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Assessing the Performance of Subinja Irrigation Scheme in the Wenchi Municipality of the Brong Ahafo Region of Ghana

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Abstract - **Performance evaluation of an irrigation system is the analysis of certain measurements taken in the field while the system is operating under actual field conditions. The principal indices for evaluating the performance of any farm irrigation system are uniformity, adequacy and efficiency. The overall aim of the evaluation process was to identify the operational problems associated with the solid set sprinkler irrigation system. The study was therefore carried out in 2011 to evaluate the application and water storage efficiencies, as well as the distribution and uniformity coefficients of Subinja Irrigation scheme in the Wenchi Municipality. Forty (40) catch cans or containers with diameter of 120 mm and a height of 140 mm were laid out on a grid having suitable square spacing 3 m× 3 m in order to determine the application rate. It was discovered that the sprinklers operate at an average application rate of 15.63 mm/hr whilst the soils also have an average infiltration rate of 11.73 mm/hr leading to runoff on the field. Distribution Uniformity and Christiansen's Coefficient of Uniformity were 60.4% and 75.63% respectively indicating that the irrigation was performing below standard. The average depth of water applied was lower than the root zone deficit resulting in storage efficiency below 100%.The application efficiency was very low at the percentage of 43.5. Problems militating against the scheme include inadequate maintenance of the system, leakage from joints, inadequate supply of sprinkler equipment and poor supervision.**

Keywords - **Application Efficiency, Distribution Uniformity, Performance Evaluation, Sprinkler Irrigation.**

I. Introduction

The agricultural sector is the main water user worldwide; on average, it accounts for 70 percent of all water use in the world and for 90 percent in arid and semi-arid countries and regions [7]. As population and household income grow, water for Irrigation will expand rapidly to meet food production demand that is expected to double between 1995 and 2025. As a response, water consumption for irrigation is expected to increase by 14 percent in developing countries and irrigation areas will increase by 45 million ha to cover close to 300 Million ha by 2030 [19]. In turn, irrigation agriculture has been one of the main Pillars of food production growth and has contributed to mitigate poverty, favour food security and Promote rural livelihoods.

In this context, further investments in new public funded irrigation networks are extensively questioned due to increasing costs and environmental damage [6], [19]. Alternative is to invest in the improvement of the efficiency of existing irrigation systems and to Provide incentives to private investments [18], [6], [20].

Sprinkler irrigation is a class of pressurised irrigation method in which water is carried through a pipe system to a point near where it will be utilised. A pressurised piped irrigation system is a network installation consisting of pipes, fittings and other devices properly designed and installed to supply water under pressure from the source of water to the irrigable area [24].

Sprinkler irrigation is suitable for most crops and adaptable to nearly all irrigable soils (and terrains) due to the availability of different range of discharge capacities. With the aid of sprinklers, water is sprayed through the air onto the soil surface or crop and the pattern of the spray simulates rainfall.

Furthermore, variation in rotational speed of sprinklers, differences in discharges and irregularity of the trajectory angle caused by riser straightness contribute to the non-uniform application problem [10].

Efficiency of irrigation water use is indeed necessary in order that limited water resources can be optimally used with less wastage and more land irrigated as a result. International agencies, like FAO and the World Bank, as well as National Governments of Third World Countries point at irrigation as an important instrument to overcome under development of physical infrastructure for efficient capture, distribution and use of water for irrigation [4]. Many parts of Ghana for instance experience water deficits, every cropping season. Africans face enormous problem as they struggle to feed themselves and to generate sufficient income to meet the most basic needs [9]. These difficulties are compounded as people are forced to farm on marginal lands which have been degraded due to population increase.

The plight of small scale, subsistence farmers is often compounded by scanty and unreliable rainfall distribution within the rainy season, as well as high variability of the precipitation from year to year. With access to water retention structures such as dams and dugout, flowing rivers, cultivation of vegetables such as tomatoes (*Lycopersicum esculentum*), cabbage (*Brasica oleracea var capitata*), garden eggs, pepper, okra and some leafy other vegetables could take place in the dry season.

In spite of sustained efforts by governments past and present, at building and rehabilitating water retention structures such as dams and dugouts, benefits in terms of yields and economic return do not always reflect the huge investment in material and human resource. This is due chiefly to waste of irrigation water. Africa's irrigation history is marked with false expectations, cost over runs and legion of failure [5].

An irrigation system in its parts comprises a very delicate machine, and these several parts constantly require adjustment and overhauling; to deprive the machine of these adjustments can only spell immediate losses of efficiency and a disaster [8].

There has been an increasing concern about the performance of irrigation systems in recent years. This is due to the fact that many projects have failed to deliver the level of performance expected [13]. There is demand for the evaluation of the water delivery performance in irrigation system. Reference to [21] shows that, the assessment of irrigation performance is clearly important to managers of irrigation projects, but it has been seriously neglected by those who allocate public funds for irrigation and by researchers. Improved management and operation of on-farm irrigation systems saves water, labour, maintenance input and may increase yield of crops. A system evaluation should measure and show the effectiveness of irrigation practices [15].

Although Brong Ahafo Region of Ghana is characterised by bimodal rainfall, there is water deficit especially for farming in some period of the year. These negatively affects agricultural productivity and for that matter food security across the nation. Reference to [17] shows that more than half of the annual rainfall is received during the short period of the raining season in Sub-Saharan Africa.

Subinja irrigation scheme is the main source of water for dry season farming and other domestic activity for the community and its environs. The irrigation scheme was no longer performing, until recently when the Government of Ghana reinvested money for its rehabilitation for use.

This study therefore evaluated the performance of the scheme as it is being put into operation, so as to suggest management strategy for efficient operation of the scheme. This was achieved by determining the uniformity coefficient and distribution uniformity, the average application rate and storage efficiency of the scheme, and the constraints associated with the use of sprinkler irrigation system were assessed.

II. Methodology

A. Description of Study Area

Subinja Irrgation Scheme is found in the Wenchi Municipality. The Municipality is located in the Western part of Brong Ahafo Region of Ghana. It is bounded to the South by Sunyani Municipality and to the North by Kintampo South District. It also shares a common boundary with Tain District to the West and Techiman Municipality also to the West. It lies within latitudes 7°30' and 8°05' North and longitudes 2°15' West and 1°55' East. In terms of land size, the Municipality covers Three Thousand Four Hundred and Ninety-Four square kilometres (3,494 km^2). Wenchi town, the district capital is 56 km to Sunyani and 29 km from Techiman. Its closeness to Techiman, a major national market, poses several benefits for agricultural production and agro-processing and farmers especially could be sensitised and supported to take advantage of this opportunity.

The 2000 National Housing and Population Census estimated the population of Wenchi District to be 166,641.

Geologically, the municipality is underlined mostly by Birrimain rock formation. The area falls under the Lower Birrimain, which consists of such metamorphosed sediments as phyillite and schist. There are also granite and granodiorite in the southeast and western parts of the Municipality.

A greater proportion of Wenchi Municipality falls under the savannah ochrosol with some lithosols. The land is generally low lying and most of the soils are sandy loam and in the valleys, loamy soils exist.

The topography is predominantly undulating with gentle slopes of less than 1% inclination. The land generally rises from 30 m above sea level to over 61 m in the North West. Apart from the North-western high land; the other areas are basins of the tributaries of the Volta and therefore low lying.

Temperature in the Municipality is generally high averaging about 24.5°C. Average maximum temperature is 30.9 (°C) and a minimum of 21.2 (°C). The hottest months are February to April.

The prevailing climatic conditions in the Municipality constitute important parameters for development. The *rainfall pattern* is characterised by seasonality, which is a limiting factor to crop cultivation and plant growth. The municipality has two main seasons – *rainy and dry seasons*.

The *rainy season* occurs between April and October with a short dry spell in August. The average annual rainfall is about 1,140 – 1,270 mm. The Municipality experiences an average of four (4) months of rain. However, rivers such as Tain, Subin and the Black Volta flow throughout the year, which can be dammed to support dry season farming. The pattern of rainfall has been erratic over the years, which has affected production levels of farmers.

The *dry season*, also known as the hamattan, occurs between November and February. This long period of dryness makes the Municipality very vulnerable and susceptible to bush fires. Bush burning is therefore very rampant during the dry seasons. Community education and fire volunteerism must be intensified to reduce the occurrences of bush fires during the dry seasons.

Generally, the Municipality is well drained. The Black Volta marks the northern boundary of the Municipality with the Northern Region. The major rivers, which serve the communities in the Municipality, are Tain, Subin, Kyiridi, Trome and Yoyo. While some of the streams dry up in the dry season, the major rivers flow throughout the year. Rivers such as Tain, Subin and the Black Volta flow throughout the year.

The Municipality falls within the moist-semi-deciduous forest and the Guinea Savannah woodland vegetation zones. The Guinea savannah woodland represents an eco-climatic zone, which has evolved in response to climatic and edaphic limiting factors and has been modified substantially by human activities.

B. Scheme Features

The scheme is a sprinkler type, found in Asubinja in Wenchi Muncipality and it was named after River Subin. The project was constructed in 1976 by Government of Ghana through Ghana Irrigation Development Authority (GIDA) and rehabilitated in 2006. It is a flowing river and it takes its source of water from Subin River. Weir is built across the river as source of water for irrigation. Length of the weir is 14.3 m, with height of 1 m and a width of 0.3 m. Two diesel and four electric pumps were planted at the site. The capacity of the pump is 45 horse power (hp) with a voltage of 415-102 volts and an efficiency of 93%. PVC pipes used have different sizes that is, 10 cm, 15 cm and 20 cm, as well as fifteen (15) hydrants. The laterals and the ten (10) sprinkler heads were at 5cm diameters. Potential area of the project is 121 ha. The irrigable area which is 60 ha benefits 25 registered farmers and 20 non registered farmers.

C. Methods of Data Collection

The experimental design of the solid set sprinkler irrigation system was defined to obtain high irrigation uniformity under low wind speed conditions. The nozzles diameter was 3.5 mm and was located at a height of 1.0 m over the soil surface. The nozzle operating pressure was kept constant during the season at 300 kPa. Catch can test data was specifically used to measure uniformity coefficient and distribution uniformity. Forty (40) catch cans or containers with diameter of 120 mm and a height of 140 mm were arranged on a grid having suitable square spacing 3 m × 3 m. The catch cans grid covered two adjacent areas between two sprinklers near the average pressure head location. Catch cans were provided to capture water falling on the outer grids on both sides of the test lateral. The sprinkler's discharge and pressure head was measured at different locations along the lateral line. Before starting the test, the pressure head and flow rate inside the test lateral(s) were made to reach steady State conditions, by allowing the system to operate for a certain time with the sprinkler heads Prevented from rotation and directed outside the test area to prevent water from falling in the cans.

Nevertheless, all cans were checked and emptied from water before starting the test and allowing sprinklers to rotate. The pressure head was checked many times during the test, particularly at the inlet and end and quarter points along the operating laterals. The test started from 9.00 a.m. to 10.00 a.m. and duration equal 1hour (hr). Out of the forty (40) catch cans thirty-nine collected water. However, care was taken that no overflow from any of the catch cans occurred. Plate 1 shows the arrangement of catch cans on the field. Qualitative data was obtained through the use of questionnaire.

The *average application rate* from the sprinklers was computed by:

$$I = \frac{kq}{Se \times Sl} \quad (1)$$

Where:
I = average application rate, mm/min k= conversion constant, 60 for metric units
q = sprinkler discharge, L/min
Se= spacing of sprinklers along the laterals, m.
Sl = spacing of laterals along the main line, m [10].

Plate 1. Arrangement of catch cans along the laterals

$$q = \frac{v}{t} \quad (2)$$

Where:
V = volume of water collected (litres)
T = container fill time (sec)
The *Distribution Uniformity (DU)* indicates the uniformity of application throughout the field and was computed by:

$$DU = \frac{\text{Average low} - \text{quater depth of water recieved}}{\text{Average depth of water recieved}} \times 100 \quad (3)$$

The *Coefficient of Uniformity (CU)* was computed by:

$$CU = 100\left(1.0 - \frac{\sum x}{nm}\right) \quad (4)$$

Where:
CU = coefficient of uniformity test, mm.
x = |z − m| = absolute deviation of the individual observations from the mean, mm.
n = number of observations.

$$m = \frac{\left(\sum z\right)}{n} \quad (5)$$

m = mean depth of observations, mm.
z = individual depth of catch observations from uniformity test, mm [10]. Reference to [10] shows that, the test data for CU>70 usually form a bell-shaped normal distribution and is reasonably symmetrical about the mean. Therefore, CU can be approximated by:

$$CU \approx \frac{\text{average low–half depth of water received}}{\text{mean depth of observations}} \times 100 \quad (6)$$

A Mini-disk Infiltrometer

This was used to conduct infiltration tests in two laterals (laterals 1 and 2) so as to determine the average infiltration rate of the soils in the scheme. To be able to determine the water delivered to the field for irrigation the average rate of discharge was computed from the sprinklers using a container of known volume and a hose to direct water into the container with stop watch set to monitor the time that the container was full. *Plate 2*: shows a mini disk infiltrometer used to conduct infiltration test one the field.

Plate 2. Mini disk infiltrometer

The infiltration rate was computed by:

$$I = ct^{\infty} \quad (7)$$

Where:
I = cumulative infiltration rate (mm)
T = time after infiltration starts (minutes)
C and ∞ are constants which depend on the soil and initial conditions [11].

D. Climatic Data for seven years (2004 - 2010) comprising monthly rainfall, temperature, relative humidity, sunshine and wind speed was obtained from Meteorological Agency of Wenchi Municipality.

E. Application Efficiency is a measure of how efficiently water has been applied to the root zone of the crop. This parameter relates the total volume of water applied by the irrigation system to the volume of water that has been added to the root zone and is available for use by the crop [1]. Thus, the application efficiency was calculated as:

$$AE = \frac{\frac{Average\ depth\ applied \times Area(ha)}{100}}{water\ delivered\ to\ the\ field(Ml)} \times 100 \quad (8)$$

Where:
Average depth applied = average depth applied including overlap
Area = area over which this average depth is applied.
Water delivered to the field = flow meter reading [1].

F. Storage Efficiency

Provides an indication of how well the irrigation satisfied the requirement to completely fill the target root zone soil moisture [1]. The storage efficiency can be approximated by relating the average depth of water applied over the field to the target root zone deficit. The root zone deficit was calculated using soil type, crop root zone and soil moisture content data of the irrigation scheme. In this case, the storage efficiency was calculated as:

$$SE = \frac{\text{average depth applied}}{\text{root zone deficit}} \times 100 \quad (9)$$

Where the maximum storage efficiency is 100%. Calculations with a result above 100% indicate losses due to runoff or deep drainage [1].

G. Sampling and Data Analysis

Purposive sampling was used to retrieve information on the activities at the irrigation site. These included farming activities, water supply schedule as well as challenges hindering the efficient performance of the irrigation scheme and the potentials available for improving upon the efficient performance of the scheme as a whole.
Quantitative data was used to determine the uniformity coefficient, distribution uniformity, and average application rate and storage efficiency of the scheme.

III. Results and Discussion

A. Crops Cultivated in the Irrigation Scheme

Vegetables grown in the scheme included garden eggs, pepper, tomatoes and okra, as indicated by the management and farmers. There are two seasons in the year mainly the major season (dry season) which starts from December through to April when the minor season (rainy season) also starts.

Crops cultivated during the dry season are the vegetables which included garden eggs, pepper, tomatoes and okra under irrigation. Maize and cowpea are cultivated in the minor season under rain fed. Due to rehabilitation works at the site, only okra was cultivated by the farmers in the major season in 2011. According to the farmers, the produce from the vegetables (garden eggs, tomatoes, pepper and okra) are of high demand in the area and irrigation was done mainly by sprinkler method.

B. The Distribution Uniformity and Christiansen's Uniformity Coefficient.

Out of the forty (40) catch cans, thirty nine (39) collected water from sprinklers 1 and 2. The results of catch can test are shown in Table 2 for the two laterals

Table 1: Catch cans Collection in Volume (mL) and Depth (mm)

Catch can Number	Depth (mm), X_1	Volume (mL),V_1	Catch can Number	Depth (mm), X_2	Volume (mL), V_2
1	20	240	21	17	225
2	13	215	22	14	220
3	12	195	23	8	185
4	11	190	24	12	195
5	21	250	25	20	240
6	18	235	26	15	210
7	25	270	27	7	170

8	11	190	28	26	280
9	26	280	29	8	185
10	13	215	30	25	270
11	23	260	31	6	166
12	23	260	32	25	270
13	20	240	33	12	195
14	5	150	34	15	210
15	18	235	35	---	---
16	21	250	36	14	220
17	11	190	37	7	170
18	17	225	38	25	270
19	13	215	39	5	150
20	26	280	40	14	220

Table 3: Combined catch pattern data in (mm) between sprinklers 1 and 2 for a 16m×18m.

S_2 ← 18m → S_2 (16m)

20 17 37 (5.9)	13 14 27 (4.1)	12 8 20 (11.1)	11 12 23 (8.1)	21 20 41 (9.9)
18 15 33 (1.9)	25 7 32 (0.9)	11 26 37 (5.9)	26 8 34 (2.9)	13 25 38 (6.9)
23 6 29 (2.1)	23 25 48 (16.9)	20 12 32 (0.9)	5 15 20 (11.1)	18 - - 18 (13.1)
21 14 35 (3.9)	11 7 28 (13.1)	17 25 42 (10.9)	13 3 16 (13.9)	26 14 30 (8.9)

S_1 S_1

(Z-m) Deviation from average

Table 3 indicates combined catch patterns in mm where the sprinklers were spaced at 16 m by 18 m, as obtained from Table 2. This was done by overlapping the right- and the left- hand catch data that is X_1 and X_2. The right-side catch in Table 3 that is X_1 was added to the left-side catch that is X_2 of the same Table 3 for both sprinklers 1 and 2; the total at each point represent a complete 1 hour irrigation. The total of the catch at all 20 grid points in Table 3 was 622 mm, with an average catch depth of 31.1 mm. Reference to [23] shows that if the catch can space is small enough, the lane spacing may be a multiple of the can spacing so that no interpolation of catch can data is required. Overlapping is simply a matter of adding one side of the distribution pattern to the other side at the correct spacing. The absolute deviations values (**z-m**) as shown in parentheses in Table 3 was used to estimate the uniformity coefficient (CU) from equation 4, whilst the average of the lowest one quarter of the catch rate (5 out of 20 grid points) was used to estimate distribution uniformity (DU) from equation 3. Table 4 shows the summary of the various calculations.

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Table 4: Values for DU, CU, and Average catch depth for the Sprinkler spacing in area of 16 m by 18 m.

Test Area (16 m x18 m)	Average Low-quarter(mm)	Average catch depth (mm)	Distribution Uniformity (DU) %	Coefficient of Uniformity (CU) %
Area between sprinklers 1 and 2	18.8	31.1	60.45	75.63

The result obtained from Table 4 indicates that, the *average distribution uniformity (DU)* is 60.45%. Reference to [22] proposed that for rotor systems, the DU should be 70% or higher. This means the scheme was performing below the recommended standard. Reference to [23] shows that, the value of DU decreases as the variation of how uniform application of water to reach every point within the irrigated area increases. Reference to [3] in his study reported that wind velocity is the main environmental factor affecting sprinkler performance; and that the value of CU is clearly affected by wind speed beyond 2.1 m/s. Wind speed in combination with sprinkler spacing has significant impact on the uniformity of set-move sprinkler irrigation systems. The changes in wind speed and direction, however, tend to increase the cumulative irrigation uniformity calculated over multiple irrigation events. Another phenomenon associated with the wind condition is 'wind skips', which occurs when there is a large difference in wind speed and/or direction between adjacent irrigation sets. This creates temporary dry zones adjacent to the sprinkler laterals on the upwind side. It is, however, not cumulative and successive irrigations/moves correct this effect [12].

C. Average Application Rate

Notwithstanding these limiting effects, [16] wrote that occasionally, wind can help improve uniformity as the randomness of wind turbulence and gusts contribute to smoothening out the distribution pattern/profile. This phenomenon was also confirmed by the farmers as they complained of poor distribution uniformity caused by high wind speeds.

The *Coefficient of Uniformity (CU)* was determined to be 75.63%, as can be seen in Table 4. Reference to [10] shows that, test data usually forms a bell-shaped normal distribution that is reasonable symmetrical about the mean for CU greater than 70%. Hence equation 6 was used to approximate CU to 76.2%. Reference to [14] reported that the Soil Conservation Service (SCS) classifies uniformity of a sprinkler irrigation system as very good, good, poor and worse if the CU value is 90 %, between 80 and 89 %, between 70 and 79 % and > 69 % respectively. The approximated value (76.2%) was found to be lower than the recommended value of CU for vegetables and other shallow rooted crops. In general, a CU of at least 85% is recommended for delicate and shallow rooted crops, such as potatoes and most other vegetables [10].

Direct discharge was measured using 1.5 litre containers with a hose connected to three different sprinklers. The average discharge was calculated to be 75 L/min using equation 2. The application rate was then calculated using equation 1 to be 15.63 mm/hr.

D. Infiltration Rate of the Soil

Infiltration test was done along the two laterals (1 and 2) to determine the rate at which water infiltrate into the soil. The calculated value for the application rate was however found to be 15.63 mm/hr from equation 1; while the average infiltration rates of the soil was also computed to be 11.73 mm/hr. The infiltration rate and cumulative infiltration depth of both laterals are shown in fig. 1- 4. Infiltration rate, which determines the potential for runoff, is dynamic. Infiltration rate decreases during irrigation, as can be seen in the infiltration rate curves below. Since the average application rate exceeded the average infiltration rate, this indicated that not all the water applied infiltrate into the soil, some of the water resulted into runoff. Reference to [2] shows that, decreasing infiltration rates combined with high water application rates make runoff a near certainty for sprinkler systems on all but sandy soils.

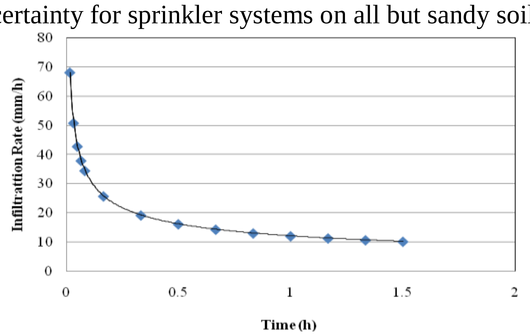

Fig.1. Infiltration rate for lateral 1

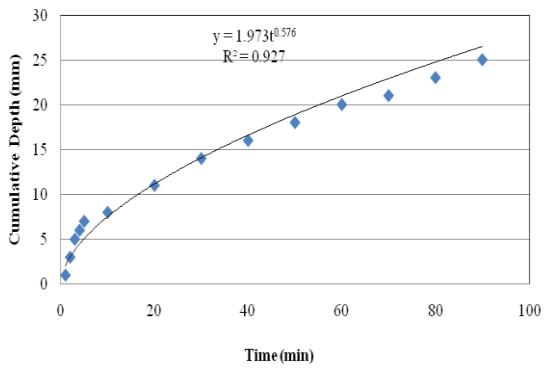

Fig.2. Cumulative depth for lateral 1

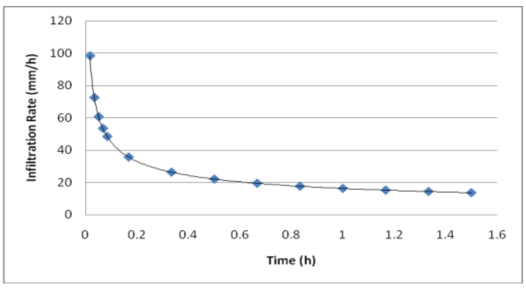

Fig.3. Infiltration rate for lateral 2

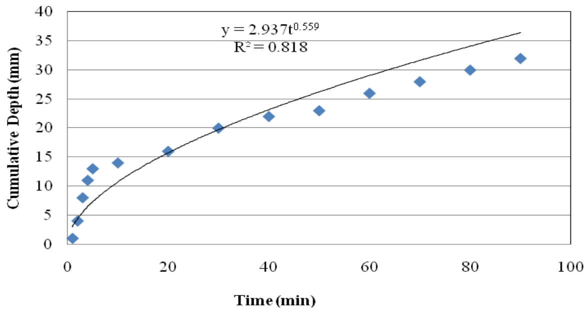

Fig.4. Cumulative depth for lateral 2

E. Application Efficiency

Having average catch can depth of 31.1 mm and area over which this average was applied is 0.0576(ha), with average flow meter reading of 0.0411ML at irrigation duration of one hour, the application efficiency was calculated using equation 8 to be 43.5%.

This low value of efficiency is due to the high value of losses during application. Reference to [2] shows that efficiency of sprinkler irrigation is in the range of 70-95%, but can be much lower due to poor design or management, as in the case of the Subinja Irrigation Project.

F. Storage Efficiency

From the soil analysis report of the Irrigation scheme (Table 5), the total available water content of the soil was 79.09 mm/m. Considering a root zone depth of 1 m and manageable allowable deficit of 50%, the root zone deficit was computed to be 39.54 mm/m. Considering the average catch depth in Table 4 to be 31.1 mm, *Storage efficiency (SE)* was calculated to be 78.6% using equation 9 indicating that the maximum storage efficiency of 100% was not reached. This means the soil is capable of storing substantial amount of water for crop utilization; however irrigation water was under applied as the Net Irrigation Requirement (NIR) was not met.

Table 5: Soil texture and a number of other soil Physical properties

Soil texture	Permeability (mm/hr)	Rooting depth of Okra(m)	Total Porosity (%)	Bulk density (g/cm^3)	Field capacity (mm/m)	Permanent wilting point (mm/m)	Total available water content(mm/m)
Loamy Sandy	11.73	1	40.53	1.5818	142.36	63.27	79.09

G. Constraints Associated With the Irrigation Scheme

Through the use of the questionnaire and personal interviews with the farmers, they indicated that, the major problem that normally affects the irrigation efficiency is the disturbance of high winds. This leads to poor water distribution uniformity which affected the quantity of water available in the soil for crops utilization.

Reference to [10] shows that, Prevailing wind conditions can have tremendous effects on the application pattern of a sprinkler system and that, anticipated wind conditions can be reduced by decreasing the spacing between nozzles both along the laterals and between the laterals during system designs with increasing wind velocity.

This suggested that, to be able to make irrigation better during high winds, the spacing between laterals and sprinklers should be reduced.

Excessive leakages from the joints on the main lines, which have been buried, hydrants and the laterals were also experienced at the site, resulting in runoff and erosion.

There was inconsistency of sprinkler spacing. The effects of the above stated problems tend to affect both coefficient and distribution uniformities of the sprinklers in the scheme. Plates 3 - 6 show the various defects of the sprinkler irrigation system.

To add to what has been said above, the risers and pipes forming the laterals at the site were not enough and therefore according to the farmers, when it is time for a farmer to irrigate, the laterals had to be carried to the person's farm which according to them is laborious and sometimes causes damage to the pipes.

According to the project management another constraint which confronted the performance of the scheme was farmer's unwillingness to for pay irrigation services, which made it extremely difficult to do minor repairs and maintenance.

Plate 3. Leakage from the main line

Plate 4. Leakage from hydrant joint


Plate 5. Broken part of the weir

Plate 6. Leakage from the control

IV. Conclusion

The results obtained is useful not only for the management of the Subinja Irrigation scheme to be able to make decisions on how to improve upon the performance efficiency of the scheme, but also would support irrigation engineers in Ghana who plan to establish similar scheme to strategise their designs to ensure efficiencies in both water distribution and application. Further studies could be conducted on the subject by considering the effects of different pressures and arrangements of the catch cans on the performance of sprinkler irrigation system. Studies could also be conducted to compare the performance of Subinja Irrigation's sprinkler system with other systems exist in Ghana.

References

[1] W. David and R. Steven. *Measuring irrigation system in the Queensland Dairy Industry*. University of Southern Queens-land, Brisbane, Austria, 2001, pp. 1-23.

[2] H. R. Danny, R. L. Freddie, A. Mahbub, P. T. Todd, A. C. Gary, L. B. Philip and M. Kyle**.** *Irrigation management series*. *Efficiencies and water losses of irrigation systems.* Cooperative Extension Service, Kansas State University, Manhattan, 1997. Available: http://longbeach.wsu.edu/cranberries/documents/efficienciesandwaterlossesofirrigationsystems.pdf. Accessed on 28th June 2011.

[3] F. Dechmi, E. Playan, J.M. Faci and M. Tejero. *Analysis of an irrigation district in north-eastern Spain. I. Characterisation and water use assessment.* Agric. Water Manage., 61, 2003a, pp. 75-92

[4] M. G. Eggink, and J. Ubbels. *Irrigation peasants and development*. Wageningen University, the Netherlands, 1984.

[5] FAO. *Water quality for agriculture*. FAO. Irrigation and Drainage paper No 33 FAO of the United Nation. Rome. Italy, 1985, pp. 193

[6] FAO. *Modernization of irrigation schemes past experience and future options*. Water Report NO12 FAO/RAP publication: 1997/22 food and Agriculture Organization of the United Nation, Rome, 1997.

[7] FAO. Economic valuation of water resources in Agriculture. From the sectional to a functional perspective of Natural Resource Management. Water reports No 27.Food and Agriculture Organization of United Nations, Rome, 2004.

[8] D. Gilmartin (1994). Scientific Empire and Imperial science: colonialism and Irrigation Technology in the Indus Basin. In the journal of Asian Studies.53 (4). Pp. 1127-1149.

[9] N.W. Hudson and R.J. Cheacle. *Working with farmers for better land Husbaddry*. Intermediate Technology publications Ltd. London, UK, 1993.

[10] J. Keller and R. D. Bliesner. *Sprinkle and Trickle Irrigation*. Van Nostrand Reinhold, New York.3-5, 1990, pp. 86-96

[11] A. N. Kostiakov. *On the dynamics of the coefficient of water in soil and on the necessity for studying it from a dynamic a point of view for purposes of amelioration*. Trans.6th comm. International Soil science Society. Russian part A, 1932, pp. 17-21.

[12] B. A. King, J. C. Sark and, D. C. Kincaid. *Irrigation uniformity*. University of Idaho,U.S.A. 2000. Accessed on 28th June from http://info.ag.uidaho.edu/pdf/BUL/BUL 0824.pdf.1-11

[13] R. L. Lenton. *Looking ahead*. International Irrigation Management Institute (IIMIS), 1988.

[14] G. E. Little, D. J. Hills and B. R. Hanson. *Uniformity in pressured irrigation system depends on design installation*. California Agric., 47, 1993, pp. 18-21.

[15] J. Meriam and J. Keller. *Farm irrigation system evaluation: A Guide for Management*. Utah State University, U.S.A. 1978, pp. 271.

[16] G. P. Merkley and Allen R.G. *Sprinkle and trickle irrigation*. Lecture Notes, Utah State University, USA. 2004. Accessed on 3rd August 2007 from sprinkler Trickler Irrigation /usufiles/L01_Course_Introduction.pdf, 10-43. http://www.myoops.org/.../

[17] W. R. Rangeley. *Irrigation in Arid Africa*. Paper presented at the World Bank Irrigation and Drainage Seminar, December, 1985.

[18] M. W. Roesgrant and M. Svendsen. *Asian food production in the 1990s*. Irrigation investment and management policy. Food policy, 18, 1993, pp. 13-32.

[19] M.W. Rosegrant, Ximing Cai and, S. Cline. *World water and food to 2005. Dealing with scarcity.* International food policy Research Institute. Washington D.C. 2003.

[20] D. Seckler. *The New Era of water resources management: from dry and wet water savings.* Research Report No 1, International Irrigation Management Institute, Colombo, Sri Lanka, 1996.

[21] L.E. Small and M. Svendsen. *A framework for assessing irrigation performance*. Washington D.C international food policy research institute, 1992.

[22] P. W. Tim and F. Z. David. *Evaluating sprinkler irrigation uniformity.* CATI, Publication No 970703, 1997. http:cati.csufresno.edu.

[23] D. W. Wigginton and S.R. Raine. *Measuring irrigation system performance in the Queensland Dairy Industry.* National Centre for Engineering in Agriculture Publication 179729/5.Toowoomba, Australia. 2001. www.landwise.org.nz

[24] K. Yoshida, H. Tanji, H. Somura, O. Toda, and K. Higuchi (2004). *Evaluation of irrigation efficiency at KM6 Project Site*. Laos, Water Resources Research Centre, Japan. Accessed on 3rd.August 2007 from http://www.wrrc. dpri.kyoto university

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