IRACST – Engineering Science and Technology: An International Journal (ESTIJ), ISSN: 2250-3498
Vol.7, No.1, Jan-Feb 2017

PERFORMANCE ASSESSMENT AND DIAGNOSTIC ANALYSIS OF MINOR IRRIGATION CANAL

Afera Halefom

Water Resources Development and Management
Indian Institute of Technology Roorkee, Roorkee-247667, Uttarakhand, India

Ermias Sisay

Water Resources Development and Management
Indian Institute of Technology Roorkee, Roorkee-247667, Uttarakhand, India

Abstract: Irrigated agriculture plays an important role in economic development of many countries worldwide. In this paper, performance and diagnostic analysis of a minor irrigation canal has been investigated. A framework for the performance assessment of irrigation water management in minor irrigation canals is proposed in this paper, based on earlier studies made in this direction. The paper presents Osrabandi/warabandi schedule, irrigation system performance evaluation (evaluation of field application efficiency), soil & water quality analysis (surface, subsurface) together with the methodologies for estimating these for the scheme as a whole during different phases of irrigation water management. For the analysis of the health of minor canal and its command area, we had conducted diagnostic analysis and found canal cross section was not uniform, weed and vegetable growth in entire canal reach, waterwastege is partially happen due to the illegal out lets of watercourse, soil moisture content (TDR) method-18%, discharge using V-notch is 37.21 lps, ultimate infiltration capacity of soil-5.87 cm/hr.

Keywords: Warabandi, TDR, diagnostic analysis, minor irrigation canals, V-notch

I. INTRODUCTION

The agricultural sector plays an important role in the fight against poverty in many regions of the world. According to [1], 70% in China, 80% of food in Pakistan and 50% in India and Indonesia each is made from irrigated farming. However, some countries have very low amount of food produced by agriculture. For example, only 9% of food is produced by agriculture in sub-Saharan Africa. There are enough water resources and land to produce enough food, but only 16.8% of the country that has very good potential has been developed for irrigated farming [2].

The performance of irrigation systems has a major role in the production of more food and irrigated farming cost. Superior irrigation management can improve irrigation performance. Three possibilities of water management were analyzed by [2] to improve food production in sub-Saharan Africa. Agriculture and irrigation practices of Democratic Republic of the Congo, Ethiopia, Cameroon, South Africa Sudan and Nigeria have been analyzed. According to them, the current administration cannot provide food safety in the region. Improvements in the institutional organization and stakeholder involvement can improve the situation. It is necessary to increase the productivity of already cultivated land and cultivation areas through improved water management measures. The study of [3] in Morocco and in the Oasis Area in Southern Tunisia suggests that appropriate relationship between farms and agro food processors, irrigated schemes can be effective for improving food productivity. [4] Conclude that irrigation can play a crucial role in the alleviation of poverty and hunger, but the ecological and societal consequences of large irrigation systems must be properly addressed. Over the last half century, developing countries have made enormous investments in irrigation infrastructure in the form of irrigation systems and have recognized their importance for food production for the growing population. These investments, along with improved plant technologies such as the use of fertilizers, hybrid varieties, plant protection techniques, etc., have enabled many countries to bring self-sufficiency into food production. Nevertheless, there is also a perception that many irrigation systems do not meet the expectations or achieve the goals. The management of water production or irrigation water management is important within any irrigation system to achieve the benefits of previous activities and investments to create irrigation potential. It is also important in the area of the catchment area and the national level where more attention is paid to the efficient management of water resources to meet the growing challenges of the growing demand for irrigation to meet the growing food needs of the population; Competition for water distribution from non-agricultural sectors with high priority; The limitation to the development of new water resources by rapidly increasing costs, technical uncertainty and environmental concerns. The operation of these irrigation plans under moderate water deficit is a complicated task [5] since not only the efficiency of the water use, but also the equity of the water distribution has to be taken into account. The most significant part of the conveyance loss is the canal seepage, which is influenced by the canal surface condition; unlined or lined, and nearly proportional to canal length. It therefore plays an important role in the consideration of the water distribution plan, especially in the large-scale irrigation project, which has long earthen canals [6, 7, and 8]. The water allocation planning in such an irrigation system becomes a complex task, but the plan should be rationalized according to the available water volume and the conditions of the irrigation systems.

About 75 per cent of the poor in developing countries live in rural areas. In these areas, agriculture is the main source of income. Access to adequate food in the rural areas of many developing countries is heavily dependent on access to natural resources, including water, needed to produce food. Around 17 percent of the world's agricultural land is irrigated and accounts for around 40 percent of the world's crop production [9]. Many evaluations have found strong direct and indirect relations between irrigation and poverty [10]. The benefits of irrigation can be attributed to higher production, higher yields, less dependence on weather conditions, lower risks and increase in agricultural activity throughout the year. Landless farmers can benefit less quickly, but increase productivity, increase cultivation areas, and provide access to water, also provides landless farmers with more employment opportunities. Irrigated agriculture is a major contributory factor in promoting employment in rural areas and preserving rural livelihoods. [9]. With irrigation, small-scale farmers can adopt more diverse build-in patterns and switch from low-cost subsistence to high-quality market-oriented production. Increased production helps provide food and affordable for the poor. Climate change and variability are directly and indirectly linked to irrigation, example changes in precipitation patterns, increasing scarcity, impacts on land and soil as well as increased competition. Irrigation also provides a defense against droughts that are likely to occur more frequently. Irrigation played a crucial role in the green revolution, entered the twentieth century, which helped saved over a billion people from hunger in many countries, especially in Asia and South America. However, since then irrigation has been very inefficient and responsible for the degradation of the environment and ecosystems. Lack of drainage in many countries causes water logging and salt content and destroys otherwise fertile land. As population growth and the demand for water consumption in irrigation increase rapidly, the struggle for safe water supplies will be more difficult to cope with, especially in arid parts of the world. Large arid areas with absolute water scarcity, affecting millions of people, many of whom are poor and underprivileged. It can be seen that there is a strong link between irrigation and drainage and hunger and poverty control, where the poor benefit from well-managed irrigation through higher yields, a lower risk for the crops of crops, the acceptance of diversified cultivation areas Higher value added And market-oriented plant production as well as permanent employment [10]. This paper takes into account the diagnostic analysis of irrigation minor canals. These usually have extensive systems of minor canals with numerous outlets along their length, the distribution of water over large areas with different soil types for the use of farmers with different sizes of land ownership.

II. MATERIALS AND METHODS

A. DISCHARGE MEASUREMENT

Using V – Notch:

The triangular-notch, thin-plate weir is used widely for measuring the flow of liquids in flumes and open channels. Simple in design and easily made from readily available materials, it is inexpensive, convenient to use, and easy to maintain. In permanent or portable form, it is frequently used to measure the flow of water in laboratories and in small, natural streams.

When several forms of weirs or flumes might be used, the triangular-notch weir is often preferred because of its greater accuracy at low flows or its lesser sensitivity to approach-channel geometry and velocity distribution. Within the range of conditions for which verification data are adequate, and with reasonable care in its construction, installation, and use, the triangular-notch, thin-plate weir is a relatively precise instrument.

Calculation of Discharge using V-notch

Initial pointer gauge reading (h1) = 38.69 cm, during no flow

Final pointer gauge reading (h2) = 61.67 cm, during FSL flow

Head of flow (H) = 61.67- 38.69 cm = 22.98 cm = 0.2298 m

Discharge (Q) = $1.47\ H^{5/2}$………………(1)

$= 1.47 * 0.2298^{5/2} = 0.03721\ m^3/sec$

=37.21 lps

Float Method:

Inexpensive and simple, this method measures surface velocity. Mean velocity is obtained using a correction factor. The basic idea is to measure the time that it takes the object to float a specified distance downstream.

$V_{surface}$ = travel distance/ travel time = L/t….(2)

Current Meter Measurement

The carrying capacity of water course at normal operation level was measured by using of current meter. Current meter is a devices used for measurement of discharge. The depth of water level in the water course was 16cm then we put the current meter from bottom to top at 0.4 * 16cm = 6.4cm. The current meter (from bottom to top is 0.4D or from top to bottom is 0.6D) is put in opposite of the flowing of water. Then we had taken the reading three times, the reason why we took three times is the level of water changes from minutes to minutes. The outlet didn't have a gauge at the inlet that's why the level of water is changing from minute to minutes. The reading of the current meter was as follows as well as the capacity of the water course was calculated by using the common formula (Discharge = Area * Velocity)

First reading of velocity 0.24m/s

Because surface velocities are typically higher than mean or average velocities

$V_{mean} = k\ V_{surface}$ where k is a coefficient that generally ranges from 0.8 for rough beds to 0.9 for smooth beds (0.85 is a commonly used value)

Q = Cross section area (A) * mean velocity (V)..(3)

Secondary reading of velocity 0.26 m/s

Third reading of the velocity 0.24 m/s

We have the average of those three reading then the value is 0.2467

Area (A) of the water course is calculated by Width (W) times the Depth (D) of water

A = W * D…………………….........(4)

W = 47cm and D =16cm then

A = 47cm * 16cm = 752 cm^2 = 0.0752m^2

Capacity of the water course is

Discharge = Area *Velocity…………..(5)

Discharge = 0.0752*0.2467 = 0.0185 m^3/s

=18.55 lps

B. The Warabandi Principle

The water distribution is regulated according to the Warabandi principle, a rigid rotation cycle with fixed duration, frequency and priority level [11]. The attraction of Warabandi system is that it is water in proportion to the size of the farmers, and it is easy to plan and operate. The main features of the Warabandi system are: Individual farms are grouped into hydrological units (chaks) of different hectares. Each chak is served by a watercourse whose capacity is proportional to the size of the chak. Any agricultural holding in the Chak is entitled to take full supply in the waters during a certain period proportional to their size. If the demand period is proportional to the size of the hold and the water flow is proportional to the size of the chak, all farmers in the command among the distributors that receive water this week will ensure a uniform volumetric allocation per hectare per week. The waters are unpolished and are served by parent channels (minor canals) with a capacity equal to the sum of the capacity of the draining watercourses. Minor canals in turn are usually ungated and are served by a sales partner whose capacity equals exactly the combined capacity of minors and direct sockets to watercourses.

C. TDR (TIME DOMAIN REFLECTOMETRY) METHOD FOR SOIL MOISTURE

A method is developed for measuring in-place density and moisture content of soil using the technique of Time Domain Reflectometry (TDR). The method is applicable for construction control of earthworks. Significant testing of the procedures on a variety of soil types, along with comparisons with other measures of density and oven dry moisture content indicates that this new method is quick, safe and sufficiently accurate for measuring in place density and moisture content of soil. Moisture content measurement of our working place was by using TDR is 18%.

D. MEASURING THE INFILTRATION RATE

Equipment

An important class of flow events involves water entry through the soil surface in a process known as infiltration. The speed of this process in relation to the water supply to the surface determines how much water penetrates into the soil and how much, if any, pond is generated and an overland flow (drain). The infiltration rate can be measured with a simple set of devices comprising two concentric rings (Fig. 2), one of 30 cm diameter, the other of 45 cm diameter. The rings are made of 3–4 mm thick and 25 cm wide mild steel. Other equipment required includes a stopwatch, a measuring flask graduated in cubic centimetres, and a scale. The scale can be made from 20 cm length mile steel hooked over the side of the inner ring. The purpose of the outer ring is to prevent the infiltrated water under the inner ring from spreading laterally. This would increase the wetting and thus increase the infiltration rate. It is therefore important to fill the inner and outer rings at the same time and to keep the water levels approximately equal in both rings.

Procedure

The procedure for carrying out the test was as follows.

1. The 30 cm diameter ring was hammered 10 cm into the soil and then the 45 cm ring was hammered into the soil to the same depth around the smaller ring. The scale was securely positioned on the inner ring to measure the water level in the inner ring. Water was carefully added to the inner ring, taking care not to disturb the bottom surface. The water was added to the outer ring at the same time until about 10 cm deep. The water in the inner ring is brought up to the level of the tip of the scale and the timing started.
2. At intervals, a measured amount of water is added to the inner ring to bring the water level back to the level of the tip of the scale. The volume of water added to each time interval is recorded and the cumulative volume added since the beginning of the procedures described (Figr-1 & 2).
3. The water level in the outer ring should be maintained at a depth close to the depth of the inner ring. The point of the outer ring should serve as a buffer to ensure that the inner ring water sinks vertically and does not spread laterally. The measurements can be stopped when the infiltration rate reaches the end rate.
4. The data are collected and calculated on a data collection form (Fig. 3), and the data then plotted to show the infiltration rate and the cumulative infiltration (Fig. 4 & 5).

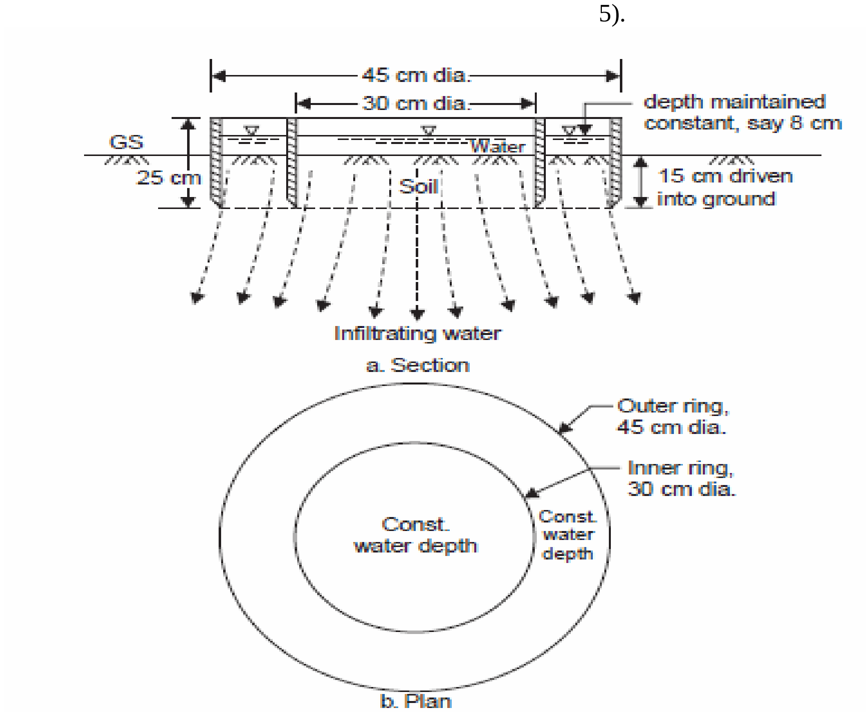

Fig-1 Double ring infiltrometer [12]

Fig-2 Infiltration Test Equipment

III. RESULT AND DISCUSSION

Numerical simulations are carried out to study the performance of the water distribution system in land ownership. The main conditions were under the Warabandi principle; all areas should receive an approximately equal water supply per unit area.

The most important observations can be made via the command area: water Courses: - Small canals providing water to the field are termed as field channels or Water-courses and are the nerve system. From our field trip the total length of water course is 780m. Some of the fields are irrigated by long length of water course which is full of weeds.

There were two types of water courses: the first one is unlined earth canals are often used in water supply on the farm. The benefits of the earth channels understood and accepted by farmers. They can be built and maintained by unskilled people and do not require any special equipment or materials. The low cost is the main advantage of the earth channels. One of the main problems with the use of ground channels in the control of weeds. Weeds in a channel which impede the flow of water, if the weeds are allowed to grow to maturity, their seeds are the yard spread through the irrigation water. Earth channels require constant maintenance to control weed growth and damage repair by cattle, rodents and erosion. In addition to the above problems, the farmer at the tip of the watercourse generally receives almost the full water requirement due to less seepage in the section near the channel exit. The water available to the farmer at the far end is usually much lower than that by the seepage. Second one is Lined channels are made of cement concrete, brick, cement mortar etc to convey water on the farm. Lining of water courses will provide nearly equal quantity of water per unit area of the landholding to all the farmers in the culturable command area. Lining reduce the labour cost in the maintaining of the water course. It is also the elimination of water logging caused by seepage in watercourses. For cultivation, further areas are available because the cross-sectional area of the channel required to carry a particular discharge through a lined channel is considerably less than the unlined channel. Then it is better to construct all the landholding lined channels in order to avoid seepages, weeds growing to the side of channels and equitable water distribution to chaks. Double ring infitrometer (fig-1&2), having the two rings eliminates the problem of overestimating the hydraulic conductivity in the field due to 3-D flow. The outer ring supplies water, which contributes to lateral flow so that the inner ring is contributing only to downward flow. Based on field observations, the infiltration rate is found to be dependent upon the initial soil water content, the hydraulic conductivity of the surface soil, the elapsed time since the onset of water application, and the presence of impeding layers and other heterogeneities within the soil profile. From the analysis of data as shown (fig-4) the infiltration rate is highest when water first enters the soil, and gradually decreases with time until a constant final rate (if) is attained (Fig.4). This behaviour is also reflected in the incremental infiltration as shown in (fig-5) shows a rapid increase in infiltration volume at short times which gradually decreases to a nearly linear rate of incremental infiltration at great times. In many natural situations, the initial water application, such as the rate of rainfall, is less than the initial infiltration capacity of the soil (fig-4), but higher than the potential end rate (if) for the soil under the given conditions. Below graph is obtained from the Double Ring Infiltrometer experiment performed in field. Diameter of the inner Ring of infiltrometer (D) =30 cm

Area = 707.14 cm

Time (min)	Incremental Time(T) (min)	Incremental Vol of water (cc)	Depth of Infiltration (cm)	Infiltration Rate (cm/hr)
0	0	0	0.00	0
0.5	0.5	520	0.74	88.24
1	0.5	430	0.61	72.97
3	2	360	0.51	15.27
5	2	520	0.74	22.06
8	3	650	0.92	18.38
12	4	650	0.92	13.79
17	5	790	1.12	13.41
23	6	760	1.07	10.75
30	7	900	1.27	10.91
45	15	2430	3.44	13.75
75	30	2570	3.63	7.27
135	60	4340	6.14	6.14
210	75	5290	7.48	5.98
270	60	5220	7.38	7.38
330	60	4600	6.51	6.51
390	60	4200	5.94	5.94
450	60	4150	5.87	5.87

Fig-3 example of a completed infiltration test recording form

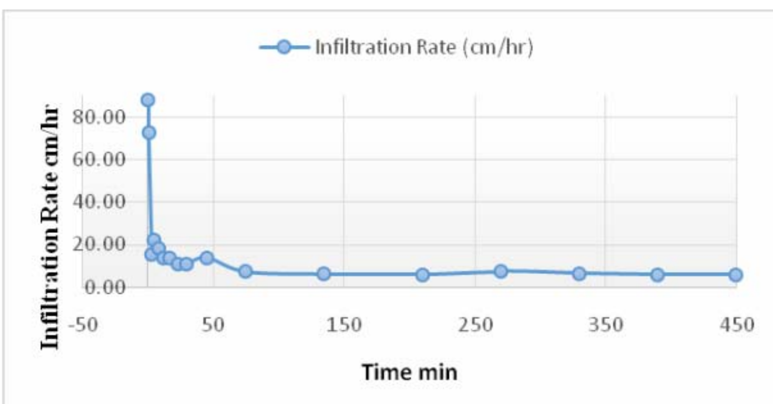

Fig-4 Graph is between Infiltration rate Vs time

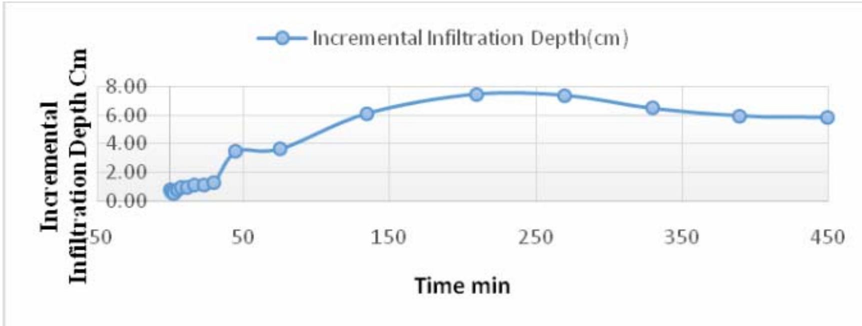

Fig-5 Graph is between Incremental infiltration depth Vs time

IV. CONCLUSION

Irrigated agriculture plays an important role in economic development of many countries worldwide. In this paper, performance and diagnostic analysis of a minor irrigation canal has been investigated. A framework for the performance assessment of irrigation water management in minor irrigation canals is proposed in this paper, based on earlier studies made in this direction.

Performance measures developed, analysis of irrigation water delivery systems with respect to the adequacy, facilitate reliability, efficiency, and equity of water delivery. The measures provide a quantitative assessment of not only the overall system performance, but also the contributions to performance from the structural and management components of the system. The methodologies to estimate these measures explained in this paper provide the irrigation authorities with the information on the performance of irrigation water management in the minor canals, their management capability, and the response of the irrigation water management to variations in physical, climatological and management aspects and insight to improve the performance during different phases of irrigation water management.

For the analysis of the health of Gadarjudda canal and its command area, we had conducted diagnostic analysis and found canal cross section was not uniform, weed and vegetable growth in entire canal reach, waterwastege is partially happen due to the illegal out lets of watercourse, soil moisture content (TDR) method-18%, discharge using V-notch is 37.21 lps , ultimate infiltration capacity of soil-5.87 cm/hr.

V. REFERENCE

1. Michael L (2007). Farm water and rural poverty reduction in developing Asia, Journal of International Commission on Irrigation and Drainage (ICID) – 56(2, 3): 127-146.
2. Ararso GS, Schultz B, Hollanders P (2009), Planning water management for secure food production in sub-saharan Afri. J. Inter. Commission on Irrigation and Drainage (ICID), 58(5): 509-521.
3. Gal PYL, Kuper M, Moulin CH, Srai RMT, Rhouma A (2009). Linking Water Saving And Productivity To Agro-Food Supply Chains: A Synthesis From Two North Afri.,Cases J. Irrigation and Drainage, 58: S320–S333.
4. Chandra A.M, Helen F (2010). Irrigation in the Context of Today's Global Food Crisis, Irrigation and Drainage, 59: 40-52
5. Sagardoy JA, Bottrall A, Uittenbogaard GO (1986) Organization, operation and maintenance of irrigation schemes, Irrigation and Drainage. FAO, Rome, p 40
6. Xie M, Kuffner U, Le Moigne G (1993) Using water efficiently: technological options, World Bank Technical, Washington, DC, p 205
7. Alam MM, Bhutta MN (2004) Comparative evaluation of canal seepage investigation techniques. Agric Water Manag 66:65–76
8. Akkuzu E, Unal HB, Karatas BS (2006) Determination of water conveyance loss in the Menemen open canal irrigation network, Turk J Agric for 31:11–22
9. Bhattarai, M., Sakthivadivel, R., Hussain, I. (2002), Irrigation impacts on income inequality and poverty alleviation: Policy issues and options for improved management of irrigation systems. Working Paper 39, Colombo, Sri Lanka: International Water Management Institute, 37pp.
10. Hussain, I. and Hanjra, M.A. (2004), Irrigation and Poverty alleviation: Review of the empirical evidence, Journal of Irrigation and Drainage, 53: 1-15.
11. Malhotra, S. P. 1982. The warabandi system and its infrastructure, New Delhi: Central Board of Irrigation and Power.
12. H.M. Raghunath (2006), Hydrology: principles-analysis-design, New Age International Publisher, 2nd edition