocarpus palustris in situ*-live mulch as reported by Ojo et al. (2007). It is good that most farmers till their land by making ridges/mounds which further improves permeability of the soil.

The major sources of water used by their farmers are streams (71.5%) and well (21.4%), very few bore holes or wells in addition to stream water. None used water from dams or stagnant water in the survey. Most of the farmers complain that the flow of the rivers/streams are very irregular and the wells dry up especially during the peak of dry season leading to crop failure and low yield. Construction of stream ponds near the streams, deep wells and stabilized earth ponds near the farm are therefore recommended.

A substantial number of farmers (46%) practice hand watering, although some have petrol engine pump. Though they complained of irregular and fluctuation in prices of fuel, high cost of fuel, and frequent breakdown of the pumps. Very few (14.9%) adopt furrow and basin (drainage channels) irrigation systems. The use of hand watering is laborious and does not produce effective and uniform wetting of the soil. Hand watering also leads to substantial water loss through runoff. The furrow and basin systems are efficient in water distribution, requires less pumping but leads to higher evaporation water loss, lower water use efficiency, and not suitable to all crops. The drainage channel systems are also labour intensive as evidenced in the data presented by comparison of partial budgeting of the different irrigation systems requirements. The use of micro- and macro-trickle irrigation system would reduce the cost of pumping, reduce water loss to evaporation and effective water use efficiency. Use of mulching if employed could further reduce evaporation water losses. Farmer must also be trained in the use of drip or trickle irrigation systems as well as maintenance of water pump.

CONCLUSION AND POLICY IMPLICATIONS

The best irrigation alternatives that have the greatest chance to work are those that help small holders move to a substantially higher productivity and income to manage their irrigation system independently. The use of drip/trickle irrigation systems, especially micro systems similar to one proposed by Batcher et al. (1996) instead of the sprinkler system, would reduce fuel consumption, cost of pumping and labour, as well as save more water for effective irrigation water management usage for dry season vegetable productivity. Bringing small holder irrigation communities in contact with stable, reliable markets for value-added products will help install upward ratchets and readiness/eagerness for irrigation management, inter- and intra-regional market competition for optimal benefits.

REFERENCES

Adekalu KO, Ogunjimi CAO (2001). Cost recovery strategies for large scale irrigation in Nigeria. Technovation 2001 (in press).

Adelatu KO, Okunade DA (2001). Effect of irrigation and tillage systems on the yield and irrigation efficiencies of Cowpea. Agriculture and Water Management (2001, in press).

AVRDC (1993). AVRDC 1993 Progress Report. Asia Vegetable Research and Development Centre. Shanhua, Taiwan (ROC), p. 537.

Batcher C, Lovell C, Murak M (1996). Simple micro-irrigation techniques for improving irrigation efficiency on vegetable gardens. Agric. Water Manage., 32(1): 37-48.

Dada BF (2001). Private irrigation in sub-Sahara Africa. In proceding of Regional seminar on private sector participation and irrigation expansion in sub-Sahara Africa pp. xix – xxi; 22 – 26 Oct. 2001, Accra, Ghana. Edited by Hilmy Sally and C.L.Abernetthy.

Hillel D (2001). Small scale irrigation for arid zones, principles and options. FAO development series No. 2, Rome, Italy.

Kintomo AA, Ogunkeyed OO, Ogungbaigbe LO (1997). Peri-Urban dry season vegetable production in Ibadan, Nigeria. Tropicultural,

15 (2): 61-65.
Merrey DJ, Shah B, Kopper T, Lange M, Samad M (2001). Reforming irrigation in sub-Sahara Africa. In proceding of Regional seminar on private sector participation and irrigation expansion in sub-Sahara Africa; 22 – 26 Oct. 2001, Accra, Ghana. Edited by Hilmy Sally and C.L.Abernetthy, pp. 101-126.
Ogunjimi LAO, Adekalu KO (2002). Problems and constraints of small scale irrigation (Fadama) in Nigeria. Food Rev. Int., 18(4): 295-304.
Ojo OD, Kintomo AA, Akintoye HA, Njoku CO (2007). In-situ live mulch weed control strategy for grain amaranth (Amaranthus cruentus L.) production. NIHORT in-house report, NIHORT, Ibadan, Nigeria, pp. 26-32.
Olasantan FO (1992). Vegetable production in traditional farming systems in Nigeria. Outlook Agric., 21: 117-127.
Olasantan FO (1994). Fertilizer use in vegetable production in Nigeria. Outlook Agric., 23: 213-222.
Olasantan FO (1996). Meeting the future vegetable needs in Nigeria: The potential role of out of season vegetables. Outlook Agric., 25(2): 95-105.
Van Leeuwen NH (2001). Irrigation reforms in Africa. In proceding of Regional seminar on private sector participation and irrigation expansion in sub-Sahara Africa Oct. 2001, Accra, Ghana. Edited by Hilmy Sally and C.L.Abernetthy, pp. 50-58; 22-26.