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Performance Assessment of Irrigation Schemes in Northern Ghana Using Comparative Performance Indicators

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Abstract : ***The study assessed the performance of irrigation schemes in Northern Ghana using comparative performance indicators. It was carried out in the Tono, Vea, Doba Libga, Bontanga and Golinga irrigation schemes in the Upper East and Northern Regions of Ghana. The performance for the years of 2010 - 2014 were evaluated using selected comparative indicators, classified into four (4) groups, namely; water delivery, physical structures, financial and crop production performance. The study revealed that the flow lengths of the main canals at the Tono, Vea, Doba and Libga irrigation schemes have reduced due to low reservoir water levels and infrastructural deficiencies. The developed irrigable area in Tono, Vea and Doba was under-utilized with irrigation rates ranging from 8 – 54 % while that of Libga, Bontanga and Golinga was put to full capacity use with irrigation rates ranging from 91 – 100 %. Irrigation service charges recovery was poor in the Vea, Libga and Bontanga schemes with recovery efficiency ranging from 19 – 52 % whereas the recovery was good in the Tono, Doba and Golinga schemes with efficiency ranging from 75 – 96 %. The irrigation schemes were not financially self-sufficient as they recorded low rates of 1.3 – 59 %. The Doba, Vea and Tono schemes recorded low sustainability of irrigated area indices 0 – 49 % whereas the Libga, Bontanga and Golinga recorded high indices of 95 - 100 %. The production levels of cereals and vegetables in the schemes had drastically declined both in area cropped and yield due to poor state of irrigation facilities, high prices of agro-chemicals, poor market, nematodes infestation and, low interest by farmers. Payment of irrigation service charges before cropping should be adopted by the management of the irrigation schemes to improve recovery rates. Penalties for non-payment of irrigation service charges should be applied on defaulters. Annual adjustment of irrigation service charges have been recommended to meet cost recovery. Public-Private Partnership (PPP) management of the irrigation schemes have also been recommended to ensure proper management and good performance.***

Index Terms: ***Performance assessment, irrigation schemes, comparative performance indicators, irrigation service charges***

1. INTRODUCTION

For agricultural production, water is a valuable resource. Scarcity and misuse of water resources pose serious and growing threats to life and sustainable development. Increasing yields and sustaining food production depends mainly on irrigation in countries where water is a limiting factor to agriculture. Therefore, development and protection of water resources, such as irrigation dams are crucial [vii]. Takeshi and Abdelhadi [xxii] projected that within the next two decades, many countries in the world are expected to face insufficient water availability to satisfy their agricultural, domestic, industrial and environmental water demands. The world population is forecasted to grow by about 30 % by the year 2025, reaching 8 billion people. Dorsan *et al*. [viii] stated that the development and maintenance of artificial water resources such as irrigation dams is crucial to secure and maintain food security for the fast increasing population in the world. Similarly, [ii] remarked that the struggle to attain food security should be assisted by increasing production through irrigated agriculture.

Africa has promoted irrigated agriculture as a means of ensuring food security as well as improving the standards of living of the rural people for many years [x], [i]. Modern irrigated agriculture started in Ghana in 1960s and as at 2007, about 33,800 ha of Ghana's land was under irrigation [xix]. Ghana cannot achieve economic growth and poverty reduction targets without significant improvement in the agricultural sector, so extensification and intensification of irrigation is the key to achieving this goal [xiv], [i].

The Ghana Irrigation Development Authority (GIDA) and Japan International Cooperation Agency (JICA) [ix] stated that most of the small-scale as well as large-scale irrigation schemes which were constructed to bring the food shortages and poverty under control in the country (Ghana) are performing below average, while the others have failed completely. Similarly, [xx] reported that many of the irrigation schemes, especially the state-managed ones experience many drawbacks and cannot perform to expectation.

Considering the huge investment costs that come with the development of irrigation schemes and the crucial roles they play in food security, employment generation, among many others in human livelihoods, many researchers and authors, including [xi], [xviii], among others have proposed, developed and used several indicators to measure irrigation systems performances worldwide. Sener *et al*. [xxi] remarked that due to the high cost of developing new irrigation schemes in recent years, it is more preferable to continuously assess the performance of the existing irrigation schemes to improve their performance than developing new ones. The authors reiterated that performance evaluation of irrigation schemes helps in the identification of the problems of the schemes. This will help the scheme managers to develop new strategies and ways of solving the problems to ensure higher performance in future. Similarly, Cakmak *et al.* [vi] pointed out that performance evaluation studies have gained significance since the early 2000s because it is the most practical tool to assess the success and failure of any irrigation scheme. Unlike in the developed countries, performance evaluation studies of irrigation schemes are not sufficient in the

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developing countries both in the aspects of their number and content.

The performances of 18 irrigation schemes in 11 different countries were evaluated using the nine comparative indicators developed by the International Water Management Institute [xviii]). These indicators have been used in the Province of Antalya, Turkey for the performance of 29 irrigation schemes [xx], 3 small-scale irrigation schemes in the Tekeze Basin [ii] and Wurno Scheme in Nigeria [xi].

Though several authors have researched into the socio-economic impact of many irrigation schemes in Northern Ghana, there is no available information on performance assessment on them. It is important that the performance of the irrigation schemes is evaluated using comparative indicators to keep track of whether or not the objectives of their construction are being achieved. This study therefore sought to assess the performance of six irrigation schemes in Northern Ghana, using selected comparative performance indicators for the years of 2010 - 2014.

2. MATERIALS AND METHODS

2.1 Description of Study Areas: The research was carried out in the Tono, Vea and Doba Irrigation Schemes in the Upper East Region and the Libga, Golinga and Bontanga Irrigation Schemes in the Northern Region of Ghana in 2015. The Tono and Doba irrigation schemes are located in the Kassena-Nankana Municipality and the Vea irrigation scheme is situated in the Bongo District of Upper East Region of Ghana [i]. The Libga, Bontanga and Golinga irrigation schemes respectively are located in the Savelugu, Kumbungu and Tolon Districts of the Northern Region of Ghana [i]. The crops grown in the schemes include rice (*Oryza sativa*), tomatoes (*Lycopersicon esculentum)* and onion (*Allium cepa*), cowpea (*Vigna unguiculata*), okra (*Hibiscus esculentus)* and roselle (*Hibiscus sabdariffa)* [i]. Characteristics of the irrigation schemes are presented in Table 1.

Table 1: Characteristics of the Irrigation Schemes

Name of Irrigation Scheme	Tono	Vea	Doba	Libga	Bontanga	Golinga
Year Constructed	1985	1980	1956	1980	1986	1976
Management	ICOUR	ICOUR	WUA	GIDA	GIDA	GIDA
Catchment Area (km^2)	650	136	0.65	165	165	124
Height of Dam wall (m)	18.59	13.4	3.9	5	12	4.5
Length of dam wall (km)	3.5	1.6	0.51	0.65	1.9	0.7
Live Storage Capacity (m^3)	83×10^6	17×10^6	170,400	597,575	20×10^6	5×10^6
Dead Storage Capacity (m^3)	10×10^6	1×10^6	-	17,407	5×10^6	149,400
Developed Irrigable Area (ha)	2490	859	7	16	495	40
Mode of Water Delivery	Gravity	Gravity	Gravity	Gravity	Gravity	Gravity

The Upper East Region is characterized by mono-modal rainy season starting between April and May and lasting until the end of September or beginning of October. Rainfall is erratic and spatially variable. Average annual rainfall ranges between 700 - 1,010 mm per year with peak rainfall occurring in late August or early September. Annual evapotranspiration is generally twice the annual precipitation and therefore, water storage reservoirs provide an important source of water supply during the dry season [xvi]; [i].

Northern Region is also characterised by one rainy season (unimodal) and total annual rainfall of about 1,000 - 1,300 mm. The rainy season is about 140 - 190 days in duration. The rainy season is from May to October in a normal year, with peak rainfall occurring in August and September. The other months (November – May) are very dry, leaving domestic and agricultural sectors to struggle for the scanty water resources available in the basin [xii]; [i].

2.2 Data Collection Methods: In this study, the approach recommended by International Programme for Technology and Research in Irrigation and Drainage for performance evaluation in irrigation and drainage sector was used [xv]; [vi]. Relevant data for performance assessment were taken from records of the irrigation schemes. The performance of the schemes for the years of 2010-2014 were assessed using the following selected comparative indicators classified into four groups namely; water delivery, physical structures, financial and crop production performance criteria.

2.2.1 Water Delivery Performance: The extent of main canal flow lengths and total irrigation water supply per hectare per season were used to assess the water delivery performance of the schemes. As given by [xi], extent of main canal flow lengths = $\frac{La}{Lt}$ x 100 %. Where: *La* - Actual total length of main canals sections still flowing (km) and *Lt* - Total length of main system canals constructed (km). Total irrigation water supply per hectare per season (m^3/ha) = $\frac{Tawd}{Ia}$ [vi]. Where: *Tawd* -Total annual water delivery (m^3) and *Ia* - Irrigated area (ha).

2.2.2 Physical Structures Performance: Physical indicators are related to the changing or losing of irrigated land in the developed area due to reasons including poor conveyance and distribution structures [xxi]. Irrigation rate (land utilization efficiency) and sustainability of irrigated area index were used to assess the physical performance of the schemes. According to [xxi], [xiii] and [vi], irrigation rate of an irrigation scheme is calculated as:

$$\text{Irrigation Rate} = \frac{Actual\ Irrigated\ area\ (ha)}{Total\ developed\ irrigable\ area\ (ha)} \times 100\ \%$$

Irrigation rate can be referred to as irrigable land utilization efficiency [iii].

Bos [v] and [xxi] defined sustainability of irrigated area index (SIAI) as:

$$SIAI = \frac{Current\ irrigated\ area\ (ha)}{Initial\ irrigated\ area\ when\ the\ scheme\ was\ fully\ completed\ (ha)} \times 100\ \%$$

2.2.3 Financial Performance: Efficiency of irrigation service charges recovery scheme and financial self-sufficiency factors and were indicators used to evaluate the financial performance of the irrigation schemes. Efficiency of irrigation

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service charges recovery (%) = $\frac{Ctaisc}{Etaisc}$ x 100 % [xi]; [xxi]. Where: *Ctaisc* - Actual total annual irrigation service charges (GHS) and *Etaisc* - Expected total annual irrigation service charges (GHS). Financial self-sufficiency factors of the schemes were computed using the equation given by [xi] and [xiii]. Financial self-sufficiency factor = $\frac{Tai}{Taome}$ x 100 %. Where: *Tai* - Total annual scheme income from water charges and diverse other revenue sources (GHS) and *Taome* - Total annual operation and maintenance expenditure of the scheme (GHS).

2.2.4 Crop Production Performance: Average irrigated area (ha) per crop and average yield (t/ha) per crop were used to evaluate the crop production performance of the schemes.

3. RESULTS AND DISCUSSION

3.1 Water Delivery Performance: Two (2) performance indicators were used, namely; extent of main canals flow lengths and estimated total irrigation water supplies per hectare per season. -Extent of Main Canals Flow Lengths: **The extent of main canals flow lengths of the irrigation schemes are presented in Table2.**

Table 2: Extent of Main Canals Flow Lengths

Scheme	Total length of main canals constructed within the scheme (km)*	Actual total length of main canals sections still flowing (km) *	Extent of main canals flow lengths (%) **
Tono	42	31.1	74
Vea	26.5	4.7	18
Doba	0.6	0	0
Libga	1.30	1.15	89
Bontanga	11.5	11.5	100
Golinga	2.3	2.3	100

(Source: * - Project Records, 2015 and ** - Desk Computation, 2015)

At Tono, the low reservoir water levels in recent times and the very poor state of the laterals have reduced the canals flow length to 74 % of the 42 km main canal. At Vea, only 18 % of the 26.5 km long main canals still flow. This was due to the breaches and siltation of the canals and laterals and, the defunct off-take valves on the left bank canal. Consequently, the fields along the canal were not cropped in the 2015. At Doba, the entire length of the main canal (0.6 km) has not being flowing since 2013 as a result of low reservoir water levels. Also, 11 % of the 1.30 km long main canal at Libga could no longer flow, mainly due to poor construction of the canal. As a result, 1 ha out of the total 16 ha developed irrigable area was left uncultivated during dry seasons since 2008.

However, the main canals and laterals of Bontanga and Golinga schemes were in good state and flow properly to the tail-ends, attaining 100 % flow length. This was due to the rehabilitation carried out in 2011-2012. According to [xi], the notional normal value for extent of main canals flow length is 100 %. However, the author reported that nearly half (45 %) of the total length of the main canals of the Wurno Irrigation Scheme in Nigeria could no longer flow due to breaches and siltation of the canals network.

-Estimated Total Irrigation Water Supply per Irrigated Area per Season: The estimated total irrigation water supplies per hectare per season for the irrigation schemes for 2010 – 2014 are presented in Table 3.

Table 3: Estimated Total Irrigation Water Supply per Irrigated Area per Season (m^3 /ha)

Total Irrigation Water Supply per Irrigated Area per Season (m^3 /ha)					
Year	2010	2011	2012	2013	2014
Tono	28,551	27,696	27,360	31,697	29,231
Vea	94,194	94,507	97,907	96,400	95,355
Doba	-	-	-	-	-
Libga	21,333	19,333	25,333	18,000	14,667
Bontanga	37,767	29,643	29,363	36,102	34,655
Golinga	35,500	38,519	32,500	39,000	37,760

(Source: Desk Computation, 2015)

At Tono, Vea and Bontanga irrigation schemes, total irrigation water supplies of 27,360 - 31,697 m^3/ha, 94,194 - 97,907 m^3/ha and 29,363 - 37,767 m^3/ha were respectively recorded. Common crops cultivated in these schemes include rice, onion, tomatoes, pepper and okra. Kuscu *et al*. [xiii] reported that in the tropics, when total irrigation water supply in a range of 24,440 – 93,980 m^3/ha is diverted to fields where the predominant crops are rice and tomatoes, it indicates that sufficient amount of water was supplied to the irrigable area. Therefore, the results obtained for the Tono and Bontanga irrigation schemes were within the range except Vea which exceeded the range of [xiii] indicating that excess amount of water was delivered to the irrigable area which could lead to waterlogging. This might be attributed to the poor state of the canals and laterals, because of seepage more water was delivered to enable it reach the tail-end farmers.

As presented in Table 3, the estimated total irrigation water supply per irrigated area recorded for the Libga irrigation scheme was in a range of 14,667 - 25,333 m^3/ha while Golinga scheme recorded 32,500 – 39,000 m^3/ha. Roselle and vegetable jute are the major crops grown in the schemes. According to [vi], a water delivery of 8,586 -13,611 m^3/ha is ideal for vegetable production on irrigation schemes which experience high evapotranspiration with soil conditions being silty loam or sandy loam. However, the results from the study indicate that excess

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amount of water was delivered to the irrigable areas of the schemes thus causing waterlogging conditions in some parts of the irrigable areas. This might be attributed to poor water control by farmers and management of the schemes. At Doba, the total irrigation water supply per irrigated area could not be determined as there was no irrigation due to low reservoir water level. Also, there were no available records on the dam's water delivery.

3.2 Physical Structures Performance

Two (2) performance indicators were used to assess the physical structures performance, namely irrigation rate and sustainability of irrigated area index.

-Irrigation Rate: Also referred to as irrigable land utilisation efficiency is the relationship of the actual irrigated area and the total developed irrigable area. The results of irrigation rates for the various schemes are presented in Table 4.Table 4: Irrigation Rates

Indicator	Irrigated Area (ha) *					DIA (ha)*	Irrigation Rate (%) **				
Year	2010	2011	2012	2013	2014		2010	2011	2012	2013	2014
Tono	1325	1189	1341	1302	637	2490	53	48	54	52	26
Vea	124	71	86	100	155	850	15	8	10	12	18
Doba	2.5	1.5	2	1.5	0	7	36	21	29	21	0
Libga	15	15	15	15	15	16	94	94	94	94	94
Bontanga	412	420	424	431	449	495	83	85	86	87	91
Golinga	20	27	32	40	40	40	50	58	63	100	100

DIA - Developed Irrigable Area

(Source: ***** - Project Records, 2015 and ****** - Desk Computation, 2015)

Tono Irrigation scheme: The irrigation rates for the scheme were found to be in a range of 26 – 54 % during the years of 2010 – 2014. The rates recorded in 2010, 2012 and 2013 suggest that barely half of the scheme's developed irrigable area was irrigated each year, whereas the rates recorded in 2011 and 2014 indicate that considerably less than half of the developed area were irrigated in those years. These lower rates of irrigation were attributed to the poor state of the laterals, low reservoir water levels and reduced flow lengths of the canals. These rates are similar to the results obtained by [vi] which ranged from 44 – 55 % in the Asartepe Irrigation Scheme for the period of 2001 - 2004.

Vea Irrigation Scheme: The irrigation rates for the scheme for the period of 2010 - 2014 were found to be very low in a range of 8 – 18 % as in Table 4.

These low irrigation rates were caused by:

- Defunct off-take valves of the left bank canal,
- Breached, weedy and silted canals and laterals,
- Waterlogging of irrigable area due to spillage from canals and laterals,
- Reduced main canals flow lengths and,
- Abandonment of irrigation by farmers due to high irrigation service charges and high prices of farm inputs.

Doba Irrigation Scheme: The calculated irrigation rates for the scheme over the past five years (2010 -2014) were also significantly lower ranging from 0 – 36 %. There was no irrigated farming in 2014 due to low reservoir water level. The broken canals and laterals as a result of lack of maintenance and repairs over the years also contributed to the low irrigation rates. Sener *et al.* [xxi] recorded irrigation rates which ranged from 15.77 - 54.47 % in the Hayrabolu Irrigation Scheme for a period of 13 years (1989 - 2001). The reasons cited for the low irrigation rates recorded on the schemes included low interest of farmers and poor state of irrigation infrastructure.

Libga, Bontanga and Golinga Schemes: From 2010 – 2014, the average irrigation rates recorded by the Libga, Bontanga and Golinga schemes respectively were found to be 94 %, 86.4 % and 74.2 %. The rates indicated that the schemes were performing better than the others earlier mentioned when compared to the notional normal value for irrigation rate (90 – 100 %) as given by [xi].

-Sustainability of Irrigated Area Index (SIAI): This is the relationship between the current irrigated area and the initial irrigated area when the scheme was first fully developed. Table 5 presents the sustainability of irrigated area indices (SIAI) for the schemes. Table 5: Sustainability of Irrigated Area Index

Scheme	Irrigated Area (ha) in 2014*	Initial Irrigated Area (ha) After Completion*	Sustainability of Irrigated Area Index (%) **
Tono	637	1293	49
Vea	155	594	26
Doba	0	7	0
Libga	15	16	94
Bontanga	449	471	95
Golinga	40	40	100

(Source: * - Project Records, 2015 and ** - Desk Computation, 2015)

The SIAI were found to be low at Tono (49 %) and Vea (26 %). The causes of the low level of SIAI at Tono include reduced flow lengths of main canals due to the low reservoir water levels and poor condition of laterals, and environmental problems of waterlogging and erosion. At Vea, the very poor SIAI recorded have been attributed to the severely breached and silted canals and laterals, defunct off-take valves and the drastically reduced flow lengths of main canals. The Doba irrigation scheme recorded zero index as a result of non-cropping of the irrigable area due to the low reservoir water level in 2014.

However, the Libga, Bontanga and Golinga schemes respectively recorded high index of 94 %, 95 % and 100 %. This indicates that the schemes have sustainable irrigated area since the indices are within the ideal range of 90 – 100 % [xi]. The Libga, Bontanga and Golinga Schemes recorded high

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sustainability indices because the demand for plot for irrigation among the farmers on the schemes is very high. There is too much pressure on the small developed irrigable areas on the schemes. Sener *et al.* [xxi] reported an average sustainable irrigated area of 97 % for irrigation schemes in Turkey. Ijir [xi] recorded 85 % sustainability of irrigated area for Wurno Irrigation Scheme in Nigeria.

3.3 Economic Performance

The economic performance of the schemes was assessed using the indicators of efficiency of irrigation service recovery and financial self-sufficiency rate.

-Efficiency of Irrigation Service Recovery: The efficiency of irrigation service charges recovery (EISCR) refers to the proportion of irrigation service charges collected out of the total expected amount. The EISCR of the schemes are shown in Table 6.

Table 6: Efficiency of Irrigation Service Charges Recovery (%)

	Expected Total Annual Irrigation Service Charges (GHS) – a*				
Year	2010	2011	2012	2013	2014
Tono	85,141	80,775	68,084	50,766	74,491
Vea	9,355	5,525	6,610	9,420	14,450
Doba	108	53	73	53	-
Libga	1,125	1,125	1,125	2,250	2,250
Bontanga	10,300	10,500	10,590	43,103	44,861
Golinga	1,500	2,025	2,400	5,850	5,850
Actual Total Annual Irrigation Service Charges (GHS) – b*					
Year	2010	2011	2012	2013	2014
Tono	79,266	70,506	55,148	41,628	55,868
Vea	4,400	1,099	2,020	2,600	2,720
Doba	100	51	65	49	-
Libga	394	461	416	540	720
Bontanga	2,480	3,200	5,493	9,879	12,326
Golinga	215	1,649	1,928	4,933	4,640
Efficiency of Irrigation Service Charges Recovery (%), (') x 100 % **					
Year	2010	2011	2012	2013	2014
Tono	93	87	81	82	75
Vea	47	20	31	28	19
Doba	93	96	89	92	-
Libga	35	41	37	24	32
Bontanga	24	30	52	23	27
Golinga	14	81	80	84	79

(Source: * – Project Records, 2015 and ** – Desk Computation, 2015)

Irrigation Service Charges (ISC): The irrigation service charges at the Tono, Vea, Libga, Bontanga and Golinga schemes in 2010 – 2012 were GHS 75 per ha and GHS 100 per ha in 2013 – 2014. The ISC for all the public irrigation schemes in the country which deliver water by gravity was the same per hectare. The ISC at the Doba scheme was GH¢ 2.50 per 0.06 ha in 2010 - 2014. The Doba irrigation scheme is operated by WUA.

Tono and Doba Schemes: The EISCR for the Tono and Doba schemes respectively were found to be between 75 – 93 % and 89 – 96 % during the years of 2010 – 2014. These recovery rates are said to be satisfactory when compared to other schemes either managed by Government or by Water Users Association (WUA) worldwide. The high rates recorded at Doba could be attributed to the lower irrigation service charges per year. Based on the irrigated area each year, the expected total irrigation service charged for 2014 was GHS 90, but due to low reservoir water level, there was no irrigation. According to [xi], the notional normal value for irrigation service charges recovery is between 90 – 100 % of the expected total irrigation service charges for the season or year. Yercan *et al.* [xxiii] recorded recovery rates of 90 – 98 % for eight irrigation schemes in Gediz River Basin in Western Turkey.

Vea Irrigation Scheme: During the years of 2010 – 2014, the EISCR recorded by the scheme were found to be in a range of 19 – 47 %. These recovery rates were very poor since less than half of the expected total irrigation service charges were recovered. The poor recovery rates have been attributed to the poor attitude of farmers towards payment of irrigation charges due to the poor state of the canals and laterals leading to non-regulatory delivery of water to fields. Most of the farmers lift water with pumps from the main drain for irrigation. These farmers normally refused to pay the irrigation charges with the excuse that they were not using water from the canals and laterals. Administrative corruption was another cause of the low recovery rates, as the study revealed that some of the service charges collected from farmers were not recorded by management. The expected and actual irrigation services for the periods of 2010 – 2014 are presented in Table 6. The low amount collected out of the expected amount resulted to the poor recovery efficiency. Sayin *et al.* [xx] determined the mean irrigation service charge rate of 29 irrigation schemes in Antalya in Turkey as 62.7 %.

Libga and Bontanga Irrigation Schemes: The EISCR for the Libga and Bontanga Schemes respectively were also found to be in a range of 24 – 41 % and 23 – 52 % for the period of 2010 - 2014, which can be said to be at unsatisfactory levels when compared with the average values for Tono and Doba. Sener *et al.* [xxi] recorded recovery rates in the range of 5.6 – 61.1 % for the Hayrabolu irrigation scheme in Turkey.

Some of the reasons for the low recovery rates in the study schemes include:

- Poor attitude of farmers towards payment of irrigation charges due to the permanent field allocation to farmers in the schemes,
- No penalties for farmers who default in the payment of irrigation service charges,
- Administrative corruption. The study revealed that some of the collected irrigation service charges are not declared by management.

Golinga Irrigation Scheme**:** The scheme recorded 14 – 84 % recovery rates over the five years period. As presented in

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Table 6, the recovery rate were very low (14 %) in 2010 because of low reservoir water level. However, during and after the rehabilitation in 2011 – 2012, the recovery rates increased to 80 – 84 %. These rates indicated satisfactory performance though slightly fell below the notional normal value for irrigation service charges recovery of 90 – 100 % [xi]. Ijir [xi] recorded 80 % recovery rate for the Wurno Irrigation Scheme in Nigeria.

-Financial Self-Sufficiency Rates (FSSRs): This is an index which relates to the ability of a scheme to sustain itself financially with respect to regular management, operation and maintenance expenditures. The financial self- sufficiencies of the schemes between the periods of 2010 - 2014 are presented in Table 7. This indicator was calculated based on the annual income from water charges and other revenue sources and total annual management, operation and maintenance expenditures of the scheme (major rehabilitation costs not included but Government subsidies in the form of staff salaries included).

Table 7: Financial Self-Sufficiency Rates (%) of the Irrigation Schemes

Total Annual Income from Water Charges and other Revenue Sources (GHS) *					
Year	2010	2011	2012	2013	2014
Tono	79,266	70,506	55,148	41,628	74,491
Vea	4,400	1,099	2,020	2,600	2,720
Doba	100	51	65	49	-
Libga	114	133	120	4,544	5,592
Bontanga	4,591	5,311	7,604	11,793	14,240
Golinga	215	1,649	1,928	4,933	4,640
Total Annual MOM Costs of the Irrigation Scheme (GHS) *					
Year	2010	2011	2012	2013	2014
Tono	133,610	129,320	160,161	150,021	185,708
Vea	41,040	40,120	60,600	61,000	66,080
Doba	180	150	160	145	-
Libga	6,101	6,106	9,081	10,187	10,899
Bontanga	21,390	20,190	30,269	35,000	37,360
Golinga	6,215	6,575	9,632	10,307	10,927
Financial Self-Sufficiency Rate (%) **					
Year	2010	2011	2012	2013	2014
Tono	59	55	34	28	40
Vea	10.7	2.7	3.3	4.3	4.1
Doba	55.6	34	40.6	33.8	-
Libga	1.9	2.2	1.3	45	51
Bontanga	21	26	25	34	38
Golinga	3	25	20	48	42

MOM – Management, Operation and Maintenance
(Source: * – Project Records, 2015 and ** – Desk Computation, 2015)

Tono Irrigation Scheme: The FSSRs for the scheme were found to be in a range of 28 – 59 %. The study revealed that from year 2010 - 2014, an average of 43 % of the scheme's management, operation and maintenance costs were generated internally while the 57 % was covered by the GoG. The scheme is under government subvention and all salaries of staff are paid by the Government. The lowest FSSR was recorded in 2013 with 28 % whereas the highest was recorded in 2010 with 59 %. These rates recorded by the Tono scheme indicate that the scheme cannot attain financial self- sufficiency if the cost recovery rates remained low as recorded in previous years. According to [xi], an irrigation scheme is financially self-sufficient if it records financial self-sufficiency rates of 100 % or more (> or = 100 %). The author determined the financial self-sufficiency rate of the Wurno Scheme in Nigeria as 40 %.

Vea Irrigation Scheme: The FSSRs for the scheme were found to be very poor in a range of 2.7 - 10.7 %. The low efficiency of irrigation services charges recovery recorded for the periods of 2010 – 2014 resulted to these low rates. The study revealed that for the five years period, an average of 5 % of the scheme's management, operation and maintenance costs were generated internally while 95 % was covered by the GoG. The scheme is also under government subvention and all salaries of staff are paid by the Government. Beyribey [iv] determined financial self-sufficiency rates of state operated irrigation schemes in Turkey to be in a range of 21 – 91 %.

Doba Irrigation Scheme: This scheme which is being managed by WUA recorded low FSSRs of 33.8 – 55.6 %. These rates clearly indicate that the scheme is not financially self-sufficient. The internally generated revenue through irrigation service charges could only cover 30 – 50 % of its annual management, operation and maintenance expenditures. The irrigation service charge of GHS 2.50 per plot (0.06 ha) is too small to make the scheme financially self-sufficient. Apart from the irrigation service charges, the scheme has no other sources of generating revenue. Ijir [xi] reported that an irrigation service charge is the only source of revenue to the sustainability of the schemes of most WUA operated schemes. Molden *et al.* [xviii] determined the financial sufficiency rates of 18 irrigation schemes located in 11 different countries in Africa as 100 – 139 % for the WUA operated irrigation schemes and 28 – 50 % for the state operated irrigation schemes.

Libga Irrigation Scheme: The scheme also recorded low FSSRs of 1.3 – 51 %. The study revealed that an average of 20 % of the scheme's management, operation and maintenance costs was generated internally during the period of 2010 - 2014 while the 80 % was covered by the GoG. The salary of the Scheme Manager is paid by the GoG while the allowances of the water bailiff are paid from the irrigation service charges collected. The low irrigation service charges recovery rates recorded each year was the cause of the low FSSRs of the scheme. Sener *et al.* [xxi] determined the Hayrabolu Irrigation Scheme's financial self-sufficiency to be in a range of 6 - 179 % in the period of 1989 - 2001. Sayin *et al.* [xx] determined the mean FSSR of 29 irrigation schemes in Antalya in Turkey as 82.2 %.

Bontanga Irrigation Scheme: The scheme recorded low FSSRs of 21 – 38 %. The study revealed that an average of 29 % of the scheme's management, operation and maintenance costs was generated internally during the period of 2010 - 2014 while the 71 % was covered by the GoG. All permanent staff on the scheme are paid by the Government. However, allowances of the two water bailiffs are paid from the irrigation service charges collected. For the scheme to attain high FSSRs, the service recovery rates have to be improved. In a study conducted in the Karacabey irrigation network, [xiii] found an average financial sufficiency rate of 94 % for the period between 2002 and 2007. Yercan *et al.* [xxiii] determined FSSRs as between 100 – 260 %

for eight irrigation schemes in Gediz River Basin in Western Turkey.

Golinga Irrigation Scheme: The scheme recorded low FSSRs of 3 – 48 % over the five (5) years period. It was revealed that an average of 21 % of the scheme's management, operation and maintenance costs was generated internally during the years of 2010 - 2014 whereas the 79 % was covered by the GoG. The salary of the Scheme Manager is paid by the GoG whereas the allowances of the two (2) water bailiffs are paid from the collected irrigation service charges. Cakmak *et al.* [vi] recorded FSSRs of 52 – 170 % for the Asartepe Irrigation Scheme in the period of 2001 - 2004.

3.4 Crop Production Performance

-Rice Production: The study revealed that Tono, Bontanga and Vea irrigation schemes produce rice in a larger scale as more than 50 % of the total irrigated area of each of these schemes is used for rice production from 2010 - 2014. The average irrigated area of 1,045 ha, 306.6 ha and 59 ha respectively was used for rice production in the Tono, Bontanga and Vea irrigation schemes. The mean yield of 4.5 t/ha was recorded at Tono, 4.2 t/ha at Bontanga and 4.0 t/ha at Vea. The average yields on the three (3) schemes are significantly higher than the average yield of rice in Ghana which was estimated to be 2.5 t/ha [xvii]. However, the Libga and Golinga schemes which cultivated the crop in a smaller scale over the five (5) years period attained lower average yields of 2.1 t/ha and 1.9 t/ha respectively. The major challenge faced by farmers in the Libga and Golinga schemes in the production of rice was the high costs of fertilizers and agro-chemicals and so they were not able to apply the recommended rates to attained optimum yields per unit area.

-Vegetable Production: The study revealed that tomato production in the schemes has drastically declined as four (4) out of the six (6) schemes namely; Doba, Libga, Bontanga and Golinga had not cultivated the crop since 2010 – 2014. Though, Tono and Vea schemes produced tomatoes, the average irrigated area for the crop over the five years period under review was 43.9 ha and 43 ha respectively. The average yield of 6.2 t/ha and 4.2 t/ha respectively for the Tono and Vea schemes is far below the annual average yield in Ghana of 15 t/ha [xvii]. The yield gap of 59 -72 % is quite huge.

For okra, the Vea and Doba schemes had not cultivated the crop since 2010 – 2014, but all the other schemes had cultivated it in smaller scale in a range of 0.5 – 52 ha. The average yield range was 2.5 – 8.3 t/ha. For onion, the production has declined drastically as only Tono and Bontanga schemes cultivated the crop in 2010 – 2014. Average area cropped in the Tono scheme was 4 ha while the area cropped at Bontanga scheme was 19 ha.

For pepper, the average area cropped in the Tono scheme in 2010 – 2014 was 45 ha while that of Bontanga scheme was 37.4 ha. It was not grown in the Vea and Doba schemes. Libga and Golinga schemes cultivated the crop on an area of 0.5 ha and 0.2 ha respectively. This clearly indicated that pepper production on the schemes has drastically declined.

-Roselle and Vegetable Jute Production: The study revealed that only farmers in the Libga and Golinga irrigation schemes undertake production of roselle (*Hibiscus sabdariffa*) and vegetable jute (*Corchorus olitorius*) for both domestic and commercial purposes. In the Libga irrigation scheme, the average irrigated area under roselle cultivation was 7.2 ha while that of vegetable jute was 3 ha. The yields range of roselle was from 45.3 – 60.04 t/ha while vegetable jute was from 3.8 – 4.2 t/ha/season. In the Golinga irrigation scheme, the average irrigated area under roselle cultivation was 7.8 ha while that of vegetable jute was 3.4 ha. The yields range of roselle was from 43.5 – 58.0 t/ha where vegetable jute was from 3.2 – 3.7t/ha/season.

Some of the reasons cited by farmers and management of the schemes for the reduction in cropped areas and yields of tomato, okra, onion and pepper on the schemes include:

- Farmers inability to apply recommended rates of agro-chemicals and fertilizers due to high cost,
- Pests and diseases infestation especially nematodes,
- Poor market resulting in low price due to Market queens preferences,
- Poor state of irrigation facilities such as canals, laterals and offtake valves,
- Low reservoir water levels due to poor rainfall regime,
- Low levels of soil fertility at the irrigable areas due to continuous cropping and,
- Salinity and sodicity problems at Libga Scheme

4. CONCLUSIONS

The study revealed that the developed irrigable areas in the Tono, Vea and Doba irrigation schemes were under-utilised with irrigation rates ranging from 8 – 54 % while that of Libga, Bontanga and Golinga irrigation schemes were put to full capacity use with irrigation rates ranging from 91 – 100 %. Irrigation service charges recovery were poor in the Vea, Libga and Bontanga irrigation schemes with rates ranging from 19 – 52 % whereas the recovery was good in the Tono, Doba and Golinga irrigation schemes with rates ranging from 75 – 96 %. All the irrigation schemes were not financially self-sufficient due to the low irrigation service charges as well as the poor ISC recovery rates recorded annually. Considering sustainability of irrigated area index, the Doba, Vea and Tono irrigation schemes performed poorly with indices of 0 – 49 % whereas the Libga, Bontanga and Golinga have high sustainable irrigated area index of 95 - 100 %. The flow lengths of the main canals at the Tono, Vea, Doba and Libga irrigation schemes had reduced due to low reservoir water levels and infrastructural deficiencies. The production levels of cereals and vegetables in the schemes had declined both in area cropped and yield due to poor state of irrigation facilities, high prices of agro-chemicals, poor market, nematodes infestation and low interest by farmers.

Landholding per farmer in the Tono, Vea and Bontanga schemes ranged from 0.2 – 1 ha while that of Libga and Golinga schemes ranged from 0.1 – 0.4 ha due to the small developed irrigable area. The average landholding per farmer in the Doba scheme was 0.06 ha due to the very small irrigable area (7 ha).

Payment of irrigation service charges (ISC) before cropping should be adopted by the management of the irrigation schemes to improve recovery rates. Penalties for non-payment of ISC should be applied on defaulters. Annual adjustment of irrigation service charges have been recommended to meet cost recovery. Public-Private Partnership (PPP) management of the irrigation schemes have been recommended to ensure proper management and good performance.

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