

Performance of Irrigation Water Delivery Structures in Six Schemes of Northern Ghana

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Abstract

The study assessed the performance and state of irrigation water delivery structures in six (6) irrigation schemes of Northern Ghana. The schemes were Tono, Ve, Doba Libga, Bontanga and Golinga in the Upper East and Northern Regions. Data was collected using interviews, physical structures, performance indicators, field observation and field measurements. The results of the study revealed that all the irrigation schemes except the Bontanga and Golinga are infrastructurally deficient with poor structure indices ranging from 30 – 96 %. The main canals in the Tono, Bontanga and Golinga irrigation schemes are in good working condition whereas that of Ve, Doba and Libga are in poor working condition due to lack of maintenance. The laterals in the Bontanga and Golinga irrigation schemes are in good working condition while the laterals in the Tono, Ve, Doba and Libga irrigation schemes are in poor condition. The off-take valves at Ve irrigation scheme are in poor working condition. Periodic maintenance of the water delivery infrastructure in the irrigation schemes is recommended to ensure irrigation water delivery for crop cultivation.

Keywords: *Performance, Irrigation, water delivery, structures*

I. INTRODUCTION

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 [1]. Various studies have shown that irrigation schemes improve food security and livelihoods of rural farmers in Africa [2], [3], [4]. However, despite their important role in improving livelihoods of rural communities in Africa, irrigation schemes have had low performance to infrastructural deficiencies [5], [6].

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 [7]. However, the twenty-two (22) public irrigation schemes which are being managed by Ghana Irrigation Development Authority (GIDA) and Irrigation Company of Upper Regions (ICOUR) and the numerous small reservoir schemes which are managed by Water Users Associations (WUAs) are battling with infrastructural problems and therefore cannot perform to their

fullest potentials, despite their promise as engines of agricultural growth [8], [9].

Irrigation water delivery structures involve structures for water control, conveyance and distribution which include valves, canals and laterals respectively [10]. An irrigation canal is a waterway, often man-made or enhanced, built for the purpose of carrying water from a source such as a dam, lake or river to irrigable lands for farming. For all gravity irrigation schemes the canals and laterals must have positive and adequate command to ensure desired flow of water onto irrigable areas. Breached canals and laterals have inadequate command and would prevent or severely curtail the transfer of water onto irrigable areas [11]. Majority of the irrigation schemes in Ghana deliver water for irrigation by gravity [9].

Adequate water may be available in the reservoir of an irrigation dam but cannot be effectively distributed around the scheme's irrigable area due to lack of inadequate canal capacities, defunct off-take valves and breached, weedy and silted canals and laterals, making it practically impossible for water to reach the tail-end areas [12]. Faulty construction, poor maintenance and farmers' ignorance of the use of certain structures are the major causes of the poor working condition of irrigation water delivery structures in irrigation schemes in Africa [11].

The study assessed the performance and state of irrigation water delivery structures in six (6) irrigation schemes of Northern Ghana.

II. MATERIALS AND METHODS

A. Description of Study Areas

The study was carried out in the Tono, Ve and Doba Irrigation Schemes in the Upper East Region and the Libga, Golinga and Bontanga Irrigation Schemes in the Northern Region of Ghana in January and February, 2015. The Tono and Doba irrigation schemes are located in the Kassena-Nankana Municipality and the Ve irrigation scheme is situated in the Bongo District of Upper East Region of Ghana [13]. The Libga, Bontanga and Golinga irrigation schemes respectively are located in the Savelugu, Kumbungu and Tolon Districts of the Northern Region of Ghana [13]. The crops grown in the schemes include rice (*Oryza sativa*), tomatoes (*Lycopersicon esculentus*) and onion (*Allium cepa*), cowpea (*Vigna unguiculata*), okra (*Hibiscus esculentus*) and roselle

(*Hibiscus sabdariffa*) [13]. Principal characteristics of the irrigation schemes are presented in Table 1.

Table 1: Principal Characteristics of the Irrigation Schemes

Name of Scheme	Year of Construction	Developed Irrigable Area (ha)	Mode of Water Delivery	No. of Off-take Valves	No. of Main Canals	Total Length of Main Canals (km)	No. of Laterals
Tono	1985	2,490	Gravity	2	2	42	82
Vea	1980	859	Gravity	5	2	26.5	60
Doba	1956	7	Gravity	1	1	0.6	10
Libga	1980	16	Gravity	1	1	1.3	8
Bontanga	1986	495	Gravity	2	2	11.5	28
Golinga	1976	40	Gravity	2	2	2.3	12

B. Data Collection Materials and Methods

Geographical Positioning System (GPS) and tape measure were materials used for the data collection. Interviews, poor structure index indicator, field observation and measurements were methods used for the study. Visual assessments were made of the conditions of physical structures (canals, laterals, control structures, intake structures, weeds, sediments, and seepage), farmers' operations and irrigation practices with relevant photographs taken and presented in this work. The volume of sediments in the main canals of each scheme

was estimated using the profile method.

III. RESULTS AND DISCUSSION

A. Poor Structure Index (PSI)

Poor structure index describes the percentage of the total number of conveyance, regulatory and flow measuring structures installed within the scheme that are in a poor state, thus not functioning, not functioning properly or at the risk of failure [14]. The poor structure indices of the schemes are presented in Table 2.

Table 2: Poor Structure Index of the Irrigation Schemes

Scheme	No. of Structures*			Total No. of C, R, Fm Structures*	No. in Good Condition*	No. in Poor Condition*	Poor Structure Index (%) **
	C	R	Fm				
Tono	84	107	1	195	105	90	46
Vea	62	75	2	139	18	121	87
Doba	11	14	0	25	1	24	96
Libga	9	18	0	27	19	8	30
Bontanga	16	80	2	98	95	3	3
Golinga	14	24	0	38	37	1	3

Where: C – Conveyance Structures (Canals and Laterals), R – Regulatory Structures (Check structures and lateral gates) and Fm - Flow measurement structures (Parshal flumes and cut throat) (Source: * - Project Records, 2015 and ** - Desk Computation, 2015)

Tono Irrigation Scheme: The scheme recorded PSI of 46 % which strongly reveals that the conditions of the structures of the scheme are in very poor working condition when compared to the recommended value (0 %) as given by [14]. The conveyance structures that are in a very poor condition are the laterals. The scheme has 82 laterals of which 75 are severely breached; all the

concrete slabs and linings are removed (Plate 1). The buried lateral pipes are also exposed and broken (Plate 2). The regulatory structures that are in poor working condition are the lateral gates. A total of 93 lateral gates were installed on the right and left bank canals of which 15 are not functioning due to detached stem from plates and worn out angle-iron (Plate 3).



Plate 1: Conditions of Laterals in Tono Irrigation Scheme



Plate 2: Exposed and Broken Lateral Pipes in Tono Scheme



Plate 3: Broken Lateral Gates in Tono Irrigation Scheme

Vea Irrigation Scheme: The scheme recorded 87 % poor structure index, which clearly indicates the conveyance, regulatory and flow measuring structures of the scheme are in poor condition. The two main canals are weedy, silted and severely breached at several sections (Plate 4), 4 out of the 5 off-take valves are defunct, all the 60 concrete lined laterals are broken, and 54 out of the 70 lateral gates are broken. Farmers find it very difficult to

regulate flow into their fields. They resort to the use of stones, grasses, sand bags or mud as lateral gates to regulate flow in their fields thus leading to low performance. In a similar study, [11] reported that 89 % of the structures of the Wuruno Irrigation Scheme in Nigeria were in poor conditions and therefore operating ineffectively.



Plate 4: Conditions of Main Canals in Vea Irrigation Scheme

Doba Irrigation Scheme: The scheme has the highest poor structure index (96 %) as presented in Table 2. This indicates that almost all the structures of the scheme are in poor working condition. It is only the offtake valve which is functioning properly. All the 10 concrete lined laterals are broken. 0.35 km of the 0.6 km long concrete lined canal is severely breached with all lateral gates and check structures removed.





Libga Irrigation Scheme: About 30 % of the scheme's conveyance and regulatory structures are in poor working condition. Portions of the canal and the laterals are breached and silted. Water cannot flow to the tail-end, due to faulty construction.



Bontanga and Golinga Irrigation Schemes: The Bontanga and Golinga schemes have recorded the lowest PSI values of 3 % and 1 % respectively. This means that 97 % and 99 % of the conveyance and regulatory structures of the Bontanga and Golinga schemes respectively are in good working condition. Therefore, in terms of structure condition index, the performances of these two schemes are better than the Tono, Vea, Doba and Libga irrigation schemes. This is as a result of the rehabilitation of the two schemes in 2011 - 2012 by the Millennium Development Authority (MiDA). In a similar study, [15] reported that the poor structure index of most irrigation schemes in United States of America fall within the range of < 1 to 20 %.

B. Main Canals of the Irrigation Schemes

The present condition of the main canals of the study irrigation schemes are presented in Table 3

Table 3: Present Condition of Main Canals


Scheme	Main Canals	Present Condition
Tono		<ol style="list-style-type: none"> 1. The 42 km long main canals have no breaches 2. It was rehabilitated in 2008, where the two (2) canals were relined with concrete 3. The canals have not been desilted since 2012. The average sediments depth was estimated to be 0.32 m 4. Estimated average volume of sediments was 17,220 m³
Veal		<ol style="list-style-type: none"> 1. The two main canals, with a total length of 26.5 km long had breached at several sections, silted and full of weeds and shrubs 2. The average depth of sediments in the canals was estimated to be 0.47 m 3. The estimated average volume of sediments (silt) in the canals was 20.670 m³
Doba		<ol style="list-style-type: none"> 1. The 0.6 km long canal had breached at several sections due to animal crossing, improper practices of farmers such as removal of slabs and water erosion 2. The average depth of sediments in the canal was estimated to be 0.15 m 3. Average volume of sediments was estimated to be 24 m³
Libga		<ol style="list-style-type: none"> 1. The 1.3 km long main canal is in a poor working condition 2. It has several cracks and displaced slabs at some sections 3. It is silted, weedy and contains considerable amounts of shrubs 4. The flow length of the canal now stands at 1.15 km due to faulty construction

Bontanga		<ol style="list-style-type: none"> 1. The 11.5 km long canals are in good working condition 2. No breaches, sediments and weeds were found in the canals 3. The canals were rehabilitated in 2011 – 2012 by MiDA
Golinga		<ol style="list-style-type: none"> 1. The 2.3 km long canals are in good working condition 2. No breaches, sediments and weeds were found in the canals 3. The canals were rehabilitated in 2011 – 2012 by MiDA

C. Laterals of the Irrigation Schemes

The present condition of the laterals of the study irrigation schemes are presented in Table 4.

Table 4: Present Condition of Laterals

Scheme	Laterals	Present Condition
Tono		<ol style="list-style-type: none"> 1. The 82 laterals with a total length of 56 km are in poor working condition 2. They have never been rehabilitated since construction was completed in 1985 3. The concrete slabs are displaced at several sections and control gates broken 4. The present condition of the laterals results in waste of irrigation water through seepage

Veal



1. The 60 laterals are in poor working condition
2. They have never been rehabilitated since construction was completed in 1980
3. All the laterals have their concrete slabs, check structures and control gates removed
4. The present condition results in waste of irrigation water through seepage

Doba



1. All the 10 laterals on the scheme are silted-up beyond recognition
2. All the lateral gates are removed
3. The arrow shows the position of a silted lateral

Libga



1. The 8 laterals are in poor working condition
2. Each lateral has breached at several sections despite the rehabilitation in 2008
3. Two (2) of the laterals at the tail-end are presently not functioning due to faulty construction of the main canal
4. The present condition results in seepage and waterlogging in the scheme

Bontanga



1. The 28 laterals are in good working condition
2. There are no breaches and they are free of sediments and weeds
3. They were rehabilitated in 2011 – 2012 by MiDA
4. The check structures are working properly

Golinga



1. All the 12 laterals are in good working condition.
2. No cracks, sediments and weeds
3. They were rehabilitated in 2011 – 2012 by MiDA
4. Some lateral and check structure gates are absent

D. Off-take Valves in the Irrigation Schemes

Tono Irrigation Scheme: The five (5) valves - 3 scour tower and 2 off-take valves installed at the headworks of the scheme are in good working condition. The 3 scour tower valves are emergency valves which discharge water at $11.2 \text{ m}^3/\text{s}$. The 2 off-take valves discharge water at $3.7 \text{ m}^3/\text{s}$. Maintenance works on the valves are carried out on monthly basis.

Vea Irrigation Scheme: Four (4) out of the five (5) valves installed at the headworks are not functioning due to technical problems. Presently, only one valve on the right bank canal is functioning. It discharges water at $1.26 \text{ m}^3/\text{s}$. As illustrated in Plate 5, the two (2) valves which were installed to discharge water at $1.07 \text{ m}^3/\text{s}$ on the left bank canal are defunct; hence no irrigation was carried out



Plate 5: Defunct Off-take Valves in Vea

on the left bank canal irrigable area in 2015. The two (2) walkways to the off-take valves in the reservoir are in dilapidated condition (Plate 6).

Doba, Libga, Bontanga and Golinga Irrigation Schemes: The off-take valves in these schemes are all in good working condition. The Doba scheme has one valve on the main canal, which discharges water at $0.15 \text{ m}^3/\text{s}$ whilst the Libga scheme has one valve on the main canal discharging water at $0.4 \text{ m}^3/\text{s}$. The Bontanga scheme has two valves; one on the right bank canal and one on the left bank canal, each valves discharge water at $1.5 \text{ m}^3/\text{s}$. The Golinga scheme also has two valves; one on the right bank canal and one on the left bank canal. The right bank canal valve has a discharge of $0.2 \text{ m}^3/\text{s}$ whereas the left bank canal valve discharges water at $0.3 \text{ m}^3/\text{s}$.



Plate 6: Condition of Walk-Way to Off-take Valves in Vea

E. Farmers Views on Existing Conditions in the Irrigation Schemes

The farmers in the schemes, especially the Vea and Tono irrigation schemes responded to the above-mentioned issues in three ways: adaptation, improvisation and maintenance and, abandonment.

Adaptation: At Vea, as a result of the low command and breached, silted and weedy canals and laterals, farmers have resorted to lifting water from the canals and drains to their fields using watering cans, buckets or by water pumps. To tackle the severe tail-end

problems in some of the areas where the canals no longer flow, farmers lift water from the main drain using water pumps as illustrated in Plate 7. On the field level individual farmers adapt to constructing several small basins and extra field ditches to serve their plots. At Tono, as a result of the breached laterals in many areas, some farmers resort to lifting water from the canals, main and primary drains to their fields using water pumps. Reference [11] reported that the farmers in the Wurno irrigation scheme in Nigeria resorted to water lifting from main drains due to poor conditions of canals and laterals.



Plate 7: Lifting Water from Canal Using Water Pump in Veia Irrigation Scheme

Improvisation and Maintenance: Although maintenance of the main canals is regarded as the responsibility of ICOUR and GIDA, farmers often take initiatives to weed and de-silt the main and secondary canals. From interviews with farmers in the Veia irrigation scheme, this practice was common in the past when the system was in a better condition. Farmers have organised informal based on laterals, primarily for the purpose of

maintaining the system at no cost. With continued neglect by ICOUR, the problems and work-load grew beyond the farmers capabilities, so now some of the farmers have stopped cleaning the canals except the laterals. In addition, farmers improvised by using sandbags, mud, sticks and stones to temporarily repair breached canals and laterals to prevent water from spreading as shown in Plate 8.



Plate 8: Breached Canal Temporarily Repaired With Sandbags by Farmers in Veia Irrigation Scheme

As a result of a collapsed check structure in the main canal, farmers on the lateral at the Tono scheme had to improvise a check structure using sandbags, grass and stones to control water to their fields as shown in Plate 9.

At the Golinga irrigation scheme where there were no lateral check structure gates, the affected farmers had to improvise gates using stones, mud, sandbags, grass and logs to control water into their fields (Plate 10). However, the use of sandbags, mud, stones, logs and sticks as a regulatory check structure also causes sedimentation of the canals and laterals.



Plate 9: Farmers Improvising Check Structure on a Canal Using Sandbags and Stones in Tono Irrigation



Plate 10: Improvised Lateral Check Structure from Stones and Grass at Golinga Irrigation Scheme

Abandonment: The overwhelming technical problems mainly the poor condition of canals, laterals and off-take valves at Ve a and the poor condition of laterals at Tono resulted in farmers wanning interest in irrigation, culminating in the decision to abandon many parts of the scheme. Farmers who could not access water to their fields as a result of the above-mentioned problems have abandoned them during dry season to do other alternative

dry season activities and only come back to the fields in the wet season to cultivate them under rain-fed. However, the efforts of the farmers indicate that for most of them this decision is a last resort. The farmers who can afford have bought water pumps of 5.5 or 6.5 HP rating in order to continue with irrigated farming at the reservoir upstream though this practice is not allowed.

IV. CONCLUSIONS

The results of the study revealed that all the irrigation schemes except the Bontanga and Golinga are infrastructurally deficient with poor structure indices. The main canals in the Tono, Bontanga and Golinga irrigation schemes are in good working condition due to the rehabilitation whereas that of Ve a, Doba and Libga are in poor working condition due to lack of maintenance and repairs. This has greatly affected efficient conveyance of water downstream. The laterals in the Bontanga and Golinga irrigation schemes are in good working condition while the laterals in the Tono, Ve a, Doba and Libga irrigation schemes are in poor condition. This has greatly affected efficient water distribution to farmlands. The offtake valves at Ve a irrigation scheme are in poor working condition. Farmers in the irrigation schemes responded to some of the constraints and problems by adaptation, improvisation, maintenance and abandonment.

[3] Oni, S. A., Maliwichi, L. L. and Obadire, O. S. (2011). Assessing the contribution of Smallholder irrigation to household food security, in comparison to dryland farming in Vhembe district of Limpopo province, South Africa. *Africa Journal of Agric. Research*, 6(10): 2188 - 2197.

[4] Chazovachii, B. (2012). The impact of small scale irrigation schemes on rural livelihoods: The case of

Based on the findings of the study, it is recommended that the water delivery structures in the Tono, Ve a, Doba and Libga irrigation schemes should be rehabilitated and maintained periodically to ensure efficient irrigation water delivery for crop cultivation.

V. REFERENCES

- [1] Hillel, D. (1997). *Small-Scale Irrigation for Arid Zones. Principles and Options*. FAO Development Series 2. Food and Agriculture Organization of the United Nations (FAO), Rome.
- [2] You, L., Ringler, C., Nelson, G., Wood-Sichra, U., Robertson, R., Wood, S., Guo, Z., Zhu, T. and Sun, Y. (2010). *What Is the Irrigation Potential for Africa? A Combined Biophysical and Socio-economic Approach*. IFPRI Discussion Paper 00993. International Food Policy Research Institute, Washington, D.C
- Panganai Irrigation Scheme, Bikita District, Zimbabwe. *J. Sust. Dev. Afr.*, 14(4): 217 – 231.
- [5] Backeberg, G. R., Bembridge, T. J., Bennie, A. T. P., Groenewald, J. A., Hammes, P. S., Pullen, R. A. and Thompson, H. (1996). *Policy proposal for irrigated agriculture in South Africa*. WRC Report KV96/96. Water Research Commission, Pretoria.
- [6] Arcus, G. (2004). *Principle, approaches and guidelines for participatory revitalization of smallholder irrigation schemes*. Year 1 Progress Report, WRC Project No.

K5//1463/4. Arcus Gibb, East London.

[7] Kyei-Baffour, N. and Ofori, E. (2006). Irrigation development and management in Ghana: prospects and challenges. *Journal of science and technology (Ghana)* 26 (2): (2006), pp.148 - 159.

[8] Miyoshi, T. and Nagayo, N. (2006). A study of the effectiveness and problems of JICA's Technical cooperation from a capacity development perspective: Case study of support for the advancement of Ghana's irrigated agriculture. Case study report on capacity development. Tokyo, Japan Institute for International Cooperation, JICA.

[9] Namara, R., Horowitz, L., Nyamadi, B. and Barry, B. (2011). *Irrigation Development in Ghana: Past Experiences, Emerging Opportunities, and Future Directions*. GSSP Working Paper No. 0027. International Food Policy Research Institute

[10] Van den Bosch, B. E.; Snellen, W. B., Brouwer, C. and Hatcho, N. (1993). *Irrigation Water Management Training Manual No. 8. Structures for Water Control and Distribution*. Food and Agriculture Organisation of the United Nations, Rome.

[11] Ijir, T. A. (1994): *The Performance of Medium Scale Jointly Managed Irrigation Schemes in Sub-Saharan*

Africa: A Study of the Wurno Irrigation Scheme, Nigeria: University Of Southampton, Faculty of Engineering and Applied Science, PhD Thesis, Pp 8. Available at <http://eprints.soton.ac.uk>. Accessed on 15/11/2014.

[12] Behailu, M., Abdulkadir, M., Mezgebu, A. and Yasin, M. (2005). *Report on Community Based Irrigation Management in the Tekeze Basin: Performance Evaluation. A Case Study on Three Small-scale Irrigation Schemes.*

[13] Adongo, T. A., Abagale, F. K and Kranjac-Berisavljevic, G. (2015). *Soil Quality of Irrigable Lands of Irrigation Schemes in Northern Ghana*. *International Journal of Innovative Science, Engineering and Technology*, Vol. 2, Issue 8.

[14] Bos, M., G. (1997): *Performance indicators for irrigation and drainage systems*. Kluwer Academic Publishers, Netherlands: Vol. 11, Issue (2), pp 119 – 137.

[15] Palmer, J. D., Clemmens, A. and Dedrick, A. (1991): *Field Survey on Irrigation Delivery Performance*. *Journal of irrigation and Drainage Engineering*. Vol. 117, No. 4, Pp. 567 – 577.