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Research Bulletin 39

Generating Employment for Rural Poor through Water Management Interventions : Model Design and Estimate

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WATER TECHNOLOGY CENTRE FOR EASTERN REGION
(Indian Council of Agricultural Research)
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Mishra, A., Jena, S.K., Mohanty, S., Sethi, R.R., and Kumar, A. (2007). *Generating Employment for Rural Poor through Water Management Interventions: Model Design and Estimate.* Research Bulletin No. 39, Water Technology Centre for Eastern Region (Indian Council of Agricultural Research), Bhubaneswar-751023, Orissa, India.

Published by

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Water Technology Centre For Eastern Region
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Printed By

Capital Business Service and Consultancy
B-51, Sahid Nagar, Bhubaneswar, Ph: (0674)2545484

PREFACE

The intention of the National Rural Employment Guarantee Act (NREGA)–2005, Ministry of Rural Development, Govt. of India, is to provide a basic employment guarantee in rural areas. The Rural Employment Guarantee Scheme (REGS) focuses on the following works:

- Water conservation and water harvesting;
- Drought proofing, including afforestation and tree plantation;
- Irrigation canals including micro and minor irrigation works;
- Provision of irrigation facility to land owned by households belonging to SC/ST, or to land of the beneficiaries of the land reforms, or to the land of the beneficiaries under *Indira Awas Jojana;*
- Renovation of traditional water bodies including desilting of tanks;
- Land development;
- Flood control and protection works including drainage in waterlogged areas;
- Rural connectivity to provide all-weather access. The construction of roads may include culverts where necessary, and within the village area may be taken up along with drains; and
- Any other works that may be notified by the Central Government in consultation with the State Government;

As is evident, out of the eight specified work items, about six items are related to various water management aspects. Besides creating employment during the creation of assets, these water management interventions will increase the overall production and productivity of the agricultural system and also generate employment even after the creation of assets. Thus, it is a win-win situation.

Implementing REGS is a multifaceted task which requires concerted effort of many agencies. Implementation of the scheme in rural areas with little availability of technical manpower may reduce the pace of the progress. Therefore, the authors have attempted here to identify effective labour intensive interventions for water conservation, water harvesting, drought proofing etc. About eighteen such water management interventions have been identified for various land forms. To make their execution easy and qualitative, exercises have also been made on preparation of simple design and estimate of each of the identified interventions. Hope this exercise will enable the professionals, persons involved in execution, *Panchayats* and also non-technical persons to easily assess the labour and material requirements while executing these works.

The authors are grateful to the Director General, Deputy Director General (NRM) and ADG (IWM), ICAR for their encouragement, guidance and support for preparation of this document. Our thanks are also to the Director and all the scientist colleagues of WTCER, Bhubaneswar.

April, 2007 AUTHORS

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INTRODUCTION

The Rural Employment Guarantee Scheme (REGS) aims at creation of 100 days guaranteed employment for each household adult seeking employment and willing to carry out unskilled manual work in a financial year. The act identifies the Gram *Panchayats* as primary implementing agency of the scheme in the villages. The village natural resource endowment like land and water would attract maximum attention in the participatory micro level planning under the scheme. The *Gram Sabha* would recommend the work and identify the employment seekers. The perspective plan of each district for REGS would be eventually based on village level micro plans developed through participatory problem identification and possible interventions. The REGS emphasizes that a substantial chunk of the budget should be spent on creation or renovation of water resources that would ensure creation of productive assets, protection of environment, creation of equal opportunities for rural women and reduction in migration of unskilled labourers.

The successful implementation of the REGS depends upon advanced planning that would ensure proper design and selection of works such that good quality assets are developed through interventions. For ready implementation of the programme the Gram *Panchayats* should be equipped with the location specific design of the interventions. Though a tailor made prescription can not be handed out to the district authorities and *Panchayats*, a general guideline for design and some sample location specific estimates of interventions would be helpful at the time of need.

The Water Technology Centre for Eastern Region has been carrying out location specific research and extension on various water management interventions in the eastern states which has not only been effective in increasing agricultural productivity in the region, but also able to generate additional on-farm and off-farm employment through the technology adoption and replications. The water management interventions like water harvesting structures for water conservation, irrigation ponds, irrigation channels including minor canals irrigation works, drainage in waterlogged areas, renovation of traditional water bodies, flood control and protection works, field bunding, contour bunding, check dams for irrigation purposes etc. form priority interventions. As the planning and implementation of the asset creation is people centric, the designs of the structures should be simple and cost effective. The present district level identification of the water management problems in the eastern region and their possible solution through REGS suggested by WTCER is an exercise towards simplification of water management interventions with user friendly designs. The districts are heterogeneous with respect to resource endowment and their exploitation. The socio-economic and agricultural scenarios also vary considerably across the eastern region. However, taking into consideration the existing physiography, topography, cropping pattern and water resource scenario, possible interventions for micro level planning and design that may be implemented through REGS across the eastern states (Orissa, West Bengal, Bihar, Assam, Chhatisgarh, Jharkhand, and Eastern UP) by the district level functionaries are identified. The technologies/interventions listed below are primarily employment generation oriented with a focus to improve the water resource scenario and farm productivity of the eastern states. The model design and estimate of these interventions with the benefit envisaged are presented below. However, the actual design and estimates depend on the exact site/ locations and may vary.

LIST OF WATER MANAGEMENT INTERVENTIONS FOR DIFFERENT LANDFORMS

Rainfed uplands

1. Field bunding/graded bunding/contour bunding.
2. Tank cum well system.
3. Percolation tank.
4. *Mahabandh* along with conveyance network involving more than 100000 m^3 storage (100 x 200 x 5m).
5. Dugout ponds in rice fields.
6. Check dams/diversion weir on well defined *Nala*.

Rainfed lowlands

7. Comprehensive drainage system inclusive of field drains, lateral drains and main drain.
8. Subsurface WHS in coastal areas.
9. Very shallow type wells in coastal areas having saline groundwater below 10 m.
10. Conversion of lowlands to aquaculture tanks.
11. Peripheral dykes for saucer shaped waterlogged areas.

Canal irrigated areas

12. Renovation of field channel/construction of new field channels.
13. Renovation of drainage system.
14. Raised and sunken bed system for small and marginal farmers.
15. Renovation of minors transferred to Water Users Associations.

Groundwater utilization

16. Groundwater utilization through open dug wells for small and marginal farmers.
17. Manually drilled shallow tube wells in alluvial areas.

Miscellaneous

18. Renovation of existing tanks/ponds on Government/community land.

MODEL DESIGN AND ESTIMATES

Rainfed uplands

1. Field bunding/ Graded bunding/ Contour bunding

Contour bunding (Plate 1) consists of constructing narrow based trapezoidal bunds on contour to impound runoff water behind them so that all the impounded water is absorbed gradually into the soil profile for crop use. Field bunding/graded bunding/contour bunding is adopted in rolling and flat lands (slopes less than 6%) to intercept the runoff flowing down the slope by an embankment whose ends may be closed to conserve moisture as well as to reduce erosion. It is also necessary in contour bunding system to remove excessive runoff resulting from high intensity storms by surplus arrangements. Contour bunding is adopted in low to medium rainfall region where water conservation is the objective; where as graded bunding is adopted in high rainfall region where soil erosion control is the objective. Bunding can be adopted on all types of relatively permeable soil (e.g. alluvial, red, laterite, brown soil, shallow and medium black soils except the deep black cotton soils). This is the most popular

Plate 1. Contour bunding

soil conservation measure in the country and is practiced on large scale in different states. While executing bunding for certain area, the spacing and cross section of the bund need to be determined.

Spacing of field bund/contour bund

The main criterion for spacing of bunds is to intercept the water before it attains erosive velocity. This will depend mainly on slope, soil, rainfall, crop coverage and conservation practices adopted. In eastern India where the annual rainfall is more than 900 mm, the vertical interval is recommended to vary between 0.6 m (for 2% slope) to 1.2 m (for 6% slope) for an average crop cover. The vertical spacing can be increased by 10% or by 15 cm to provide better location, alignment or to avoid obstacle.

Cross-section of the field bund

The cross section of the bund (Plate 2) is kept as trapezoidal with top width 30 cm, side slope 1:1, height 45 cm, and bottom width 1.2 m (as determined from the study at WTCER). It is expected that height will reduce due to compaction after the 1st rain. Considering the small farm holding in eastern India, the above cross section is recommended. The construction should start from the top of the catchment and proceed downwards. The cross section of the bund is shown in Figure 1.

Plate 2. Field bunding in rice field

Disposal of excess water

In order to protect the bund from being over topped and also for avoiding damage to crop due to standing water, surplus weirs are constructed to dispose off the excess water. This could be either a clear over-fall stone weir or a prefabricated cement

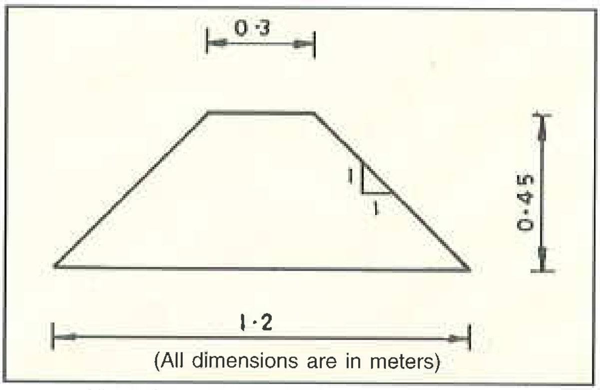


Fig.1 Cross section of bund for 1ha land

concrete weir/drop structure. The crest length should be 30 cm to 50 cm. A brick masonry broad-crested rectangular weir can also be used as surplus weir.

Estimation of earthwork, materials, cost and mandays

It is considered that 1 ha land (100 m x 100 m field size) has been divided into two equal parts. So the average bund length assuming only two sides of each small unit (0.5 ha) to be bunded is 300 m/ha land.

Area of cross section=0.3375 m^2

Volume of earth work = 0.3375 x 300= 101.25 m^3

Cost of excavation and formation of bund @ Rs.30/ m^3=101.25 x 30=Rs.3,038

Assuming cost of brick masonry broad-crested rectangular weir/ prefabricated cement concrete drop structure = Rs.662

Total cost of construction=Rs.3,700/ ha

Considering the wage of unskilled labour as Rs. 60 per day and skilled labour as Rs. 100 per day, the total man days generated/ ha = 52 (Unskilled=50, Skilled=2).

Benefit envisaged

After creation of assets i.e. construction of bunds, it is expected that moisture/ nutrient availability in the field will enhance. This will result increase in *kharif* paddy yield from 1.5 t/ha to 2 t/ha. It is also expected that pulses/ oilseeds can be grown using the residual moisture. Total investment, mandays generated, production potential increased, potential mandays generation due to asset created is given in Table No. 1.

Table 1. Income and mandays generation in the event of bunding intervention

Technology	Investment/ ha(Rs.)	Man days generation	Production potential (t/ha)				Potential income generation (Rs)/yr			Potential mandays generation due to asset created
			Crop	Pre	Post	Increase	Pre	Post	Increase	
Contour bunding/ field bunding/ graded bunding	3700/ha	52	Paddy	1.5	2.0	0.5	9000	12000	3000	20
			Pulses/ oil seed	0	0.75	0.75	0	7500	7500	30
Total							9000	19500	10500	50

2. Tank cum well system

The technology of tank cum well system which is developed and field tested at WTCER, involves construction of tanks and wells in series along the drainage line in a watershed. This technology is recommended for plateau areas with slope of 2 to 5%. The tanks act as a water harvesting structure in the watershed. The runoff is stored in the tank and can be used for meeting the irrigation requirement in the post monsoon season and supplemental irrigation requirement of monsoon season crop. The site for the intervention should be selected in such a way that the area should have a well defined valley where the runoff flows either as overland flow or channel flow. However, severely gullied area should be avoided. The well is constructed at about 100 to 300 m distance on downstream of the tank to arrest the water that is lost by seepage from the tank. If the tank is relatively big having considerable groundwater recharge, then more than one dug-well can be constructed with spacing of 200-300 m. The tanks may dry up by the months of February or March. After drying up of tanks, wells will be very useful in meeting the irrigation requirement of the crops. The schematic diagram of the tank cum well system is shown in Figures 2 & 3.

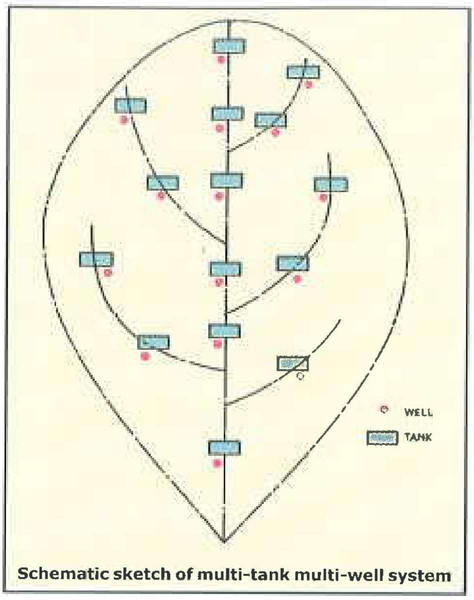


Fig. 2 Possible locations of multi tank cum well system in a hypothetical watershed

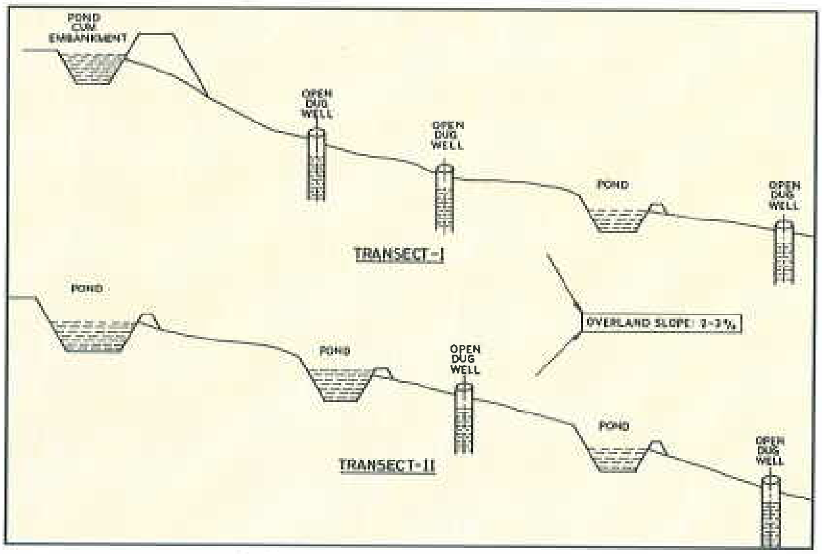


Fig. 3 Schematic diagram of tank cum well system in two transects

Design

A model design is presented for a watershed of 500 ha area. The cultivable land is approximately 200 ha. We can create irrigation facilities for 30% of the total cultivable area by this tank-cum well system. Thus, with this system irrigation facilities can be created for 60 ha area. One set of tank (5000 m^3) and well can irrigate about 4 ha area. So, 15 tanks and 15 wells are to be developed for creating the water resource to irrigate 60 ha area. Though the average size of one tank is assumed as 5000 m^3, but it can vary from 4000 m^3 to 6000 m^3. Capacity of the tanks can be lower in the first and second order streams and it can be higher for higher order streams. The depth of tank should vary from 2.5 to 3 m. The side slope can be fixed as 1:1. The excavated earth will be used for construction of the embankment around it. If there is excess excavated earth, then it may be used to fill up the depression area in the watershed or it may be transported to a place where soil is required. So, the design and specification are as follows.

Number of tanks = 15

Number of wells = 15

Capacity of one tank = 5000 m^3 (average value)

Gross capacity of tanks = 75,000 m^3.

Width of tank at the ground level = 40 m × 40 m.

Width of tank at the bottom = 34 m × 34 m.

Depth = 3 m

Side slope = 1:1

Earthwork required to construct one tank = 4116 m^3 $\approx$ 4100 m^3

Total earthwork for 15 tanks = 4100 × 15 = 61,500 m^3

Embankment top width = 4m

Embankment bottom width = 9.8 m $\approx$ 10 m

Embankment height = 2.9 m $\approx$ 3.0 m

Embankment side slope = 1:1

Total area under the ponds = 5.4 ha.

Inside diameter of the well = 5m

Thickness of well wall = 30 cm

Depth of well = 8m

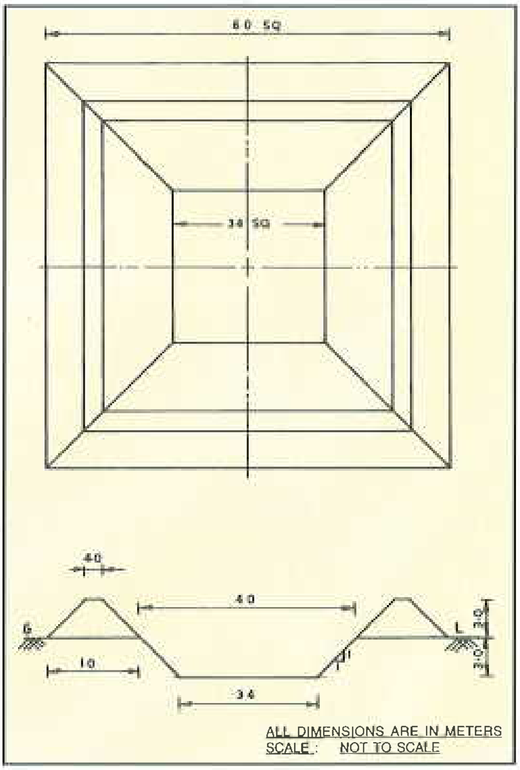


Fig. 4 Plan and elevation of the tank

The embankment has been designed by using all the excavated earth from the site. The dimensions of the embankment can be reduced if some of the excavated soil is used to fill up the depression in nearby areas or transported to a different site. The plan with elevation of the tank and dug well are shown in Figure 4 and 5, respectively.

Cost estimate

(i)	Earthwork in tanks @Rs. 30.00/m^3 for 61,500 m^3	Rs. 18,45,000.00
(ii)	Cost of pipe spillways for outflow	Rs. 75,000.00
(iii)	Cost of wells @Rs.41,000 per well	Rs. 6,15,000.00
(iv)	Cost of pipelines and accessories	Rs. 2,00,000.00
(v)	Cost of 15 Nos. 2 hp electric pumps and accessories	Rs. 1,60,000.00
(vi)	Cost of infrastructure for providing electricity	Rs. 2,00,000.00
(vii)	Amount to be deposited for paying dividend to the farmers whose land has to be taken	Rs. 2,00,000.00
	Total investment	Rs. 32,95,000.00

Total mandays generated

Earthwork: unskilled-30,000 mandays

Well: skilled- 300 & unskilled-3000 mandays

Pipe spillway for outlet: unskilled-200 mandays

Pipeline and pump installation: skilled-250 & unskilled 800 mandays

Total: skilled- 550 mandays and unskilled – 34,000 mandays

Benefit envisaged

By adoption of this technology, it is expected that assured supplemental irrigation can be provided to transplanted rice in 60 ha area during *kharif* season. Besides this, it is also estimated that irrigation water will be available for cultivation of 25 ha area in *rabi* season and 15 ha area in summer season. Out of the 40 ha area in post-monsoon

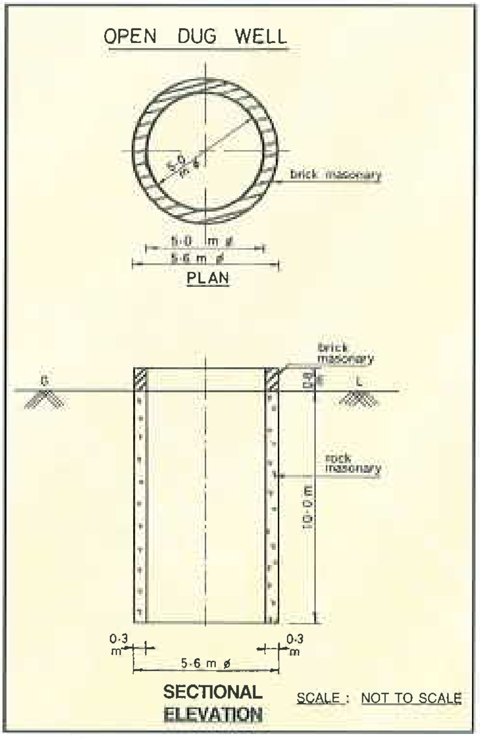


Fig. 5 Plan and elevation of open dug well

season, 10 ha can be put under vegetables and 30 ha can be put under pulses or oilseeds. Pisciculture can be undertaken in the tanks. The detailed increase in production, gross income generation, additional mandays created due to asset creation are given in Table 2.

Table 2. Income generation and creation of mandays in constructing "tank cum well system" for 60 ha command area

Technology	Investment/ ha(Rs.)	Man days generation	Production potential (t/ha)				Potential gross income generation (Rs) per system per year			Potential mandays generation due to asset created
			Crop	Pre	Post	Increase	Pre	Post	Increase	
Tank-cum well system for 500 ha catch ment area	Rs. 32,95, 000.00	34550 (skilled –550 unskill ed- 34000)	Kharif Paddy in 60 ha	1.0	3.0	2.0	360000	1080000	720000	60x50
			Rabi/ summer Pulses/ oil seed in 30 ha	0	1.5	1.5	0	450000	450000	30x30
			Rabi/ summer vege tables in 10 ha	0	10	10	0	400000	400000	10x250
			Fish	0	400 kg/ pond	400 kg/pond	0	240000	240000	500
Total							360000	2170000	1810000	6900

3. Percolation tank

Percolation tank (Plate 3) is a farm pond type structure constructed in relatively permeable soils in the upper reaches of the watershed to facilitate groundwater recharge. The runoff from the catchment gets harvested in the percolation tank where it gets sufficient time to slowly recharge to groundwater. The percolation tanks are generally constructed in the first and second order streams. The average catchment area in these streams is about 50 ha. So, one percolation tank can be constructed in a 50 ha catchment area. The plan and elevation diagram of a percolation tank is shown in Figure 6.

Design

Area of the tank at the ground level
= 30 m ×30 m

Area of the tank at the bottom = 26 m × 26 m

Depth = 2 m

Side slope = 1:1

Total earthwork (square area with 1:1 side slope) = 1/6 (30^3-26^3) = 1570 m^3.

Top width of embankment = 3 m

Bottom width of embankment = 7 m

Height of embankment = 2 m

Side slope = 1:1

Assume seepage rate = 10 mm/day

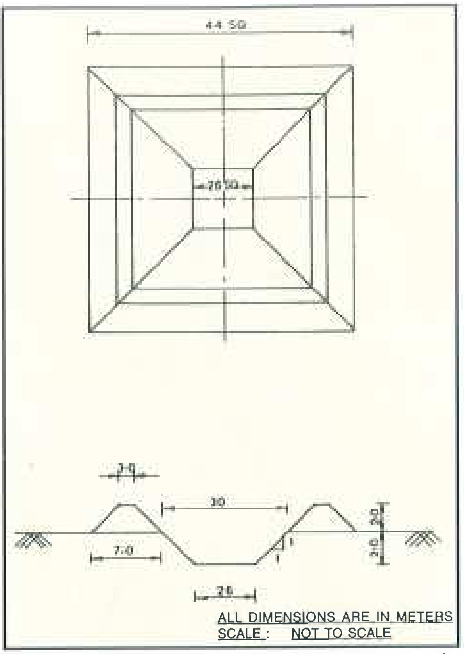


Fig. 6 Plan and elevation of percolation tank

So, total volume of water recharged = 30 × 30 × 0.01 × 150 days = 1350 m^3.

Estimate

(i)	Earthwork excavation @ Rs.30.00/ m^3 for 1570 m^3	Rs. 47,100.00
(ii)	Pipe spillway (Lump sum)	Rs. 5,000.00
	Total	**Rs.52,100.00**
		≈ Rs. 52,000.00

Mandays required = 800 unskilled

Benefit envisaged

The construction of percolation tank at the upstream reaches of the watershed will facilitate in groundwater recharge. The recharged groundwater will increase the groundwater level in the lower reaches of the watershed. This recharged water can be withdrawn by wells and meet the irrigation water requirement of both monsoon and dry season crops.


Plate 3. Percolation tank

4. Mahabandh along with conveyance network involving more than 1,00,000 m^3 storage

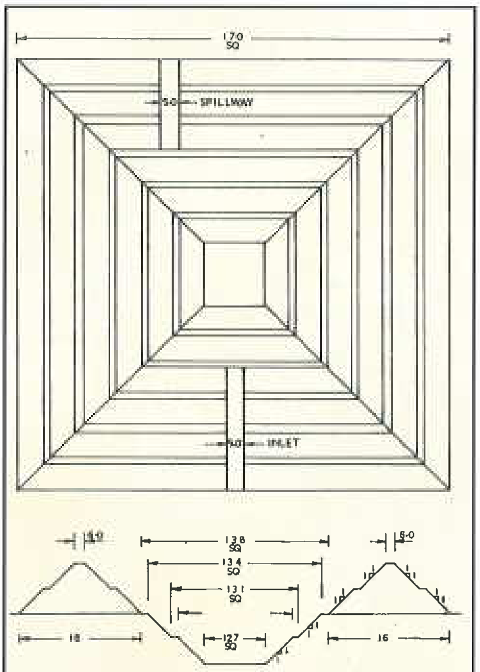
Mahabandh (Plate 4) is a large size water harvesting structure. This structure is feasible only when a minimum catchment area of 100 ha is available and a submergence area of 3 ha is available with a possible depth of 5 m. This technology can be used in plateau areas with 2 to 5% slope. Generally the site should be selected in such a way that some depression is already available and maximum storage area can be achieved with minimum of earthwork.

Plate 4. A view of *Mahabandha*

Design

Area of the catchment = 100 ha.

Reliable runoff at 80 % probability = 165 mm



Side slopes are 1:1
Berms are of 2 m width
All dimensions are in meter

Fig. 7 Plan and elevation of *Mahabandh*

Hence total runoff = $100 \times 10^4 \times 0.165$ = 1,65,000 m^3.

Area of the *Mahabandh* = 134 m×134 m (found by trial and error)

Considering average seepage loss of 6 mm/ day and average evaporation loss of 4 mm/ day, the total loss through seepage and evaporation = $134 \times 134 \times 0.01 \times 365$ = 65,540 m^3.

Hence, capacity of the *Mahabandh* = 1,65,000 – 65,540 = 99,460 $m^3 \approx$ 1,00,000 m^3.

But the location of *Mahabandh* is decided in such a manner that some depression is already available and a significant storage is achieved by the embankments. Hence, the effective earthwork that is required may be considered about 50% of the capacity = 50,000 m^3.

For excavation of 50,000 m^3 earth, the design dimensions are as follows:

Area of *Mahabandh* at ground level = 134 m × 134 m

Area of *Mahabandh* at bottom = 124 m × 124 m

Depth = 3 m

Side slope = 1: 1

One berm of 2 m width is provided at 1.5 m depth.

Embankment height = 3 m

Embankment top width = 6 m

Embankment bottom width = 16 m

Side slope = 1:1.

Berms of 2 m width are provided both in the upstream and down stream side at 1.5 m height. Inlet of 5 m width is provided for inflow of water and a spillway is provided for safe disposal of excess water.

Area covered by *Mahabandh* 170 m × 170 m = 2.89 ha.

All the soils that are excavated can not be used in the embankment. Rest of the soil can be used for filling up the nearby depression area or transported to a distant area. Some more soil can be accommodated by increasing the dimension of the embankment. The diagram of the *Mahabandh* is shown in Figure 7.

Estimate

(i)	Earthwork @ Rs.30.00/ m^3 for 50,000 m^3	Rs. 15,00,000.00
(ii)	Spillway and inlet (Lump sum)	Rs. 1,00,000.00
(iii)	Conveyance network (Lump sum)	Rs. 1,00,000.00
	Total	**Rs. 17,00,000.00**

Total mandays generated

Earthwork	= 25,000 mandays (unskilled)
Spillway and inlet	= 500 mandays (unskilled) & 100 mandays (skilled)
Conveyance network	= 500 mandays (unskilled) & 100 mandays (skilled)
Total	= 26,000 mandays (unskilled) & 200 mandays (skilled)

Benefit envisaged

By adoption of this technology, it is expected that assured irrigation can be made available to transplanted rice of 40 ha area during *kharif* season. In addition to this, water will also be available for cultivation of 15 ha area in *rabi* season. Out of the 15 ha area in *rabi* season, 5 ha can be put under vegetables and 10 ha under pulses or oilseeds. Pisciculture can also be undertaken in the *Mahabandh*. The increase in production, gross income generation, additional mandays created due to asset creation are given in Table 3.

Table 3. Income generation and creation of mandays in constructing Mahabandh along with conveyance network to command 40 ha area

Technology	Invest ment/ ha(Rs.)	Man days gene ration	Production potential (t/ha)				Potential gross income generation (Rs) per year			Potential mandays generation due to asset created
			Crop	Pre	Post	Increase	Pre	Post	Increase	
Mahabandh along with conveyance network for 100 ha catch ment area	Rs. 17,00, 000.00	26200 (skilled 200 un- skilled -26000)	Kharif Paddy in 40 ha	1.0	2.5	1.5	240000	600000	360000	40x50
			Rabi Pulses/ oil seed in 10 ha	0	1.5	1.5	0	150000	150000	10 x30
			Rabi vege tables in 5 ha	0	10	10	0	200000	200000	5 x 250
			Fish	0	2400kg (total)	2400kg (total)	0	96000	96000	500
Total							240000	1046000	806000	4050

5. Dugout ponds in rice fields

Plate 5. Dug out pond

Dugout ponds (Plate 5) are usually recommended in rainfed medium lands where water is not available for irrigation after monsoon prohibiting cultivation of *rabi* crops. In this approach, approximately 5-10% of total area of the rice field is converted to a dugout pond. The pond is kept at the lower most corner of the field or on the down stream side of the field. A broad crested brick masonry rectangular weir is to be constructed, so that it allows excess water from rice field to drain into the pond. This pond is used for aquaculture during monsoon and its embankement is used for growing horticultural crops. The stored water is used for giving supplemental irrigations to *Kharif* crops and irrigating *rabi* crops. The depth of the pond is kept as 2.5 m and side slope as 1:1. The excavated soil is used for making embankment around the pond and excess excavated soil is transported to nearby areas. The drawing of the pond along with its embankment is presented in Figure 8.

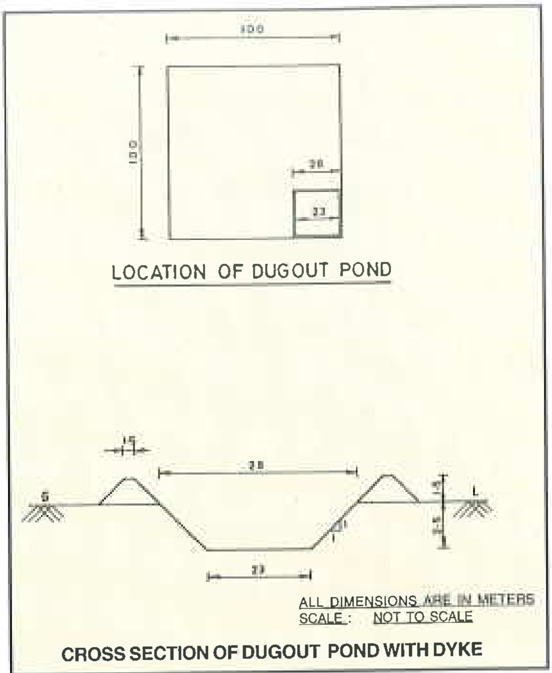


Fig. 8 Location and cross section of dugout pond suitable for 1 ha land

Design and estimate for 1 ha field

Area used for dugout sunken pond should be less than 10% of the field, where seepage loss is less than 6 mm/day.

Size of the pond = 800 m^2 at top (Assuming 8% area to be used for pond)

Size of the pond at top= 28 m x 28 m.

Depth of pond = 2.5 m, Side slope= 1:1.

Size of the pond at bottom = 23 m x 23 m.

Total volume of earth work=1641 m^3 (approx.).

Assuming cost of excavation is Rs.30 m^3, cost of earthwork excavation = 1641 x 30 = Rs. 49,230.

Volume of soil to be used in the embankment = {(1.5 +4.5)/2} x 1.5 x 30.5 x 4 = 545 m^3.

Cost of transportation of excess soil @ Rs.15/ m^3 for (1641-545= 1096 m^3) = Rs.16,440

Brick masonry surplus weir or inlet pipe along with catch pit = Rs.1000 (lump sum).

Total cost of the work = 49,230 + 16,440 + 1,000 = Rs. 66,670

Total mandays generated = 900 (Unskilled = 870, skilled = 30).

Benefit envisaged

After creation of assets i.e. excavation of dug out pond, it is expected that irrigation can be provided during dry spells of *kharif* season. This will increase *kharif* paddy yield from 1.5 t/ha to 2.5 t/ha. It is also expected that pulses/ oilseeds can be grown using the residual moisture as well as one irrigation can be provided if needed using the harvested rainwater from the pond. Short duration pisciculture and ducks rearing can be taken up in the pond. Growing of horticultural crops in the ponds embankment viz., banana, papaya and creeper vegetable can be taken up. During *rabi* season vegetable can be grown in 0.5 ha of area, which will be irrigated using the water stored in the dug out pond. Total investment, mandays generated, production potential increased, potential mandays generation due to asset created in one hectare area is given in Table 4.

Table 4. Income generation and creation of mandays in constructing dug out pond in rice fields

Technology	Investment/ha (Rs.)	Man days generation	Production potential (t/ha)				Potential income generation (Rs)/year			Potential mandays generation due to asset created
			Crop	Pre	Post	Increase	Pre	Post	Increase	
Dugout pond in 1 ha land	66670 = 49230 (Excavation of pond) + 16440 (trans portation of soil) + 1000 (inlet pipe)	900 (unskilled = 870, skilled =30)	Paddy	1.5	2.5	1	9000	15000	6000	30
			Pulses/ oil seed in 0.9 ha	0	1.35	1.35	0	13500	13500	40
			Or, Potato/ vegetable in 0.5 ha	0	10.0	10.0	0	20000 from 0.5 ha	20000 from 0.5 ha	125
			Fish	0	150 kg	150 kg	0	6000	6000	40
			Duck	0	50 nos.	50 nos.	0	2000	2000	15
			Banana	0	100 nos.	100 nos.	0	4000	4000	20
			Papaya	0	1000 kg	1000 kg	0	4000	4000	20
			Creeper	0	200 kg	200 kg	0	1000	1000	10
Total							9000	45500 or (52000)	36500 or (43000)	175 or (260)

6. Check dams/ diversion weir on well defined *Nala*

Check dams (Plate 6) are constructed across a *Nala* with the objective of soil and water conservation and diversion weirs (Plate 7) are constructed in the *Nala* for irrigation by diverting water from it. Check dams can be temporary or permanent structures. Drop structures are generally constructed across the gullies as permanent check dams. The eroded soils are checked by the drop structures and soil is conserved. Pipe networks can be provided to divert the water stored in the *Nala* for meeting the irrigation requirement. The diagram of the drop spillway/ check dam is shown in Figure 9. The design of the check dam/ diversion weir has been done considering a catchment area of 200 ha.

Plate 6. Check dam

Plate 7. Diversion weir

Design

Catchment area = 200 ha.

Intensity of rainfall at 10 year frequency for the region= 60 mm/hr.

Runoff coefficient = 0.35.

Peak discharge = $0.35 \times 60 \times 200 = 11.66$ cumecs.

The discharge in the weir is given by the relation $Q = 1.66\ L\ h^{3/2}$

On solving the equation we get a number of L (width of weir) and h (height of water over the crest) values. A suitable value of L and h is generally selected. In this case a value of L= 5 m and h= 1.25 m is selected. The ratio of L/h should always be equal to or greater than 2 for all rectangular channels. Adding freeboard, the h value is selected as 1.4 m.

The h/F ratio should be kept lower than 0.50 with an absolute maximum of 0.75. A value of 0.75 is considered here as the depth of *Nala* will not allow a bigger F (fall) value.

$h/F = 0.75 \Rightarrow F = h/0.75 = 1.25/0.75 = 1.66 \approx 1.7$ m.

Length of headwall extension E = (3+0.6) or 1.5 F whichever is greater,
Here E = 3.6 m.

Length of basin $L_B = F\,(2.28\,h/F + 0.52) = 1.7\,(2.28 \times 1.4/1.7 + 0.52) = 4.07$ m ≈ 4.0 m.

Height of wing wall and sidewall at the junction J = 2h = 2.8 m.

M = 2 (F + 1.33h - J) = 2(1.7 + 1.33 × 1.4 - 2.8) = 1.524 m ≈ 1.5 m.

L = (L_B + 0.1) - M = (4 + 0.1) -1.5 = 2.6 m.

Height of longitudinal sill $s_{h=}$ 1.4/4 = 0.35 m = 35 cm.

Height of transverse sill $s_{t=}$ 1.4/3 = 0.46 m = 46 cm.

Thickness of apron for different values of overall F are given below

Over fall, F (m)	0.5-0.75 m	1.0-1.75 m	2.0-3.0 m
Apron thickness (cm)	20 cm	25 cm	30 cm

So, a thickness of 25 cm is selected here.

Wall thickness - top widths and minimum base widths of headwall, sidewall, wing wall and headwall extensions for different wall heights for masonry construction are given below.

Description	Head wall	Side wall	Wing wall and head wall extension
Minimum top Width (m)	0.45	0.30	0.30
Height (m)		Recommended base widths	
0.5	0.45	0.30	0.30
1.0	0.67	0.55	0.40
1.5	1.0	0.82	0.60
2.0	1.33	1.10	0.80
2.5	1.67	1.37	1.00
3.0	2.0	1.65	1.20
3.5	-	-	1.40
4.0	-	-	1.60
4.5	-	-	1.80

Using the above table, following dimensions were finalized in the present case.

Headwall – Top width 0.45 m and bottom width 1.15 m

Sidewall- Top width 0.30 m and bottom width 0.95 m

Wing wall and headwall extension – Top width 0.30 m and bottom width 0.70 m.

The design has been done for extreme cases which very rarely occur. So, by taking a little worthwhile risk, the dimensions and thereby price can be reduced.

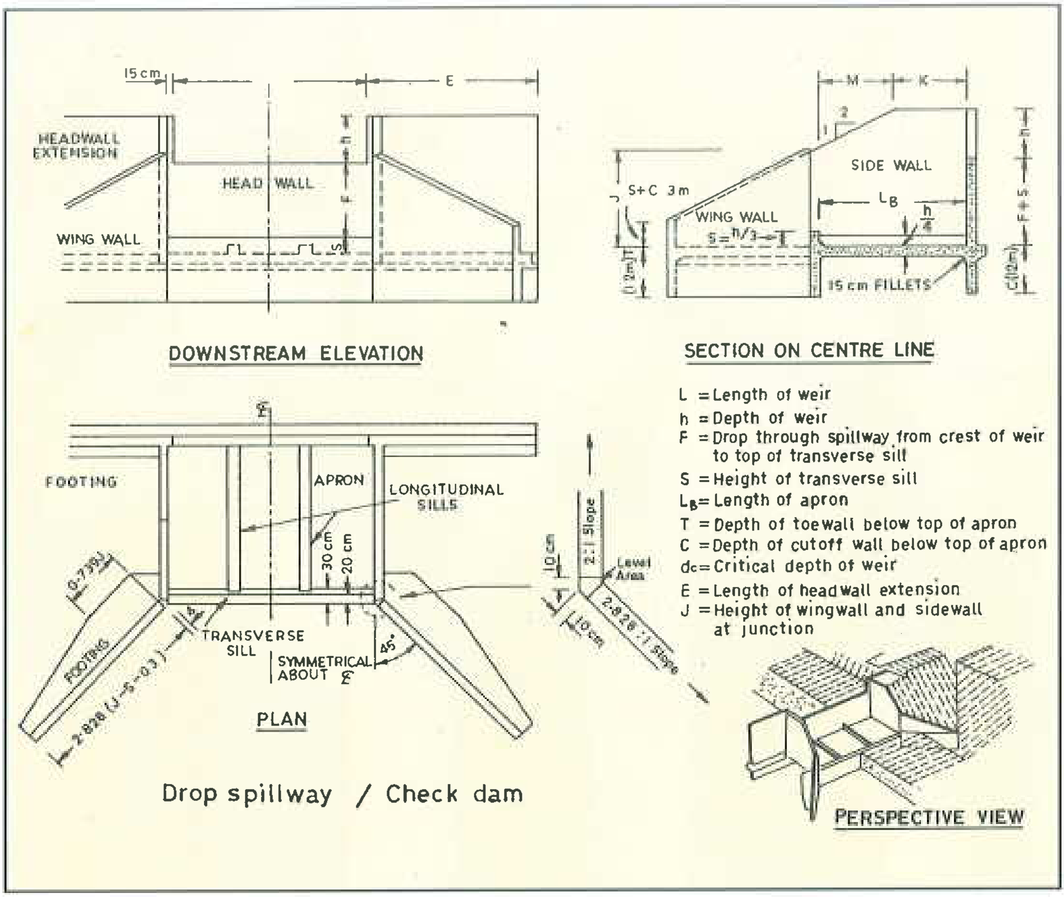


Fig. 9 Plan, elevation and perspective view of check dam

Cost estimate

Drop structure/ check dam	=	Rs. 1,20,000.00
Pipelines (300 m) & accessories	=	Rs. 30,000.00
Total		Rs. 1,50,000.00

Mandays required = 650 (500 unskilled and 150 skilled) per one checkdam and conveyance system.

Benefit envisaged

Construction of two sets of spillways and pipelines can give assured irrigation to 20 ha paddy cultivation in *kharif* season. So, the required investment is Rs. 3 lakhs/20 ha. This can improve the paddy yield and income of the farmers. The detailed increase in production, increase in gross income, additional mandays created due to asset creation is given in Table 5.

Table 5. Income generation and creation of mandays in constructing check dam/ diversion weir for 20 ha command area

Technology	Invest ment/ha (Rs.)	Man days generation	Production potential (t/ha)				Potential gross Income generation (Rs) per system per year			Potential mandays generation due to asset created
			Crop	Pre	Post	Increase	Pre	Post	Increase	
Checkdam/ diversion weir (200 ha catch ment area)	Rs. 3,00,000.00	1300 (skilled – 300 unskilled - 1000)	*Kharif* Paddy in 20 ha	1.0	1.5	0.5	120000	180000	60000	20 x20
Total							120000	180000	60000	400

Rainfed lowlands

7. Comprehensive drainage system inclusive of main drains, and lateral drains

Agricultural drainage is the removal and disposal of excess water from agricultural lands. The cause for waterlogging/ water congestion problem at a specific location may be one or a combination of several factors. Solution to waterlogging problem consists of both controlling the source of excess water as well as adequate provision for the removal of the excess water that is likely to occur. Surface drainage is the safe removal of excess water from the land surface through land shaping and well laid out drainage ditches. Surface drainage uses the potential energy that exists due to land elevation to provide a hydraulic gradient for the movement of water. Surface drainage system is recommended where a clear out fall or outlet exist for safe removal of excess water.

Design of the comprehensive drainage system

Assuming the area to be treated with surface drainage as 1000 ha and square shaped the dimensions works out to be 3162 m x 3162 m. The layout of comprehensive drainage system suitable for 1000 ha land along with the location of main drain and lateral drain is presented in Figure 10. Also the figure presents the cross section of both main and lateral drain.

Length of main drain = 2371 m

Length of each lateral drain = 790 m (4 numbers)

The drainage coefficient of the area ranges from 0.6 to 2.5 cm/day for open ditches for small agricultural areas. The drainage coefficient of agricultural lands of eastern India is assumed here as 3.0 cm/day. The shape of the drainage ditch is assumed as trapezoidal with a side slope of 1:1.

Main drain

Drainage coefficient = 3 cm/day.

Rate of flow through drain

= (0.03 x 1000 x 10000)/ (24 x 60 x 60) = 3.472 m^3/sec.

Side slope: 1:1

Assuming depth of flow d =1.75 m,

Bottom width = b= 2 d tan $\theta/2$ =2d tan (22.5^0) = 1.45 m.

Top width= 1.75 +1.45 + 1.75 = 4.95 m.

Length of side = 2.47 m.

Wetted perimeter = P= (2 x 2.47) + 1.45 = 6.40 m.

Area of cross section = 5.6 m^2

Hydraulic radius = R = A/P = 0.875 m.

Assuming drain slope = 0.1% = 0.001 m/m and Manning's roughness coefficient (n) = 0.04

Velocity of flow,

$$V = \frac{1}{n} \times R^{2/3} \times S^{1/2} = 0.72 \text{ m/sec}$$

(using Manning's formula).

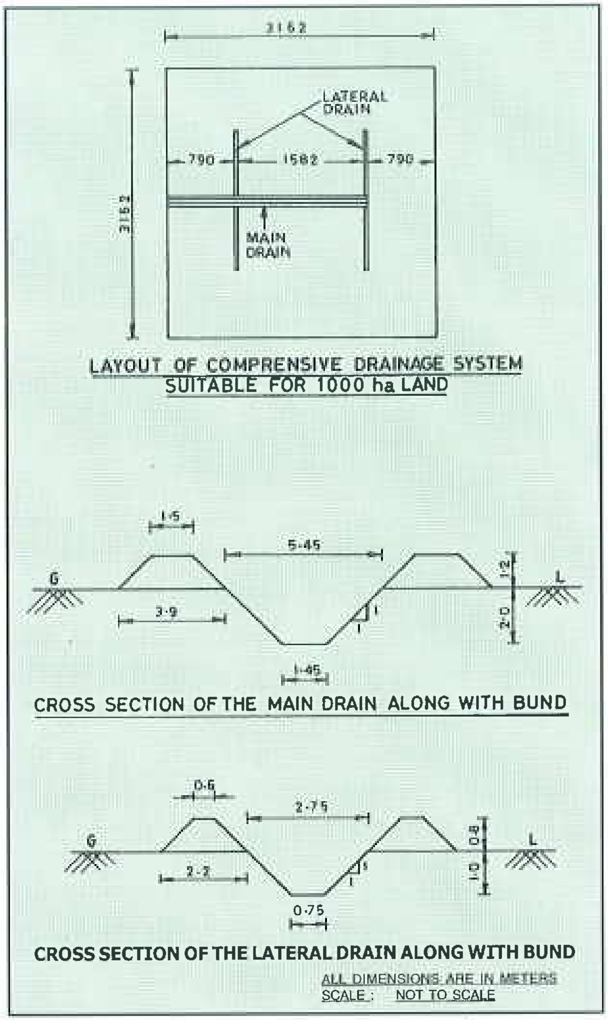


Fig. 10 Layout and cross section of main and lateral drain of a comprehensive drainage system for 1000 ha

This value of the velocity is in the permissible range. Considering the free board of 0.25 m, the final cross section of the drain is: Bottom width = 1.45 m, total depth of drain including free board = 2 m, side slope = 1:1, top width = 5.45 m.

$$Total\ volume\ of\ earthwork = \frac{(5.45 + 1.45)}{2} \times 2 = 6.9\, m^3 \text{ per m length of drain}$$

Total cost of excavation= 6.9 x 2371 x Rs.30= Rs.4,90,797.00

Cost of excavation per running meter = 6.9 x 30= Rs.207.00

No. of mandays generated for the whole area = 4,90,797/60 = 8180 (unskilled)

Lateral drain

Drainage coefficient = 3 cm/day

Rate of flow through drain = 3.472/4 = 0.868 m^3/sec

Side slope= 1:1

Assuming depth of flow, d = 0.9 m b = 2 d tan $\theta/2$ = 0.75 m

Top width= 2.55 m

Length of side= 1.27 m

P= (2 x 1.27) + 0.75= 3.29 m

A= 1.49 m^2

Hydraulic radius = R= A/P = 0.45 m

Assume, longitudinal slope= 0.1% = 0.001 m/m, n = 0.04

Using Manning's formula, $V=1/n \times R^{2/3} \times S^{1/2}$ = 0.46 m/sec

The velocity is in the permissible range. Considering the free board of 0.10 m, the final cross section of the lateral drain is: Bottom width=0.75 m, total depth of drain including free board = 1 m, side slope = 1:1, top width = 2.75 m.

Total volume of earth work for 1 m running length = 1.75 m^3

Cost of excavation per running meter of drain= 1.75 x 30 = Rs.53.00

Total cost of excavation for all four lateral drains of 790 m each= 790 x 4 x 1.75 x 30 = Rs.1,65,900.00

Total number of mandays generated = 2765 (unskilled)

Total mandays generated= 8180 + 2765 = 10945 (unskilled) for 1000 ha area.

Benefit envisaged

It is expected that by laying out comprehensive drainage system in 1000 ha area, the waterlogging problem will be controlled. This will result in increasing the yield of *kharif* paddy from 1 t/ha to 2 t/ha. Also during *rabi* season pulses/ oilseeds can be grown in 1000 ha by utilizing the residual moisture, which was otherwise remaining fallow. Investment to be made, mandays created, income to be generated and potential mandays to be generated due to assets creation are provided in Table 6.

Table 6. Income generation and creation of mandays in laying out comprehensive drainage system in 1000 ha area

Technology	Invest ment/ha 1000 ha (Rs.)	Mandays gene-ration	Production potential (t/ha)				Potential income generation (Rs) per ha per year			Potential mandays generation due to asset created
			Crop	Pre	Post	Increase	Pre	Post	Increase	
Compre hensive Drainage system for 1000 ha area. (a) Main drain= 2.37 km,	(a) Cost of excavation of main drain: Rs.490797	8180	Paddy in 1000 ha	1	2	1	6000	12000	6000	20x1000
			Pulses/ oil seed in 1000 ha	0	0.75	0.75	0	7500	7500	30x1000
(b)lateral drain= 3.16 km	(b) Cost of excavation of lateral drain: Rs.165900	2765	Prospects of putting timber crop along drain should be explored (Local suitable species) on main drain of 2.1 km	0	1000 plants	1000 plants	0	100	100	20 x 1000
Total	Rs.656697.00	10945					6000x1000	19600x1000	13600x1000	70x1000

8. Sub surface water harvesting structure in coastal areas

In coastal areas, water is available in plenty during monsoon and during post monsoon season it is scarce. At many places thick impervious layers (2-3 m thick) exist at a depth varying between 3 to 5 m below ground level. This layer does not yield any water appreciably. Ironically, at many places saline water is present below this impervious layer. However, the top 3 to 5 m soil is generally porous and appreciable amount of water flows laterally, if a pond is excavated. With this background, subsurface WHS (Plate 8) with depth varying between 2-4 m is recommended. The area of the pond may vary depending upon the site and soil type up to a depth of 2-4 m. Pond area can be kept as 10-15% of the total area of the field, so that the water stored in it can irrigate rest 85-90% of the field during *rabi* season.

Plate 8. Sub surface water harvesting structure

Design and cost estimate

Pumping tests in large number of sites with varying pond sizes (square shaped ponds) reveals that the rate of recuperation ranges from 1.58 m^3/h to 4.07 m^3/h. Assuming an average value of 3 m^3/h, 72 m^3 of water will recuperate in one day. In a week about 490 m^3 of water can be used for irrigation purpose. For 1 ha land if we convert 12% of area into SSWHS, the area to be irrigated = 88%= 8800 m^2.

Assuming 5 cm of irrigation in one week during *rabi* season = 8800 x 0.05= 440 m^3 of water is required. Hence one unit of SSWHS of size 1200 m^2 is suitable for 1 ha land.

Considering square shaped pond, the dimension is 35 m x 35 m, depth of SSWHS= 2.5 m, side slope= 1:1. Volume of earth work works out to be 2656 m^3. The layout and cross section of the sub surface water harvesting structure is presented in the Figure 11. Most of the soils excavated were utilized for formation of bund.

Cost of earth work @ Rs.30/m^3= 2656 x 30= Rs.79,680.00

Number of mandays generated= 1328 (unskilled)

Benefit envisaged

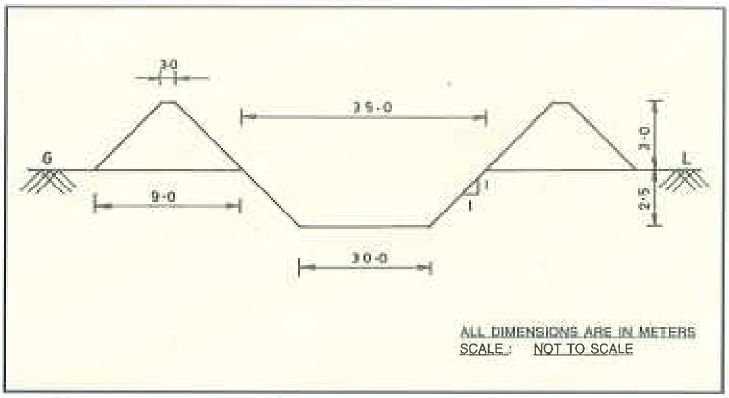


Fig 11 Cross section of sub surface water harvesting structure

By implementation of SSWHS to harvest fresh water flowing laterally in subsurface, it is expected that during *kharif* season the yield of paddy will increase by 0.7 t/ha. Pulses and oilseeds can be grown in 0.88 ha area using residual moisture and providing irrigation once, if required. In the pond system fish and duck can be reared and on-dyke horticulture viz., banana, papaya and creeper vegetable can be undertaken on the bund. During *rabi* season vegetable can be undertaken in 0.5 ha area. Investment to be made for this intervention, mandays to be generated, potential income and potential mandays generation due to assets created are given in Table 7.

Table 7. Income generation and creation of mandays in constructing sub surface water harvesting structure in coastal areas

Technology	Invest ment/ha 1000 ha (Rs.)	Mandays gene-ration	Production potential (t/ha)				Potential income generation (Rs)			Potential mandays generation due to asset created
			Crop	Pre	Post	Increase	Pre	Post	Increase	
Sub surface water harvesting structure in coastal area for 1 ha land (pond size 12%=35 m x 35 m, 2.5 m depth, side slope 1:1)	79680	1328	Paddy	1.5	2.2/ 0.88 ha	0.7	9000	13200	4200	20
			Pulses/ oil seed in 0.88 ha	0	0.88	0.88	0	8800	8800	30
			Or, Potato/ vegetable in 0.5 ha	0	10.0	10.0	0	20000	20000	125
			Fish	0	225 kg	225 kg	0	9000	9000	40
			Duck	0	50 nos.	50 nos.	0	2000	2000	15
			Banana	0	100 nos.	100 nos.	0	4000	4000	15
			Papaya	0	1000 kg	1000 kg	0	4000	4000	15
			Creeper	0	200 kg	200 kg	0	1000	1000	10
Total							9000	39000 or, 50200	30000 or, 41200	145 or 240

9. Very shallow tube wells in coastal areas having saline groundwater below 10 m

The groundwater situation in coastal areas of Eastern India is very peculiar. In many places there are thin (2-3m thick) layers of sweet water aquifer floating above the saline aquifers. Thus, the existing technology of exploiting groundwater through shallow/ deep tube wells will lead to drawing water from saline aquifers. As coastal areas very near to sea (<10km away from sea) don't have enough source for irrigation water except few creeks, the exploitation of these thin top layer aquifers can provide irrigation to small holdings. The design of very shallow tube wells in coastal areas should be such that the saline aquifer is not subjected to any withdrawal pressure. The investment cost for providing irrigation through this system will be Rs 4500 and it can command 1-1.5 ha area.

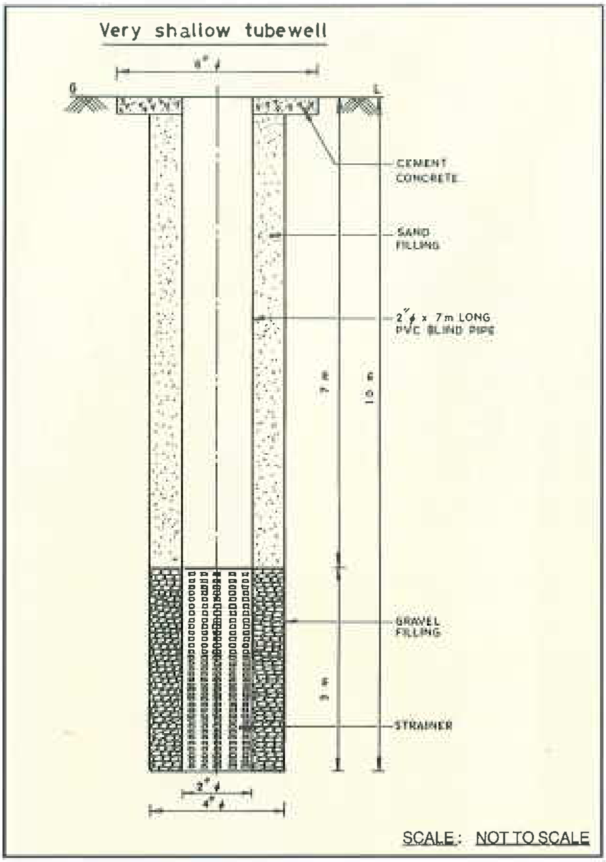


Fig. 12 Cross sectional view of very shallow tube well

Design specifications

The depth of shallow tube well is 10m. The length of blank pipe and strainer pipe will depend upon the lithology of the area. The diameter of the well should be 2" and size of prime mover/pump sets should be 2hp or less. The schematic diagram of shallow tube well is shown in Figure 12.

Cost and material estimate

Labour cost			
Manual drilling	= 10m @ Rs 200/m	=	Rs.2,000
Material cost			
Cost of 2 hp pumsets with accessories		=	Rs.10,000
PVC pipe (2" dia) Schedule 80	= 7m @ 132/m	=	Rs.924

PVC ribbed screen pipe (2" dia)	= 3m @ 170/m	=	Rs.510
Filler materials (Gravel)	= $2m^3$ @350/m^3	=	Rs.700
Cement concrete foundation and plastering	= lump sum	=	Rs.350
Sub total (material cost)		=	Rs.12,484
Total Investment		=	**Rs. 14,484**
			Rs. 14,500

Total mandays required = 20 (skilled)

Benefit envisaged

By adoption of this technology it is expected that assured irrigation can be supplied for growing paddy in 1 ha area and the yield increase will be from 1.5 t/ha to 2 t/ha. Besides this, irrigation water will also be available for cultivation of pulses/ oil seed in 1 ha area or vegetables in 0.2 ha area during *rabi* season. The detailed increase in production, mandays to be created during implementation, increase in gross income, additional mandays to be created due to asset creation is given in Table 8.

Table 8. Income generation and creation of mandays in the event of very shallow tube wells in coastal areas

Technology	Investment/ha 1000 ha (Rs.)	Man-days generation	Production potential (t/ha)				Potential income generation (Rs)/year			Potential mandays generation due to asset created
			Crop	Pre	Post	Increase	Pre	Post	Increase	
Very shallow tube well up to a depth of 10m in coastal areas	14500 (Excavation cost 2000 + material cost 2500+ cost of 2 hp pump set 10000)	20 (skilled)	Paddy	1.5	2	0.5	9000	12000	3000	20
			Pulses/ oil seed	0.5	1	0.5	5000	10000	5000	30
			Or, vegetable in 0.2 ha	0	10	10	0	8000	8000	60
Total							14000	22000 or (20000)	8000 or (6000)	50 or (80)

10. Conversion of lowlands to aquaculture tanks

There is a vast area in eastern region where waterlogging condition prevails. Due to topographical depression in low lying areas, it is generally observed that, water stagnation up to a depth of 0.5 m or more occurs during monsoon. In the areas where water availability is plenty, conversion of low lands to aquaculture tank (Plate 9) is a feasible technology. Here, the water quality is good. Thus, by excavation of big aquaculture tank, it is possible to harvest and store large quantity of fresh rain water. Embankment of these aquaculture tanks can be used for horticultural plantations. This also acts as drainage system to low lying areas, where non availability of clear outfall prohibits execution of surface drain.

Plate 9. Conversion of low land to aquaculture tank with horticulture on the embankment

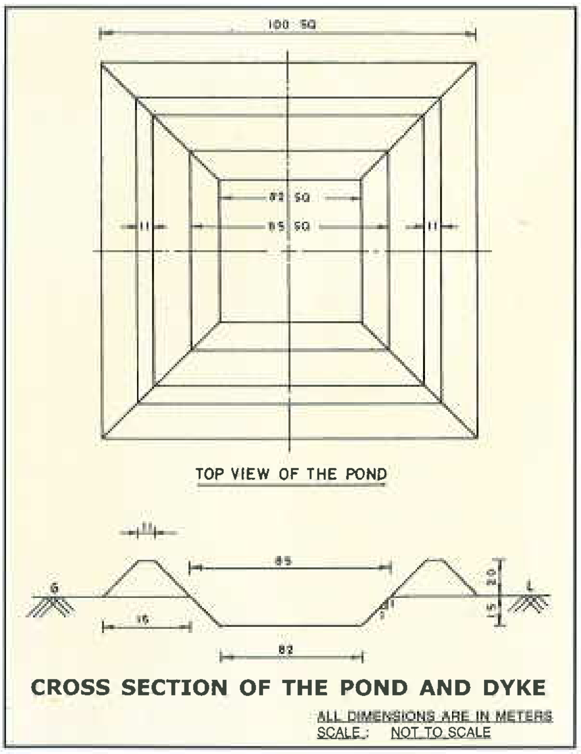


Fig. 13 Plan and cross sectional view of the aquaculture tank made in 1 ha of lowland

Design of tanks

Assuming 1 ha of land with dimension 100 m x 100 m, the portion of the area which will be converted to tank is 85 m x 85 m. Depth of excavation = 1.5 m. Top width of tank = 85 m, Assuming side slope = 1:1, bottom width works out as 82 m. Total volume of soil to be excavated = 10462 m^3.

The dimension of the embankment around the tank is made as 15 m base width, 11 m top width and 2 m height. Volume of soil required to construct the embankment = 9620 m^3.

Volume of soil to be excavated is about 840 m^3 extra than volume of soil required to make the embankment. In case these 840 m^3 is put over the embankment, there will be an increase in height by 17 cm. Realizing that after rain and compaction there will be a decrease in embankment height, the net height of the embankment will be range between 1.75 m- 2.0 m.

The cross section of the aquaculture tank converting 1 ha of low land is presented in Figure 13. Cost of earthwork excavation @Rs.30/ m^3= 10462 x 30 = Rs.3,13,860.00.

Thus, mandays which will be generated from this earthwork = 5230 (unskilled).

Benefit envisaged

By adopting this technology viz., conversion of 1 ha lowland to aquaculture tank, the whole land which was under paddy cultivation will get converted to an integrated aquaculture tank cum embankment horticultural system. The yield of paddy in low lying area is generally very low (1 t/ha). The tank area, which is

Table 9. Income generation and creation of mandays in the event of conversion of low lands to aquaculture tank

Technology	Invest ment/ha 1000 ha (Rs.)	Man-days gene-ration	Production potential (t/ha)				Potential income generation (Rs)			Potential mandays generation due to asset created
			Crop	Pre	Post	Increase	Pre	Post	Increase	
Conversion of low lands to aquaculture tank for 1 ha (100m x 100m) land i) pond size = 85mx85m, 1.5m depth, side slope 1:1 ii) Bund is 15m base width, top 11m and height 2.1m	313800 for exca-vation	5230	Paddy	1	0	-1	6000	0	-6000	-50
			Fish	0	2.5 ton	2.5 ton	0	100000	100000	250
			Duck	0	200 nos.	200 nos.	0	8000	8000	30
			Poultry	0	1000	1000 no	0	40000	40000	150
			Banana	0	250 nos.	250 nos.	0	10000	10000	30
			Papaya	0	2500 kg	2500 kg	0	10000	10000	30
			Vegetable	0	2000 kg	2000 kg	0	10000	10000	75
			Timber/ fruits	0	30 nos.	30 nos.	0	5000 in 10 years	5000 in 10 years	10
Total							6000	183000	177000	525

about 88% of the total area, will be used for fish and duck rearing. Poultry will be reared on the embankment along with growing of banana, papaya, fruit crops/ timber and other vegetables leading to productivity enhancement the of the system. The total investment for this technology, mandays generated, potential income generation and potential mandays generation due to assets created is presented in Table 9.

11. Peripheral dykes for saucer shaped waterlogged areas

For saucer shaped waterlogged area, peripheral dykes are recommended to minimize water congestion problem. Waterlogged areas where drainage is not possible due to topography and non availability of outlet or clear out fall, this intervention is recommended. In this, concentric dykes are constructed, so that standing water level between two dykes remains within a range.

After constructing the outer peripheral dyke, the next immediate dyke is placed at a distance, so that the water stagnation level remains < 50 cm between these two dykes. The next peripheral dyke is placed at a distance, so that the water stagnation level varies between 50-75 cm between second and third dykes. Similarly, the next one fixed at a distance to maintain the water level in the range of 75-100 cm. The most inner circle or peripheral dyke is constructed to hold water stagnation level beyond 1 m depth. This is presented in the Figure 14.

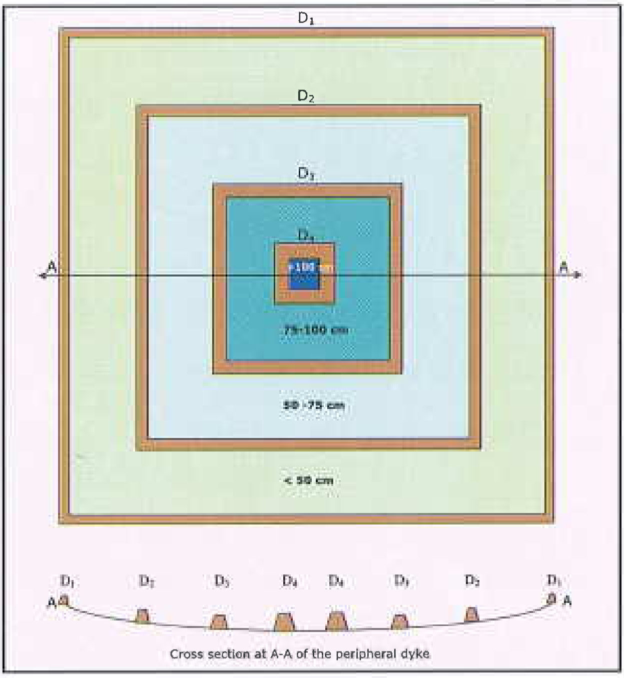


Fig. 14 Plan and cross sectional view of peripheral dykes

Design of peripheral dyke

Assume one saucer shape area of 1000 ha of square size.

Dimension of the area = 3162 m x 3162 m

The length of most outer dyke = 12650 m

The slope of the land = $\frac{0.75 \times 100}{1500} = 0.05\%$

The distance between D_1 and D_2 = 500 m

Similarly the distance between D_2 & D_3 and D_3 & D_4 = 500 m

Length of D_2 = 2162 x 4 = 8648 m

Length of D_3 = 1162 x 4 = 4648 m

Length of D_4 = 162 x 4 = 648 m

Dimension of D_1: Top width = 30 cm

Position of surplus weir = 25 cm

Height = 45 cm

Side slope = 1:1

Bottom width = 1.20 m

Cross sectional area of $D_1 = \frac{(1.20 + 0.3)}{2} \times 0.45 = 0.3375\ m^2$

Total volume of earth work = 0.3375 x 12650 = 4269 m^3

Cost of earthwork @ Rs.30/m^3 = 4269 x 30 = Rs.1,28,070.00

Mandays that will be generated from above earthwork volume = 2130 (unskilled)

II. Dimension of D_2: Height of the bund = 75 cm

Position of surplus weir at 50 cm

Top width = 60 cm

Bottom width = 2.10 m

Side slope = 1:1

Cross sectional area of $D_2 = \frac{(2.10 + 0.6)}{2} \times 0.75 = 1.0125\ m^2$

Total volume of earth work = 1.0125 x 8648 = 8756 m^3

Cost of earthwork @ Rs.30/m^3 = 8756 x 30 = Rs.2,62,680.00

Cost of broad crested brick cement surplus weir Rs.800 x 40 = Rs.32,000 (Total 40 numbers, 10 nos. in one side)

Mandays which will be generated = 4378 (unskilled) + 40 (skilled) = 4420

III. Dimension of D_3: Height of the bund = 1.20 m

Position of Surplus weir = 0.75 m

Top width = 0.9 m

Bottom width = 3.3 m

Side slope = 1:1

Cross sectional area of $D_3 = \frac{(0.9+3.3)}{2} x1.2 = 2.52\ m^2$

Total volume of earth work = 2.52 x 4648=11713 m^3

Cost of earthwork @ Rs.30/m^3 = 11713 x 30 = Rs.3,51,390.00

Cost of broad crested brick cement surplus weir Rs.3000 x 16 nos. = Rs.48,000.00

Mandays which will be generated = 5856 (unskilled) + 44 (skilled) = 5900

IV. Dimension of D_4: Height of the bund 2 m

Top width = 1.5 m

Bottom width = 5.5 m

Side slope = 1:1

Cross sectional area of $D_4 = \frac{(1.5 + 5.5)}{2} \times 2 = 7\ m^2$

Total volume of earth work = 7 x 648.= 4536 m^3

Cost of earthwork @ Rs.30/m^3 = 4536 x 30 = Rs.1,36,080.00

Cost of inlet pipes 24 nos. (30 cm diameter hume pipes)= Rs.32,000.00

Mandays which will be generated = 2268 (unskilled) + 12 (skilled) = 2280

Benefits envisaged

Execution of this intervention in the whole area, which used to be waterlogged with a productivity of kharif paddy as low as 1 t/ha will now have crop diversification and possibility of growing second crop. The area between the first (outer) dyke and the second dyke in which the water level will be kept less than 50 cm can now be utilized for growing paddy during kharif and pulses/ oilseeds during rabi season. The area between the second and third dyke can be utilized for growing paddy in 200 ha area and aquatic crop in 132 ha area. The area between third and fourth dyke can be utilized for paddy in 120 ha area and seasonal fish in 12 ha area. The inner most area, which is surrounded by the fourth dyke will have water depth more than 100 cm. This area will be utilized solely for aquaculture and the inner most dyke will be grown with on-dyke horticulture viz., banana, papaya and vegetables. The investment required for this intervention, mandays to be generated, potential income generation per annum and potential mandays to be generated due to creation of asset are presented in Table 10.

Table 10. Income generation and creation of mandays as a result of peripheral dykes construction

Technology	Investment/ha (Rs.)	Mandays generation	Production potential (t/ha)				Potential income generation (Rs)/year			Potential mandays generation due to asset created
			Crop	Pre	Post	Increase	Pre	Post	Increase	
Peripheral dykes for saucer shaped waterlogged area of 1000 ha	Rs.128070 Outer $d_1$dyke, =12650m, CSA: 0.3375 m^2	2130 (un-skilled)	Paddy in 533 ha	1	2	1	6000x533	12000x533	6000x533= 3198000	20x533= 10660
			Pulses/ oil seed in 533 ha	0	0.75	0.75	0	7500x533	7500x533= 3997500	30x533= 15990
	Rs. 294680 2nd dyke, d_2= 8648m, CSA: 1.0125 m^2.	4420 (un skilled =4378, skilled =40)	Paddy in 200 ha	1	1.75	0.75	6000x200	10500x 200	4500x 200= 900000	20x200= 4000
			Aquatic crop in 132 ha	0	1	1	0	5000x132	5000x132= 660000	20x132= 2640
	Rs. 399390 3rd dyke, d_3= 4648m, CSA: 2.52 m^2.	5900 (unskilled = 5856, skilled =44)	Paddy in 120 ha	1	1.5	0.5	6000x120	9000x120	3000x120	20x120 = 2400
			Seasonal fish in 12 ha	0	800 kg x 12	800 kg x 12	0	32000x12	32000x12	12x50= 600
	Rs.168080 4th dyke, d_3= 648 m, CSA: 7 m^2.	2280 (unskilled = 2268, skilled =12)	Fish	0	7 ton	7 ton	0	280000	280000	250
			Banana	0	400 nos.	400 nos.	0	16000	16000	50
			Papaya	0	4000 kg	4000 kg	0	16000	16000	50
			Vegetable	0	3000 kg	3000 kg	0	15000	15000	125
Total	990220	unskilled =14632, skilled=96					5118000	14944500	9826500	36765

Canal irrigated areas

12. Construction and renovation of water course and field channel

Irrigation through canal system is most popular surface irrigation system of the country. Farmers mostly use earthen channels (Plate 10) for conveying water without lining the bottom or sides of the channel. It can be built and maintained by unskilled persons and require no special equipment or materials. The low initial cost is a major advantage of earthen channels. However, these channels generally become defunct over time and there is need for their renovation/maintenance. For efficient irrigation water conveyance, it is essential that field channels are constructed and maintained. In some places, field channels which are required to supply irrigation water to individual fields are found absent. Therefore, emphasis has been laid here with the construction of field channels in addition to the water courses. To irrigate about 25 ha of square shaped area i.e. command area of one outlet, approximately 375 m length of watercourse and 4 nos. of 100 m length of field channel each are proposed (Fig. 15). The standard carrying capacity of the water course is 35 lps and field channel is 12 lps.

Plate 10. View of a field channel

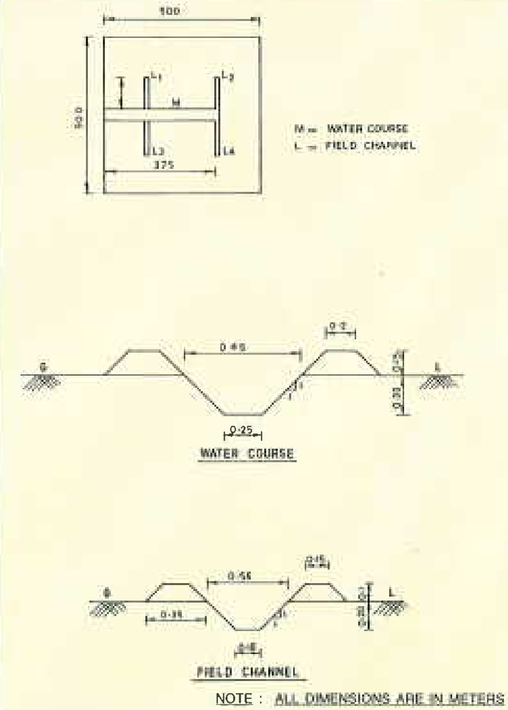
Design of water course

Assume depth of flow, d= 30 cm and side slope = 1: 1.

Bottom width = b = 2 d tan $\theta/2$
= 2d tan (22.5^0) = 25 cm.

Top width = 2 x 30 + 25 = 85 cm.

Length of side = 30 $\sqrt{2}$ = 42.5 cm.



Construction/ Renovation of water course and field channel

Fig. 15 Layout and cross sectional view of water course and field channel

Wetted perimeter = P = (2 x 42.5) + 25= 110 cm = 1.1 m

Area of cross section, A = (85 + 25)/2 x 30 = 1650 cm^2 = 0.165 m^2.

Hydraulic radius = R= A/P= 0.15 m.

Assuming longitudinal slope of the channel = 0.1% = 0.001 m/m, Manning's roughness coefficient, n = 0.04 and using Manning's formula,

$$V = \frac{1}{n} \times R^{2/3} \times S^{1/2} = 0.223 \text{ m/sec.}$$

The velocity is in the permissible range. The excavated soil will be deposited on both sides to act as freeboard.

Volume of earthwork = 0.165 x 375 = 61.87 m^3

Cost of earthwork excavation @ Rs.30/m^3= 61.87 x 30= Rs.1856.00

No. of mandays generated = 1856/60 = 31 (unskilled)

Design of field channel

Assume depth of flow, d= 20 cm and side slope = 1: 1.

Bottom width = b= 2 d tan θ/2 =2d tan (22.5^0) = 16 cm.

Top width= 2 x 20 + 16 = 56 cm.

Length of side= 20 $\sqrt{2}$ = 28 cm.

Wetted perimeter = P= (2x28) + 16= 72 cm.

Area of cross section, A = (56 + 16)/2 x 20 = 0.072 m^2.

Hydraulic radius = R= A/P= 0.1 m.

Assuming longitudinal slope of the channel = 0.1% = 0.001 m/m, Manning's roughness coefficient, n=0.04 and using Manning's formula, V=1/n x $R^{2/3}$ x $S^{1/2}$ = 0.17 m/sec.

The velocity is in the permissible range. The excavated soil will be deposited on both sides to act as freeboard.

Volume of earthwork = 0.072 x 400 = 28.8 m^3.

Cost of earthwork excavation @ Rs.30/m^3= 28.8 x 30= Rs.864.00

No. of mandays generated = 864/60= 15 (unskilled)

Total volume of earthwork = 61.87 + 28.8 = 90.67

Total cost of excavation = Rs.1,856 + Rs.864 = Rs.2,720.00

Total mandays generated = 31+ 15 = 46 (unskilled)

Renovation of earthen channel

It is assumed that 50% of earthwork is needed for renovation of the earthen channel. Hence total volume of earthwork in water course and field channels in

25 ha area are $31 m^3$ and $14.4 m^3$ respectively. Total cost of earthwork excavation for renovation of water course and field channels is Rs.1360 for 25 ha command area. Mandays required for renovation will be 23.

Benefit envisaged

By adoption of this technology irrigation water will be available for transplanted rice in 25 ha area in *kharif* season. Apart from this, during *rabi* season, either 25 ha area will be under pulses/oil seed or 5 ha area will be put under vegetables. The detailed increase in production, increase in gross income, additional mandays generated due to asset creation are given in Table 11.

Table 11. Income generation and creation of mandays in the event of construction/ renovation of water course and field channels

Technology	Investment per 25 ha command area(Rs.)	Man-days generation	Production potential (t/ha)				Potential income generation (Rs)			Potential mandays generation due to asset created
			Crop	Pre	Post	Increase	Pre	Post	Increase	
Construction of field channel/ Renovation of field channel for 25 ha command area	2720 (Cost of earthwork excavation of water course Rs.1856 and field channels Rs.864)	46	Paddy	1.5	2	0.5	225000	300000	75000	20 x 25
			Pulses/ oil seed	0.5	1	0.5	125000	250000	125000	15 x 25
			Or, vegetable in 5 ha	0	10	10	0	200000	200000	200 x 5
Total							350000	550000 or (52000)	200000 or (170000)	875 or (1250)
(a) Length of main channel is 375m (b) Length of each lateral channel 100m (4 nos.)	Cost of earthwork excavation for renovation of water course and field channels is Rs.1360 (assuming 50% of the earthwork is needed for renovation)	23	Paddy	1.75	2.0	0.25	262500	300000	37500	10 x 25
			Pulses/ oil seed	0.75	1	0.25	187500	250000	62500	15 x 25
			Or, vegetable in 5 ha	7	10	3	140000	200000	60000	50 x 5
Total							450000 or (402500)	550000 or (500000)	100000 or (97500)	625 or (500)

13. Renovation of drainage system

The eastern region faces with water congestion problem due to high rainfall, saucer shaped topography and poor out fall conditions. This is a serious impediment in realizing the agricultural potential of this region. Drainage system is designed based on the rainfall, size of the drainage basin, runoff characteristics of the area including slope, soil, vegetation and crop coverage. Renovation of the drainage system is required if the system has not sufficient capacity to carry the design flow. Due to siltation and sliding of the soils sides of the ditch, system needs periodical maintenance. Renovation should start from the down stream side.

The detailed design of drainage system has been given in description of item No.7. Assuming the desired drainage density to be 0.5 km per square kilometer area, the length of main drain is 2.371 km, and there will be 4 nos. of lateral drains each of 790 m length (trapezoidal shape).

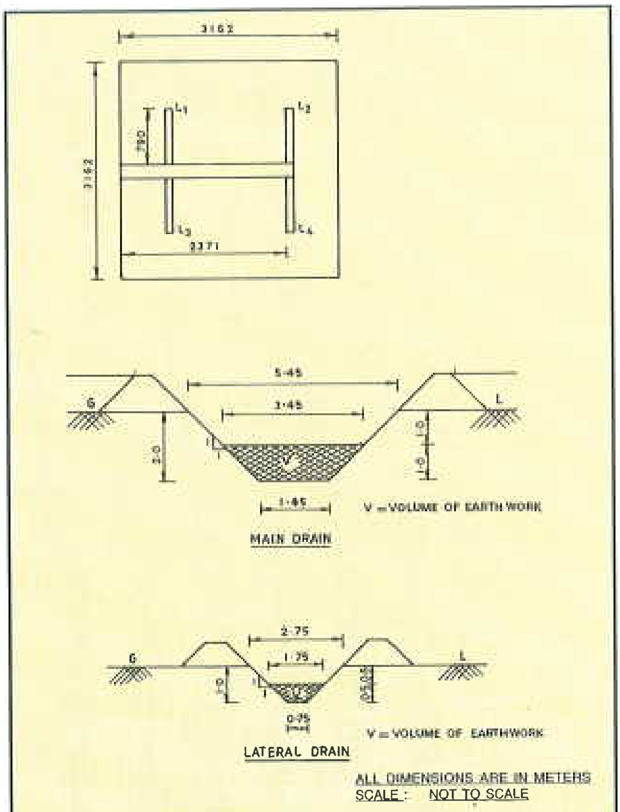
Design of main drain: Bottom width = 1.45 m, Top width = 5.45 m, depth = 2 m, side slope = 1:1 (Lay out is shown in Figure 16). Design of lateral drain: bottom width = 0.75 m, Top width = 2.75 m, depth = 1 m, side slope = 1:1.

Renovation of drainage system is considered assuming that 50% of the carrying capacity of the drainage ditches is silted up.

Estimate for renovation of drainage system in 1000 ha area

Total volume of earthwork in main drain = (3.45 + 1.45)/2 x 1 x 2371 = 5809 m^3

Total volume of earthwork in lateral drains = (0.75 + 1.75)/2 x 0.5 x 790 x 4 =1975m^3



Renovation of drainage system

Fig. 16 Layout and cross sectional view of drainage system

Cost of earthwork excavation @ Rs.30/m^3 = (5809 + 1975) x 30 = Rs.2,33,520.00

Total mandays required is 3892

Benefit envisaged

By renovating the drainage channels, it is expected that there will be a better water regime in the area treated leading to enhanced crop yield. Paddy production from the entire area during *kharif* season and pulses/oil seed production from 50% area during *rabi* season will be enhanced. The details of the income and mandays generation due renovation of drainage system is given in the Table 12.

Table 12. Income generation and creation of mandays due to renovation of drainage channel

Technology	Invest-ment per 1000 ha(Rs.)	Mandays gene-ration for 1000 ha	Production potential (t/ha)				Potential income generation (Rs)			Potential mandays generation due to asset created
			Crop	Pre	Post	Increase	Pre	Post	Increase	
Renovation of drainage channel for 1000 ha square size area	2,33,520	3892	Paddy	1.5	2.0	0.5	9000x 1000	12000x 1000	3000x 1000	10 x 1000
			Pulses/ oil seed	0.5	1	0.5	5000x 500	10000x 500	5000x 500	15 x 500
Total							11500000	17000000	5500000	17500

14. Raised and sunken bed system

Raised and sunken bed system (Plate 11) is a technology developed by WTCER which can be used for lowlands and medium lands in canal commands. Here, alternate raised and sunken beds are created by digging out soil from one strip of land and dumping it on an adjacent strip. The width of each strip is about 5 m. A 30 cm depth of soil is dug out from one strip and is used to raise the height of adjacent strip. So, the effective difference between the levels of raised and sunken bed is 60 cm. In the sunken bed, paddy can be cultivated and in the raised bed, vegetables can be grown. The schematic diagram of the raised and sunken bed is shown in Figure 17.

Plate 11. Raised and sunken bed system

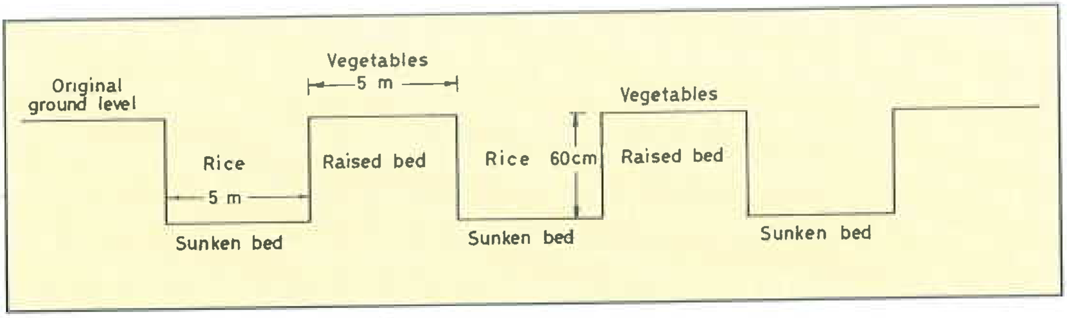


Fig. 17 Schematic diagram of alternate raised and sunken bed system

Modification in field topography through construction of alternate raised and sunken beds improves the physical environment of the soil. Removal of topsoil may initially reduce fertility level of the sunken bed. To minimize the adverse impact, application of FYM and compost @10 t/ha, growing sesbania in sunken beds during dry season and mixing the same before rice planting is recommended for the initial two years.

Design specification and cost estimate

Width of the bed = 5 m

Raised bed = 30 cm above ground level

Sunken bed = 30 cm below ground level

Length = depending upon the size of the field

Total length of twin beds/ha = 10,000/10 = 1000 m

Total earthwork = 1000 × 5 × 0.3 = 1500 m^3.

Cost of earthwork @Rs.30.00/ m^3 for 1500 m^3 = Rs.45,000.00/ha

Mandays required = 750 /ha (unskilled).

Benefit envisaged

By adoption of this technology, 50% of paddy area during the *kharif* season can be diversified to vegetable crops. Vegetables are much more profitable than the paddy crop. Similarly, in the *rabi* season, farmers also grow rice in canal command areas. Conversion of 50% land to vegetables will save water and increase the production and income of the farmers. Fish culture in the sunken bed will add to the benefit of the farmers. The detailed increase in production, increase in gross income, additional mandays created due to asset creation etc. are presented in Table 13.

Table 13. Increase in production and generation of mandays in Raised and sunken bed system

Technology	Investment (Rs.)	Man-days gene-ration	Production potential (t/ha)				Potential gross income generation (Rs) per ha per year			Potential mandays generation due to asset created
			Crop	Pre	Post	Increase	Pre	Post	Increase	
Raised and sunken bed for 1 ha area	Rs. 45,000.00	Unskilled - 750	*Kharif* Paddy	4.0 (in 1 ha)	5.0(in 0.5 ha)	1.0	24000	15000	-9000	80 x 1 - 100 x 0.5
			Kharif vege-tables in 0.5 ha	0	5	5	0	20000	20000	250 x 0.5
			Rabi Paddy	4.0 (in 1 ha)	4.5 (in 0.5 ha)	0.5	24000	13500	-10500	80 x1 - 100 x 0.5
			Rabi vege-tables in 0.5 ha	0	10	10	0	20000	20000	250 x 0.5
			Fish	0	1000 kg (total)	1000 kg (total)	0	40000	40000	0
Total							48000	108500	60500	190

15. Renovation of minors including field channels transferred to WUAs under PIM

Under participatory irrigation management programs, the maintenance of tertiary level irrigation system is being transferred to Water Users Associations (WUAs). The capacity of the minors is generally reduced due to siltation. Because of this, irrigation water does not flow to the tail reach of the command area. This reduces the efficiency of the canal irrigation system. So, renovation of the minors including the field channels is highly essential.

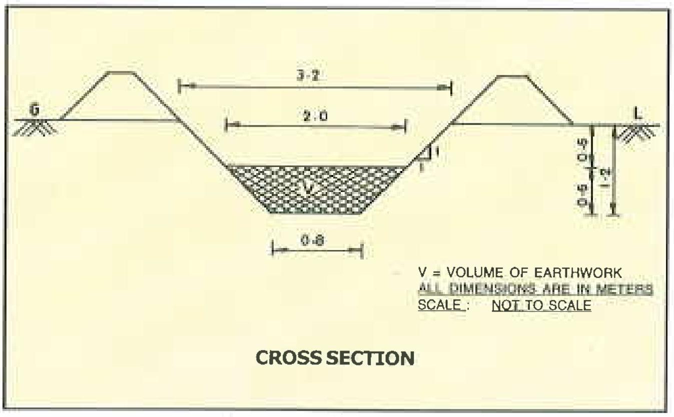


Fig. 18 Renovation of minor canal

Design

The depth of flow in the minor, d = 1m

For economical section, b= 2d tan $\theta/2$= 2×1×tan 22.5° = 0.83 m ≈ 0.8 m.

Side slope of the channel = 1:1.

Area of flow= (b + d) d = (0.8+1) × 1 = 1.8 m^2.

Wetted perimeter = $2\sqrt{2}$ d + b = 2 × 1.414 × 1 + 0.8 = 3.628 m

Hydraulic radius, R= A/P = 1.8/3.628 = 0.496 m

Velocity = $(1/n) \times R^{2/3} S^{1/2} = (1/0.04) \times (0.496)^{2/3} (0.001)^{1/2}$= 0.495 ≈ 0.5 m/sec.

This velocity is well within the safe limit.

Then design discharge of the minor is 1.8 × 0.5 = 0.9 m^3/sec.

Depth of minor after considering the freeboard = 1.2 m

Command area of the minor having 0.9 cumec discharge is 600 ha.

It is assumed that for renovation, we need to remove soil from the bottom half depth of the minor i.e. 0.6 m depth.

Then area for earthwork = (0.6 + 0.8) × 0.6 = 0.84 m^2.

Average length of a minor = 3 km = 3000 m.

Hence total earthwork for the minor = 3000 × 0.84 = 2520 m^3.

The cross-section of the minor is shown in Figure 18.

Estimate

(i)	Earthwork @ Rs. 30.00/ m^3 for 2,520 m^3	= Rs.75,600.00
(ii)	Cost of renovation of field channels for 600 ha command (@Rs.1360.00/25 ha as obtained in item no: 12)	= Rs.32,640.00
	Total	= Rs.1,08,240.00

Mandays required = 1804 (unskilled)

Benefit envisaged

By renovation of the minors, it is expected that irrigation water availability will be improved in one-third (tail reach) of the command area i.e. in an area of 200 ha. So, the paddy production in *kharif* season and vegetables, pulses and oilseed production in *rabi* season will be improved. This will further generate additional mandays and enhance employment in the command. The detailed increase in production, increase in gross income, and additional mandays created due to asset creation are given in Table 14.

Table 14. Renovation of minors (including field channels) transferred to WUAs under PIM (effective command area 200 ha)

Technology	Investment (Rs.)	Mandays generation	Production potential (t/ha)				Potential gross income generation (Rs) per system per year			Potential mandays generation due to asset created
			Crop	Pre	Post	Increase	Pre	Post	Increase	
Renovation of minor including field channels having a command area of 600 ha.	Rs.108240	Unskilled - 1804	*Kharif* Paddy in 200 ha	2.0	2.25	0.25	2400000	2700000	300000	200 x10
			Rabi Pulses/ oil seed in 170 ha	0.75	1.0	0.25	1275000	1700000	425000	170 x15
			Rabi vege-tables in 30 ha	7	10	3	840000	1200000	360000	30 x50
Total							4515000	5600000	1085000	6050

Groundwater utilization

16. Groundwater utilization through open dug wells for small and marginal farmers

Surface flow based minor irrigation systems are very common in plateau areas of eastern region which have hard rock aquifers. Due to coarse textured soil structure and poor water distribution system, there is a significant loss of water due to seepage. This leads to poor availability of irrigation water especially during *rabi* and summer season. However, it has been observed that in the tail reach of flow based MI systems irrigation water resources can be successfully created through open dug wells (Plate 12). The diameter of

Plate 12. View of an open dug well

the well can be about 5 m and size of prime mover should be 2hp-5hp depending on the availability of water in the well. The depth of open well may be kept at about 10 m. The schematic diagram of open well is shown in Figure 19. The investment cost for providing irrigation through this system is around Rs.40,000.00 and it can command 2 ha area.

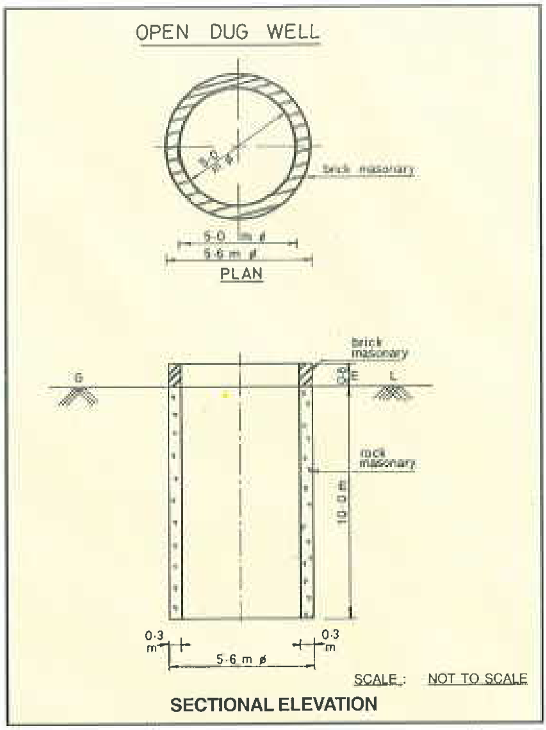


Fig. 19 Plan and elevation of open dug well

Average cost of earthwork excavation for 1 m^3 of earthwork including lead and lift is Rs.45.

Skilled and unskilled labour charge per day is Rs.100 and Rs.60 respectively.

Design and estimate

Total volume of earthwork for the dug well (10m depth, 5.6 m outer diameter) = 246 m^3 ≈

Cost of excavation	=	$246m^3$ @Rs.45/ m^3	=	Rs.11,070
Cost of brick masonry	=	$5m^3$ @Rs.1000/ m^3	=	Rs.5,000
Cost of rock masonry	=	$50m^3$ @Rs.500/ m^3	=	Rs.25,000
		Total cost	=	Rs.41,070
				Rs.41, 000

Total Mandays required =185 (unskilled) + 20 (skilled)

Benefit envisaged

By adoption of this intervention, assured irrigation can be provided to 2 ha paddy crop in *kharif* season. Besides this, during *rabi* season, out of 2 ha area, 0.5 ha area can be put under vegetables or whole of 2 ha can be put under pulses/oil seed. The detailed increase in production, increase in gross income, and additional mandays due to asset creation are presented in Table No. 15.

Table 15. Income generation and creation of mandays due to open dug well construction

Technology	Investment per 2 ha (Rs.)	Mandays gene-ration	Production potential (t/ha)				Potential income generation (Rs)			Potential mandays generation due to asset created
			Crop	Pre	Post	Increase	Pre	Post	Increase	
Groundwater through open dug wells for small and marginal farmers	41,000	185 (un skilled) 20 (skilled)	Paddy	1.5	2	0.5	18000	24000	6000	20 x 2
			Pulses/ oil seed	0.5	1	0.5	10000	20000	10000	15 x 2
			Or, vege table in 0.5 ha	0	10	10	0	20000	20000	200 x 0.5
Total							28000	44000	16000	70 or (140)

17. Shallow tube wells drilled by manual drills in alluvial areas

In the coastal belt of eastern India, the deeper aquifers are saline and fresh water floats over the poor quality groundwater. The exploitation of groundwater is meager due to poor resource base of the farmers. The NREGS funds can be utilized for increasing irrigated area through exploitation of top layer of fresh water available in the shallow aquifers. Hence, it is proposed to install bore wells through manual drilling in alluvial areas (Plate 13). These areas fall under granular zone with alternate layer of sand and clay up to the depth of 60-70 m below soil surface. Generally first aquifer falls at 40-60 m

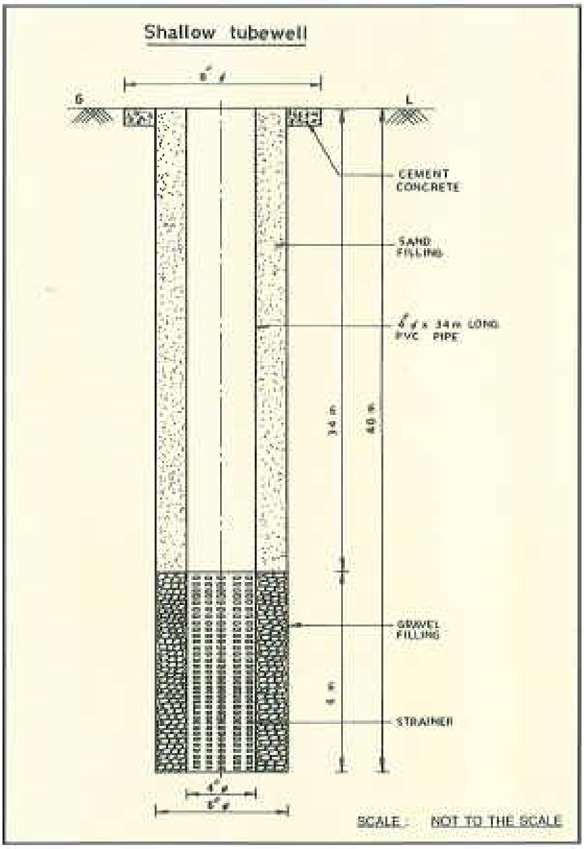


Fig. 20 Cross sectional view of a shallow tube well

depth below ground surface. The investment cost for providing irrigation through this system will be Rs.36400 and it can command 6-8 ha. The cross sectional view of shallow bore wells is presented in Fig. 20.

Plate 13. Shallow tube well in alluvial region

Design

The depth of shallow tube well is 40 m. The length of blank pipe and strainer pipe will depend on the lithology of the area. The diameter of the well should be 4" and size of prime mover should be 3hp-5hp.

Estimate

Labour cost			
Manually drilling	=	40m @Rs.200/m	= Rs. 8,000
Material cost			
Cost of 3 hp prime mover with accessories	=	Rs.15,000	
PVC pipe (4" dia) Schedule 80	=	34m @ Rs.230/m	= Rs. 7,820
PVC ribbed screen pipe (4" dia)	=	6m @ Rs.340/m	= Rs. 2,040
Filter materials			
Sand	=	2m³ @ Rs.300/m³	= Rs. 600
Gravel	=	7m³ @ Rs.350/m³	= Rs. 2,450
Cement concrete foundation and plastering	=	Lump sum	= Rs. 500
		Total	**= Rs. 36,410**

Total Mandays required = 80 skilled labour (Rs. 100/skilled labour)

Benefit envisaged

By implementing this intervention, assured irrigation can be provided to 6 ha paddy cultivation in *kharif* season. Besides this, during *rabi* season, out of 6 ha area, 2 ha area can be put under vegetables and 4 ha can be put under pulses/oil seed. The detailed calculation showing increase in production, increase in gross income, additional mandays created due to asset creation etc. are presented in Table 16.

Table 16. Income generation and creation of mandays for shallow tube wells drilled manually in alluvial areas

Technology	Invest-ment per 6 ha(Rs.)	Man-days gene-ration	Production potential (t/ha)				Potential income generation (Rs/ha)			Potential mandays generation due to asset created
			Crop	Pre	Post	Increase	Pre	Post	Increase	
Manually drilled shallow tube wells in alluvial areas	36400	80	Paddy in 6 ha	1.5	2	0.5	54000	72000	18000	20 x 6
			Pulses/ oil seed in 4 ha	0.5	1	0.5	20000	40000	20000	15 x 4
			vegetable in 2 ha	0	10	10	0	80000	80000	200 x 2
Total							74000	192000	118000	580

Miscellaneous

18. Renovation of existing tanks/ponds on Government/Community land

There are large numbers of tanks/ponds and water bodies already present in rural areas of Eastern India. Those are of various sizes, shapes and depths. They cater to the need of rural population and animals for their domestic as well as agricultural uses. They also act as source to recharge ground water. Due to various reasons most of these water bodies at present are in a neglected state. The washouts of surrounding area in the form of soil and nutrients cause sedimentation in those water bodies. There is also wild grass and weed infestation in those ponds. If renovated, these ponds will cater the need of the rural human and animal population to a greater extent both for domestic and agricultural purposes. Therefore, renovation of existing ponds and water bodies are suggested as an effective water management strategy for providing irrigation as well as pisciculture. Since the water bodies are of various shape, size and depth, it is suggested to renovate those by excavating 1m depth soil from the bottom.

Design

Assuming the volume of the pond = 4000 m^3 and one fourth volume of earth need to be removed, total earthwork = 1000 m^3, Assuming the earthwork excavation rate as Rs.30/ m^3, the total expenditure to be incurred for earthwork excavation is Rs.30,000.00.

Benefits envisaged

By renovation of the tanks, it is expected that the paddy yield of the surrounding area which will get irrigation water from these ponds will increase from 1.75 t/ha to 2 t/ha. In our above calculation it is considered that one ha of paddy will be benefited. The fish yield in the tank will increase from 300 kg to 400 kg from 1000 m^2 area of pond. The investment, mandays generation while creating asset and after creation of asset, and potential income generated are given in Table 17.

Table 17. Income generation and creation of mandays in the event of renovation of existing tanks/ponds

Technology	Investment (per 1 pond)	Man-days gene-ration	Production potential (t/ha)				Potential income generation (Rs)			Potential mandays generation due to asset created
			Crop	Pre	Post	Increase	Pre	Post	Increase	
Renovation of existing tanks/ ponds on Government/ Community land	30,000	500 (un skilled)	Paddy (1 ha area)	1.75	2.0	0.25	10500	12000	1500	10
			Fish (1000 m^2)	0.3	0.4	0.1	12000	16000	4000	10
Total							22500	28000	5500	20