

Improving Conveyance Efficiency through Canal Lining in Command Area: A Case Study

P. B. Jadhav

M. Tech (Ag. Engg.) Student,
College of Agril. Engg. & Tech., Dr. Balasaheb
Sawant Konkan Krishi Vidyapeeth, Dapoli
Email: jadhavpradnya12@gmail.com

R. T. Thokal

Chief Scientist,
AICRP on Water Management

M. S. Mane

Professor & Head,
Deptt. of Irrigation & Drainage Engg.,
College of Agril. Engineering & Tech.,
Dapoli

H. N. Bhange

Assistant Professor,
Department of Soil & Water Conservation Engineering,
College of Agril. Engg. & Tech., Dapoli

S. R. Kale

Associate Professor,
Department of Irrigation & Drainage Engineering,
College of Agril. Engg. & Tech., Dapoli

Abstract – Conveyance losses from lined and unlined sections of canal irrigation network were determined under existing situation and the scenarios for different management strategy were developed to utilize saved water for irrigation. Panchnadi Minor Irrigation Project was taken as a case study. The study revealed that overall efficiencies of the lined and unlined sections of main canal and unlined field channels under existing condition were 75.1, 52.3 and 34.8%, respectively. Conveyance losses through canal network of the command were 0.97 Mm³ amounting to about 67% of the total live storage. The study also indicated that 0.263 Mm³ water can be saved due to conversion of unlined sections of main canal water and 0.113 Mm³ can be saved through conversion of unlined field channels into lined sections. With these savings, about 30 and 19 ha additional area can be brought under irrigation by keeping existing cropping pattern unaltered. The conveyance efficiency can be improved to 75 per cent from the present efficiency. Water saving to the tune of 0.65 and 0.17 Mm³ can be achieved through conversion of existing main canal sections and field channels, through which an additional area 73.3 and 19.3 ha additional area can be irrigated. Thus, total water saving of 0.82 Mm³ can be achieved and 92.6 ha additional area can be brought under irrigation.

The scenarios were developed by considering the area additional area distributed among the first three highest benefiting crops like banana, watermelon and chilli using Aquacrop model developed by FAO. The gross water allocation was reduced about 26% and 57% while the project net benefit can be increased by 3.3 times (78.6 lakh) and 6 times (141.1 lakh) more than projected benefit (Rs. 23.67 lakh) under existing conditions when unlined canal sections is converted into lined sections or when whole canal network is replaced by closed conduit.

Keywords – Conveyance Loss, Conveyance Efficiency, Lined, Unlined Canal Sections.

I. INTRODUCTION

Scarcity of water resources and growing competition for water in many sectors reduce its availability for irrigation. The growing water demand to meet urban and industrial needs has raised serious concerns as to the future of irrigated agriculture and many parts of the world (FAO, 2000). An FAO analysis (2003) of 93 developing countries expects increase of agricultural production over the period

1998-2030 by 49% in rain fed and by 81% in irrigated regions. Therefore, much of the additional food production is expected to come from irrigated land, three quarters of which are located in developing countries. In developing countries, the irrigated area in 1998 has nearly doubled than that in 1962. FAO estimates that the irrigated area in the selected 93 developing countries will only grow by 23% over the 1998-2030 periods. However, the effective harvested irrigated area (considering the increase in cropping intensity) is expected to increase by 34%. This means that more area needs to be brought under irrigation to produce more crops with the present available water resources.

Canals continue to be major conveyance systems for delivering water for irrigation in India. But seepage loss from irrigation canals constitutes a substantial percentage of the usable water. By the time the water reaches the field, it has been estimated that the seepage losses are of the order of 45% of the water supplied at the head of the canal (Sharma and Chawla, 1975). According to the Indian Standards (Measurement, 1980), the loss of water by seepage from unlined canals in India generally varies from 0.3 to 0.7 m³/s per 106 m² of wetted surface. It has been estimated (Sharma and Chawla, 1975) that if seepage loss is prevented in alluvial canals in India, about 6,000,000 ha of additional area could be irrigated. Seepage losses have been identified as a significant loss from the irrigation channels from both water quantity and environmental degradation perspective. Canal conveyance losses include seepage and evaporation losses, of which evaporation loss in irrigation networks is generally not taken into consideration (Xie *et al.*, 1993; ANCID, 2000). Badenhorst *et al.*, (2002) revealed that seepage loss in the irrigation canals accounted for the major portion of water conveyance loss (98.37%) while approximately 0.3 per cent of the total stream is lost due to evaporation. Seepage from a lined canal occurs at a reduced rate. An examination of canals by Wachyan and Rushton (1987) indicated that even with the greatest care the lining does not remain perfect. A well-maintained canal with 99% perfect lining reduces seepage about 30-40% (Wachyan and Rushton, 1987); seepage from canal cannot be controlled completely. Significant seepage losses do occur from a canal even if it is lined. This problem more

aggravates in percolative soils. Thus, the conversion of canal lining to pipeline may lead to further reduction in seepage losses. With the objective of saving of harvested water in tanks, the study was undertaken and scenarios were developed for different canal management strategies.

II. MATERIALS AND METHODOLOGY

A. Study area

The study area selected for this study is the command area of Panchnadi Minor Irrigation Project, which is located on Panchnadi river Dapoli tehsil of Ratnagiri district, Maharashtra state (India). The location map of Panchnadi Minor Irrigation Project is shown in Fig. 1.1. The command area is located at $73^{\circ} 10'$ E longitude and $17^{\circ} 37'$ N latitude. Total storage, active or live storage and dead storage of tank are 1.738 Mm^3 , 1.461 Mm^3 and 0.277 Mm^3 respectively. The right bank canal of distribution system covers the length of 2.91 km and area under irrigation is 71 ha and 100 percent earthwork is completed. The left bank canal covers the length of 1.32 km, and area under irrigation is 20 ha. The proposed total area under irrigation of tank is 114 ha.

The proposed cropping pattern consists of 28.5 ha (25%) under plantation crops, 62.7 ha (55%) under vegetables, pulses and groundnut and 22.8 ha (20%) under *rabi* paddy. The area under existing cropping pattern is 30.70 per cent compared to the proposed cropping pattern. The existing area under arecanut, coconut, mango, *rabi* paddy, vegetables is 96.4, 60, 30, 5 and 53.33 per cent of proposed area. The banana is a new crop under existing cropping pattern. The horticulture crops like cashew and mango are cultivated at upstream of the tank and the farmers starve for the share of irrigation water directly from tank.

Major part of the irrigation command is occupied by sandy clay (70.03 per cent sand, 18 per cent silt and 11.97 per cent clay) soil followed by sandy clay loam (55.22 per cent sand, 18.75 per cent silt and 26.025 per cent clay) soil.

B. Measurement of conveyance losses

The conveyance loss comprising seepage and evaporation losses from reservoir were considered as 10 per cent of the live storage of the reservoir i.e. 0.146 Mm^3 according to geotechnical report of Panchnadi minor irrigation project (Anonymous, 1999), while those were determined in the canal network as per the section. Sections were classified as lined and unlined.

C. Measurement of seepage losses through canal network

Seepage loss through canal network was determined by using volume balance equation. Dimensions of canal section and field channel were measured with the help of measuring tape and velocity at two sections under consideration in each lined and unlined main canal section and unlined field channel sections was measured using current meter.

$$\text{Seepage Loss} = (Q_1 - Q_2) \quad (1)$$

Where, conveyance loss in m^3/s ; Q_1 is discharge at upstream end, m^3/s ; Q_2 is discharge at downstream end, m^3/s and d is distance between two points, m .

Discharges were determined by using following equations

$$A_1 = \left(\frac{TW_1 + BW_1}{2} \right) \times H_1 \quad \dots (2)$$

$$A_2 = \left(\frac{TW_2 + BW_2}{2} \right) \times H_2 \quad \dots (3)$$

$$Q_1 = A_1 \times V_1 \quad \dots (4)$$

$$Q_2 = A_2 \times V_2 \quad \dots (5)$$

Where, TW_1 and TW_2 are top widths of water surface in canal section (m); BW_1 and BW_2 are bottom widths of canal section (m); H_1 and H_2 are depths of water surfaces from bottom (m); A_1 and A_2 are cross sectional areas (m^2); V_1 and V_2 are water velocities at (m/s) and Q_1 and Q_2 are discharges (m^3/s) at points 1 and 2, respectively.

D. Calculation of evaporation losses

Evaporation loss depends on the evaporative demand of the atmosphere and was calculated in the different canal sections as follows,

$$E = E_s \times \text{Evap} \quad \dots (6)$$

$$E_s = TW_s \times L \quad \dots (7)$$

Where, E is evaporation loss (m^3/day); E_s is surface area of water exposed for evaporation (m^2); Evap is evaporation rate (m/day); TW_s is top width of exposed water surface in canal section (m) and L is length of canal (m).

E. Conveyance loss

The conveyance loss of water due to seepage and evaporation from irrigation canals constitutes a substantial part of the usable water and is calculated as,

$$\text{Conveyance loss} = \text{Evaporation loss} + \text{Seepage loss} \quad (8)$$

F. Water conveyance efficiency

Conveyance efficiency is used to evaluate the efficiency of the system conveying water. It is also used to measure the efficiency of channels conveying water from source to fields. Water conveyance efficiency may be defined as the percentage ratio of the amount of water delivered to fields or farms to the amount of water diverted from sources.

$$\text{Conveyance Efficiency} = \left(\frac{Q_2}{Q_1} \right) \times 100 \quad \dots (9)$$

G. Scenario development for increasing conveyance efficiency by canal lining or adaption of closed conduit

The conveyance efficiency in the unlined irrigation system, which was about 56 per cent, can be increased to 88 per cent, when the whole system is lined. Therefore there is considerable scope of improving the efficiency of water use by lining the system (Anonymous, 1972).

Pipe flow offers many advantages over open channels in water conveyance and distribution. The average conveyance efficiency of PVC buried pipe ranged from 94.46 per cent to 95.37 per cent and rate of water loss ranged from 5.45 per cent to 9.55 per cent. The conveyance efficiency of pipe flow increased up to 95 per cent (Rahman *et al.*, 2011).

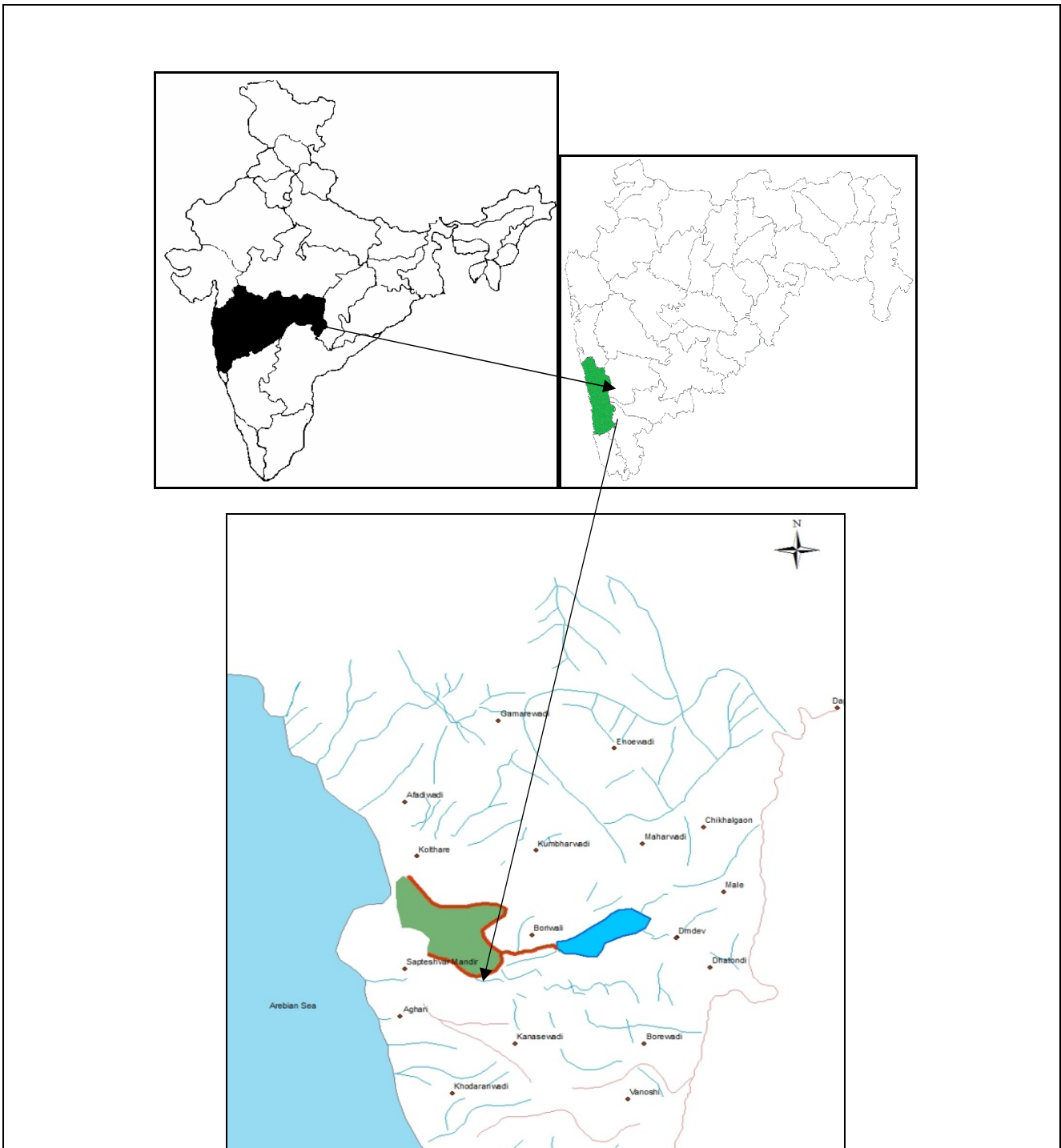


Fig.1.1. Location map of study area

III. RESULTS

The main canal is lined for 1.33 km and remaining length (0.67 km) is unlined. The whole field channel length (0.29 km) is unlined. Conveyance losses from the canal network determined under existing situation were worked out and are presented in Table I to Table III.

Results in Table I to III indicated that overall conveyance efficiency of the lined, unlined section of the main canal and field channel was observed as 75.3, 52.1

and 34.8 per cent respectively. The conveyance loss per metre length of main canal in the section 1 (0-40m chainage) was significantly more than the other lined sections of main canal (Table I). This indicated the priority of maintenance in this section is essential as compared to other lined sections of main canal. In lined, unlined main canal sections and field channels, the evaporation loss was 1.32 per cent, 0.22 per cent and 0.045 per cent of total loss. Conveyance loss in lined and unlined sections of main canal indicated the decreasing trend as the chainage

increased, however, the same trend was not observed in the unlined sections of field channels (Table I to III). This was only due to irregular shapes throughout the length and poor maintenance of the field channels and they have lost their regular shapes after construction. The conveyance

loss (m^3/m canal length) of first unlined section of canal was 6.6 per cent more than first lined section, while this loss was 3 times more in second section. In case of the third section the loss was 2.4 times more in unlined section than lined section of canal.

Table I: Conveyance loss and conveyance efficiency in lined sections of main canal

Chainage (m) in canal section	Conveyance loss (Mm^3)			Conveyance loss (m^3/m canal length)	Overall conveyance efficiency (%)
	Seepage loss (Mm^3)	Evaporation loss (Mm^3)	Total loss (Mm^3)		
0-40	0.049	9.9×10^{-5}	0.05	1250	75.3
281-480	0.057	3.56×10^{-4}	0.06	300	
631-720	0.022	1.52×10^{-4}	0.02	222	
1001-2000	0.054	1.87×10^{-3}	0.06	60	
Total	0.183	2.45×10^{-3}	0.184		

Table II: Conveyance loss and conveyance efficiency in unlined sections of main canal

Chainage (m) in canal section	Conveyance loss (Mm^3)			Conveyance loss (m^3/m canal length)	Overall conveyance efficiency (%)
	Seepage loss (Mm^3)	Evaporation loss (Mm^3)	Total loss (Mm^3)		
41-280	0.32	5.39×10^{-4}	0.32	1333	52.1
481-630	0.14	2.57×10^{-4}	0.14	933	
721-1000	0.15	5.54×10^{-4}	0.15	536	
Total	0.61	1.34×10^{-3}	0.61		

Table III: Conveyance loss and conveyance efficiency in unlined sections of field channels

Chainage (m) in canal section	Conveyance loss (Mm^3)			Conveyance loss (m^3/m canal length)	Overall conveyance efficiency (%)
	Seepage loss (Mm^3)	Evaporation loss (Mm^3)	Total loss (Mm^3)		
210	0.044	3.76×10^{-5}	0.0441	1917	34.8
630	0.044	3.88×10^{-6}	0.0442	485	
1030	0.041	2.43×10^{-5}	0.041	1171	
1400	0.031	1.41×10^{-5}	0.031	1000	
1700	0.024	8.17×10^{-5}	0.024	218	
Total	0.183	8.16×10^{-5}	0.183		

The evaporation losses in lined canal were observed to be more than the unlined section because the length of lined section is about 2 times that of the unlined section. The total loss from lined, unlined main canal sections and unlined field channels was observed as 0.184, 0.61 and 0.183 Mm^3 , respectively.

The canal runs from 1st October to 31st May for about 240 days. Thus the total conveyance loss was calculated for run time of canal during 240 days. Also the net and gross water requirements of crops under each outlet for existing cropping pattern were calculated. The results indicated that the net water requirement for crops in command area is 0.31 Mm^3 while gross water requirement is 1.43 Mm^3 . This indicated the overall efficiency of the project was about 22%. It was also seen that the major losses (0.97 Mm^3) through the canal network which comes about 67% of the total live storage. These results emphasize that there is a need of management intervention through either converting the unlined canal network sections into lined sections or replacing the existing canal network with pipeline. The scenarios were developed for these aspects.

A. Management strategies

Improving conveyance efficiency through lining the unlined sections of canal network

The results on conveyance losses in the canal network explained in the previous section indicated that the conveyance efficiency of unlined main canal sections having the total length 0.67 km was 52.1%. Also conveyance efficiency was very poor (34.8%) for the unlined field channels. This indicated the scope to improve the conveyance efficiency of the canal network sections at least up to 75 per cent through lining. Thus the scenarios were developed for these sections for lining the unlined sections of the canal network and improving conveyance efficiency so as to quantify the water saving by reducing these losses. The probable water saving and predicted additional area that can be brought under irrigation after converting unlined sections of main canal and field channel into lined sections are given in Table IV and Table V, respectively.

Table IV: Project water saving and additional area that can be irrigated after converting unlined sections of main canal in lined sections

Chainage (m) in canal section	Conveyance efficiency before lining (%)	Conveyance efficiency after lining (%)	Total loss (Mm ³) before lining	Total loss (Mm ³) after lining	Projected water saving (Mm ³)	Projected additional area (ha) through water saving
41-280	58	75	0.32	0.192	0.13	14.7
481-630	64	75	0.14	0.097	0.043	4.9
721-1000	35	75	0.15	0.056	0.09	10.2
Total					0.263	29.8

Table V: Water saving and additional area that can be irrigated after converting unlined sections of field channel in lined sections

Chainage (m) in canal section	Conveyance efficiency before lining (%)	Conveyance efficiency after lining (%)	Total loss (Mm ³) before lining	Total loss (Mm ³) after lining	Projected water saving (Mm ³)	Projected additional area (ha) through water saving
210	38	75	0.0441	0.018	0.026	2.9
630	36	75	0.0442	0.017	0.027	3.0
1030	34	75	0.041	0.015	0.025	2.8
1400	33	75	0.031	0.012	0.019	2.1
1700	32.5	75	0.024	0.009	0.015	1.7
Total					0.113	12.5

The results in Table IV and V indicated that 0.263 Mm³ of water can be saved from which 29.8 ha additional area can be irrigated by lining the unlined sections of main canal are converted into lined sections. Similarly 0.113 Mm³ of water can be saved from which 12.5 ha additional area can be irrigated by providing lining to unlined field channels. Thus, 0.376 Mm³ of water can be saved from which total 43 ha additional area can be irrigated through lining to unlined sections of unlined main canal and field channels and thus improving conveyance efficiency up to 75 per cent from the present efficiency.

Improving conveyance efficiency by providing closed conduit canal network

Total evaporation loss from canal network was 0.004 Mm³ which was about 0.40% of the total losses (Table I to III). Rahman *et al.* (2011) revealed that average conveyance efficiency of PVC buried pipe ranged from 94.46 to 95.37 per cent and rate of water loss ranged from

5.45 to 9.55 per cent. The evaporation losses, however of the negligible amount as compared to seepage losses, can also be controlled through the closed conduit networking. The pipe line/closed conduit networking can also facilitate the adaption of micro irrigation.

The results indicated that with the conversion of unlined and lined sections of canal network into closed conduit, an additional area of 73.3 ha can be irrigated with the saved water of 0.65 Mm³ (Table VI) i.e. about two times more than the existing area under irrigation can be irrigated. Also an additional area of 19.3 ha i.e. about half of the existing area under irrigation can be irrigated through the conversion of unlined field channels with closed conduit. If whole canal network is converted in closed conduit then and additional area of 92.6 ha can be brought under irrigation i.e. about 2.6 times more than the existing area with the water saving of 0.82 Mm³.

Table VI: Water saving and additional area that can be irrigated through conversion of unlined canal network by closed conduit

Chainage (m) in canal section	Conveyance efficiency before conversion (%)	Conveyance efficiency after conversion (%)	Total loss (Mm ³) before conversion	Total loss (Mm ³) after conversion	Projected water saving (Mm ³)	Predicted additional area (ha) through water saving
Main canal sections						
0-40	94	95	0.049	0.041	0.008	0.9
41-280	58	95	0.318	0.038	0.28	31.6
281-480	87	95	0.062	0.022	0.04	4.5
481-630	64	95	0.139	0.019	0.12	13.5
631-720	91	95	0.022	0.012	0.01	1.1
721-1000	35	95	0.151	0.011	0.14	15.8
1000-2000	29	95	0.056	0.004	0.052	5.9
Total					0.65	73.3

Field channel sections						
210	38	95	0.0441	0.004	0.040	4.5
630	36	95	0.0442	0.003	0.041	4.7
1030	34	95	0.041	0.003	0.038	4.3
1400	33	95	0.031	0.002	0.029	3.3
1700	32.5	95	0.024	0.002	0.022	2.5
Total					0.17	19.3
Grand Total					0.82	92.6

IV. CONCLUSION

The water loss from tank as well as canal network through seepage was determined and evaporation loss was estimated for Panchnadi Minor Irrigation Project in Konkan region. The conveyance efficiency of the lined, unlined section of the main canal and field channel was observed as 75.3, 52.1 and 34.8%, respectively. The total loss from lined, unlined main canal sections and unlined field channels was observed as 0.184, 0.61 and 0.183 Mm³, respectively. The conveyance loss per metre length of main canal in the section 1 (0-40m chainage) was significantly more than the other lined sections of main canal. The scenarios developed for providing lining to unlined sections of canal network or conversion of canal network indicated that providing the lining to unlined sections of main canal can bring an additional area of 29.8 ha with water saving of 0.263 Mm³ and 12.5 ha additional area can be irrigated by providing lining to unlined field channels through water saving of 0.113 Mm³. Thus, 0.376 Mm³ of water can be saved from which total 43 ha additional area can be irrigated through lining to unlined sections of unlined main canal and field channels and thus improving conveyance efficiency up to 75 per cent from the present efficiency. Similarly conversion of unlined canal network into closed conduit can bring an additional area of 92.6 ha through water saving of 0.82 Mm³.

REFERENCES

- [1] ANCID. 2000. Open channel seepage and control—literature review of channel seepage identification and measurement. Australian National Committee on Irrigation and Drainage (ANCID), Victoria, Australia. Vol 1.1.
- [2] Anonymous. 1972. Lining of Irrigation Channels'. Report of irrigation commission, Ministry of Irrigation and Power, Govt. of India, New Delhi. (I):116-119.
- [3] Anonymous. 1999. Geotechnical report on Panchnadi Minor Irrigation Scheme. Irrigation Department, Government of Maharashtra. Report No. 382.
- [4] J.W. Badenhorst, M. De Lange, M.E. Mokwena and R.J. Rutherford, 2002. Water conservation and water demand management in agriculture: development of water management plans by irrigation water suppliers in South Africa. In: ICID Eighteenth Congress Best Paper for 6th Hassan Ismail Award Paper, Montreal.
- [5] Food and Agriculture Organization. 2000. Deficit irrigation practices. Water Reports No. 22. Rome, Italy: United Nations FAO.
- [6] Food and Agriculture Organization, 2003. World agriculture: towards 2015/2030. Earthscan Publications Ltd. London, 432pp.
- [7] "Measurement of seepage losses from canals" (1980). IS: 9452 (part I & II). Indian Standard Code of Practice. Indian Bureau of Standard, New Delhi.

- [8] Rahman, M., A. H. M. Kamal, A. A. Mamun and S. U. Miah. 2011. Study on the irrigation water distribution system developed by barind multipurpose development authority. Journal of Bangladesh Association of Young Resarchers 1(2): 63-71.
- [9] Sharma, H.D. and Chawla, A.S. 1975. Manual of canal lining. Technical Report No. 14. Central Board of Irrigation and Power, New Delhi.
- [10] Wachyan, E. and Rushton, K.R. 1987. Water losses from irrigation canals. J. Hydrology, Amsterdam, 92(3-4): 275-288.
- [11] Xie, M., U. Kuffner and G. Le Moigne. 1993. Using water efficiently: technological options. World Bank Technical Paper Number 205. Washington, D.C., USA.

AUTHOR'S PROFILE



Miss. Pradnya Balkrishna Jadhav

did her B. Tech (Agricultural Engineering) from Mahatma Phule Krishi Vidyapeeth, Rahuri (Maharashtra) and M. Tech (Agricultural Engineering) with specialization in Irrigation & Drainage Engineering from Dr. B.S. Konkan Krishi Vidyapeeth, Dapoli (Maharashtra). Presently she is doing Ph.D. from department of Irrigation & Drainage Engineering in Mahatma Phule Krishi Vidyapeeth, Rahuri (Maharashtra).



Rajesh Tulshiram Thokal

Present Designation: Chief Scientist, All India Co-ordinated Research Project on Water Management, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Dist. Ratnagiri
Date of Birth: 25/06/1966
Email: rtt1966@yahoo.com

Qualification: Ph.D. (Irrigation Water Management Engineering)
Experience: 24 Years

Areas of specialization: Irrigation & Drainage Engineering, Remote Sensing and GIS, Water Management, land reclamation

Publications:

Research papers:	38
Technical papers:	30
Extension articles:	10
Technical bulletins:	01
Books:	08
M. Tech (Agril. Engg.) students guided:	04
PG Advisory Committee Member:	08
Ph.D. Advisory Committee Member	02
Recommendations for farmers:	08

Prizes/Awards/Honours:

1. Tenant of UNDP Fellowship for M.Tech studies during 1988-1990
2. Subject Prize Award in Agricultural Engineering conferred by Institution of Engineers (India), Kolkata to Mr. R. T. Thokal and Mr. D.M. Mahale for the paper entitled "Influence of Meteorological Variables on Weekly, Monthly and Seasonal Pan Evaporation under Humid Climatic Conditions of Dapoli" published in the Journal of the Institution of Engineers (India) Vol.:88:12-17. This award was conferred in 23rd Indian Engineering Congress held at Warangal on December 12, 2008.



Dr. M. S. Mane

completed Bachelors (1990) and Masters degree (1992) in Agricultural Engineering from Mahatma Phule Krishi Vidyapeth, Rahuri (Maharashtra). His Specialization for Masters was on Irrigation & Drainage Engineering also completed Ph.D. from IARI, New Delhi in Soil & Water Conservation Engineering. He is having total 20 years of experience in research, education and extension. He has written number of research papers in internationally abstracted papers and received three awards for the best papers out of them. Presently he is working as Professor & Head, Department of Irrigation & Drainage Engineering, College of Agril. Engineering and Technology, Dapoli (M.S.).



Shri. Harshalkumar Namdeorao Bhange

(b. 1st May, 1976) completed Bachelors in Agricultural Engineering from Dr. PDKV, Akola, MS, India in 1997 and Masters Degree in Agricultural Engineering with specialization in Soil Water Engineering and Management, IGKV, Raipur, CG, India in 2000. He is Member of Institution of engineers (India), Indian Society of Agricultural Engineering, Indian Association of Hydrologists Association of Agrometeorologists. Presently working as Assistant Professor (SWCE), College of Agricultural Engineering and Technology, Dapoli, Dist Ratnagiri, MS, India. He is working in the field of watershed development, surface rainwater harvesting, since last 13 years, that includes teaching, research and extension. He has contributed in 12 state level recommendations.



Prof. S. R. Kale

did his post-graduation in Water Resource Development from IIT, Roorkee. He has rendered his services In Kukadi command as developed engineer followed by field research in water resource management in Dr. B.S. Konkan Krishi Vidyapith, Dapoli (Maharashtra). He has his credit three books, about twenty research papers and more than fifty popular articles on rain water harvesting, micro irrigation system and resource development. He was also actively involved in design and execution of list irrigation and drip irrigation for orchards crops like mango, cashew and coconut in Konkan region. Presently he is working as associate professor in Faculty of Agriculture Engineering.