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Tank Irrigation in India: Future Management Strategies and Investment Options

K. Palanisami

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Tank Irrigation in India: Future Management Strategies and Investment Options

के पलानीसामी
K. Palanisami

आर्थिक विश्लेषण और अनुसंधान विभाग
Department of Economic Analysis and Research
राष्ट्रीय कृषि और ग्रामीण विकास बैंक, मुंबई
National Bank for Agriculture and Rural Development, Mumbai

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National Bank for Agriculture and Rural Development

Office Address
National Bank for Agriculture and Rural Development
Plot No. C-24. 'G' Block, Bandra-Kurla Complex
Bandra (E), Mumbai - 400051
Email : dear@nabard.org
Website : www.nabard.org

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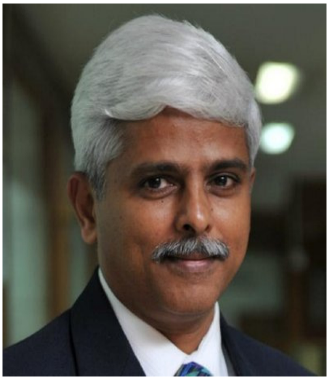
Foreword



There is a vast body of research available on topics related to agriculture and rural development in the academic world. But, most of it is in the technical realm and not in a form which could feed into the policy. Research must first lead to better understanding of a subject and then into a robust policy, wherever it can, so that it touches the multitude of Indians across the length and breadth of our country through better public policy and efficient services. Discussion with my colleagues on this issue lead to this new series "Research & Policy". We wish that this series will provide the breadth and depth of research into an area topped up by a lucid presentation for the policy makers.

I am happy to present the tenth publication in this series on "Tank Irrigation in India" written by Dr. K. Palanisami.

I wish this new series acts as a bridge between the researchers and policymakers.

P. V. S. Suryakumar
Deputy Managing Director

Preface

Agriculture sector proved a silver lining in the pandemic period registering a positive growth in the covid times. Yet it faces various structural challenges to be addressed to make it profitable. For, the majority of the population is still dependent on the sector. As we all know, investing in research is one of the best strategies to address problems of agriculture. Equally important is to communicate the research findings to policy makers to design and tweak policies that matter. During one of our meetings with Shri P. V. S. Suryakumar, our DMD, we had loud thinking if we can commission a few review papers on select themes. We thought that it is appropriate to request veteran scholars who spent prime of their life on a given research theme to attempt such a work where they will distil their understanding and the research done on the theme in a short paper. Duly encouraged by DMD and our Former Chairman, we wrote to a dozen eminent scholars. And the response was overwhelming resulting in Department of Economic Analysis and Research (DEAR), the research wing of NABARD, initiating the "Research and Policy" series. The motivation is, thus, to get a few handles from research that can help effective policy intervention. This series will be useful to policy makers and researchers alike.

The "Research and Policy" series is an attempt to get a glimpse of hardcore research findings in a capsule form thereby making it more effective and communicative to policymakers. The group of researchers who agreed to prepare a review of research have spent their life in the field of agricultural research. Our purpose here, as we communicated to them, was not just to get literature survey but to get researcher's heart and their experience which they gained during their long passionate innings. The paper is expected to highlights various issues, policy relevance, prescription, and suggestion for future papers on the themes of interest to NABARD.

Tanks enjoyed pride of the place once with a respectable share in irrigation in Semi-Arid Tropic (SAT) regions. They deteriorated over the years and are no more a reckonable source of irrigation. Having reached the limits to the expansion of canal and well irrigation, tank water harvesting and irrigation offers the best investment strategy for stabilising the irrigation potential and livelihood options in the rural

India. In light of this, the current paper on Tank Irrigation in India, written by Dr. K. Palanisami, Emeritus Scientist, International Water Management Institute (IWMI), Colombo assumes importance. Dr. Palanisami has a distinguished academic career, with research interests in water economics and policy, impact evaluation, investment modelling, technology transfer and climate change.

The paper begins by examining the performance and status of tank irrigation in different regions of the country. It then discusses how various factors over different time periods have contributed to the decline in tank system performance. Furthermore, the author illustrates the dynamics of tank systems in relation to numerous factors such as rainfall, groundwater, population, agriculture, and other multiple uses, among others. At the end, the author reviews various steps taken at various levels of government in tank rehabilitation and modernisation and provides policy recommendations for sustainable and effective methods for restoring the tank system in the changing dynamics.

In bringing this series as planned, we would like to express our sincere gratitude to our Chairman Shri Suchindra Misra for his support and to Shri P. V. S. Suryakumar, DMD for being the inspiration and the driving force behind the publication of this first of its kind series. We also thanks Dr. G. R. Chintala, Former Chairman, NABARD for his inspiring leadership, unstinted support and guidance. We are grateful to the authors of this series who agreed to write on themes relevant to NABARD in such a short period of time. Indeed, it has been a great privilege for us.

I acknowledge the contributions of the officers of DEAR, NABARD especially Dr. Vinod Kumar, GM; Dr. Ashutosh Kumar, DGM; Smt Geeta Acharya, Manager; Ms Neha Gupta, Shri Vinay Jadhav, Assistant Managers, and others who coordinated with the authors and the editor to bring out the series as envisaged.

Thanks are due to Dr. J. Dennis Rajakumar, Director, EPWRF and his team for their contribution in copy editing and bringing uniformity to the document.

K. J. Satyasai
Chief General Manager
Department of Economic Analysis and Research (DEAR)
NABARD, Mumbai-400051

Acknowledgement

Indeed, this assignment has provided me an opportunity to do a meta analysis of the tank irrigation research mostly done my me. I wish to thank Dr. K. J. Satyasai, Chief General Manager, Department of Economic Analysis and Research (DEAR), NABARD for providing an opportunity to consolidate my 40 years of work on tank irrigation and prepare a policy report. I also thank my partner scientists/ experts in different states who earlier worked with me in different programmes on tank irrigation in India and abroad. I am indebted to Dr. Ratna Reddy, Director, Livelihoods and Natural Resource Management Institute, Hyderabad who shared the tank related time series data from the earlier tank irrigation research studies. Dr. V. Puhazhendhi, former General Manager, NABARD, was instrumental in encouraging me to do such synthesis studies on tank irrigation, and I am much thankful to him for his encouragement and suggestions on the earlier version of the report. I am also thankful to Dr. D. Suresh Kumar, Director, Centre for Agricultural and Rural Development Studies, Tamil Nadu Agricultural University, and Dr. Arivelarasan, Agricultural Economist for checking and providing the latest data on tank irrigated area in India.

K. Palanisami
Emeritus Scientist
International Water Management Institute
New Delhi/Colombo.

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Abbreviations

ACIAR	Australian Council for International Agricultural Research
ADB	Asian Development Bank
ADMI	Accelerated Development of Minor Irrigation
AIBP	Accelerated Irrigation Benefit Programme
AP	Andhra Pradesh
APCBTMP	Andhra Pradesh Community Based Tank Management Project
CADWM	Command Area Development and Water Management
DES	Directorate of Economics and Statistics
DHAN	Development of Humane Action
EEC	European Economic Community
GDGS	Gaalmukt Dharan and Gaalyukt Shivar
GoI	Government of India
GoK	Government of Karnataka
IPCC	Intergovernmental Panel on Climate Change
IRRI	International Rice Research Institute
IWMI	International Water Management Institute
JSYS	Jala Samvardhane Yojana Sangha
KCBTMP	Karnataka Community Based Tank Management Project
KfW	Kreditanstalt für Wiederaufbau

(Contd….)

Abbreviations *(Contd….)*

M&M	Major and Medium
MMIP	Maharashtra Minor Irrigation Project
MGNREGA	Mahatma Gandhi National Rural Employment Guarantee Act
NAAS	National Academy of Agricultural Sciences
NABARD	National Bank for Agriculture and Rural Development
NEM	Northeast Monsoon
NGO	Non-governmental Organization
NREGP	National Rural Employment Guarantee Programme
NSA	Net Sown Area
OCTMP	Orissa Community Tank Management Project
OWRCP	Odisha Water Resources Consolidation Project
PRADAN	Professional Assistance for Development Action
PU	Panchayat Union
PWD	Public Works Department
RIDF	Rural Infrastructure Development Fund
RKVY	Rashtriya Krishi Vikas Yojana
RRR	Revival, Restoration and Rehabilitation
Rs	Rupees
SHGs	Self-Help Groups
SPWD	Society for Promotion of Wastelands Development

(Contd….)

Abbreviations *(Concluded)*

SWM	Southwest Monsoon
sq km	square kilometer
TBS	Tarun Bharat Sangh
TN-IAMWARM	Tamil Nadu-Irrigated Agriculture Modernisation and Water-bodies Restoration and Management
TS	Tank Storage
UTs	Union Territories
WRCP	Water Resources Consolidation Project
WRM	Water Resources Management
WUAs	Water User Associations

Executive Summary

Tanks are rainfall dependent century old gravity irrigation systems located mostly in arid and semi-arid regions. There are about 0.25 million tanks in India. The tank irrigated area was 1.67 million hectare (m.ha) in 2018, having declined from 3.3 m.ha in 1953. The southern states account for about 60% of the tank irrigated areas in the country. Years of disrepair, neglect and lack of proactive management have adversely affected productivity and efficiency of tanks. Encroachment of the tank catchment, improper land use in the upstream and siltation of the tank water spread over years had reduced the tank storage capacity by about 30% in most of the regions resulting in poor performance of tank irrigation.

Given the constraints to the future expansion of canal irrigation and groundwater development in the country, irrigation tanks have now re-emerged as the best example of providing extensive (protective) irrigation in the semi-arid tropics. Because these tanks are distributed across the landscape benefitting mostly small and marginal farmers, tanks are considered as the best adaptation to climate change. Also, in terms of future investment options in irrigation, tanks offer more scope for low-cost investment. Now, a lot of interest is seen among the funding agencies to invest in tank rehabilitation and modernisation. The question is how to go ahead with the revival of tanks and tank irrigation. There are emerging challenges (hotspots) and also opportunities (bright spots) that may spell out what can be done to revive the tanks in a sustainable manner. This report discusses most of these aspects in detail.

Tank rehabilitation started around four decades ago in the early 1980s with the primary focus on physical rehabilitation with a view to increase agricultural productivity, but very little attention was paid towards institutional development, maintenance and management. Tank rehabilitation had undergone many notable changes over the years in terms of their objectives and focus of funding pattern and funding sources, physical components prioritised for rehabilitation, implementation pattern and institutional architecture.

Looking at the past rehabilitation performance and the needs of the future, improving the livelihood of the rural community through increasing the total benefits from multiple uses of the tanks should be the objective of future tank rehabilitation programmes. Accordingly, this report suggests six time-tested options for future modernisation. They are:

- Option 1: Desilting only in selected locations in the tank water spread area. Normally it covers from 20% to 30% of the water spread area.
- Option 2: Desilting the entire tank water spread area to a given depth.
- Option 3: Converting the tanks into percolation ponds by closing the sluices when the tank water storage is less than 40% averaged in the last 5 years.
- Option 4: Providing 1-2 fillings to the tanks during the tank season from the nearby canal, anaicut, or river systems.
- Option 5: Developing full groundwater in the command area by working out the feasible (optimal) number of wells in the tank command area using annual groundwater draft. It is expected that in the tank commands, about 20% increase in the number of wells is possible.
- Option 6: Adopting sluice rotation (opening and closing the sluices in alternate weeks) so that ground water and tank water would be simultaneously (conjunctively) used throughout the crop season.

In order to implement the above options in a sustainable manner, the report provides detailed answers to the following questions:

What will the key components of tank modernisation be?

Tank modernisation should primarily comprise catchment treatment, foreshore plantations, creation of dead storage for community and livestock use, improvement of supply channels and tank structure, on-farm development works, crop and water management, and provision of community wells wherever feasible. Rehabilitation focus should be on distribution of water based on crop demand and adoption of crop and water management practices through on-farm development.

The rehabilitation budget should be allocated in the ratio of 10%, 75%, and 15%, respectively, to institutional development, physical works and maintenance. A one-time investment of 15% for maintenance and management activity is to be allocated from the rehabilitation funds.

How could the modernisation options be prioritised in the tanks?

Most of the modernisation programmes followed a standard package (blue print) approach, which is not effective. For greater cost effectiveness, it is important to identify selective (customised) modernisation strategies to suit different tank typologies. For instance, in the eastern and western regions, the key attention of tank rehabilitation is still on increasing agricultural productivity – where the benefits mostly accrue to the landowners (landlords) with the landless remaining merely as labourers. In most cases in the southern region, more focus is given for improving livelihood opportunities – household in the village receives benefits in one way or another from the multiple uses of tanks.

In the case of construction of new tanks and rehabilitation of the existing tanks, it is suggested that in the Eastern region, where small tanks and ponds are common, construction of new tanks and ponds can be an attractive investment option. It is economical to invest in rehabilitation of the existing tanks in other regions, where a large number of tanks are existing and where watershed programmes are competing for rainfall storages.

What are the factors that will make tank modernisation sustainable?

The focus of rehabilitation in the future will be more on water acquisition, storage and distribution. The cascade approach should be followed in restoring tanks, if the full benefits of harvesting the runoff from a micro watershed and effective groundwater recharge are to be realised.

In this entire process of designing tank rehabilitation, capacity building is the core without which sustainability cannot be attained. The first part of the capacity building should focus on strengthening the tank user groups, creating awareness and introducing income generating sources to self-help groups (SHGs). The second part of training can start during the implementation of the rehabilitation works with a due focus on the crop and water management and operation maintenance aspects of tanks. The third part of the training can start focusing on managing tank and tank irrigation under the guidance of water user associations (WUAs).

The Mahatma Gandhi National Rural Employment Guarantee Scheme (MGNREGS) manpower can be better used in tank improvement works, so that the impact of the MGNREGS labour could be measurable. Integration of tank and groundwater system and integration of tanks and social forestry should be carefully inbuilt in the modernisation programme, as they will be highly complementary to improved tank performance. As part of the modernisation process, a database on tanks in the cascade should be generated so as to help to analyse a variety of technical, socio-economic, and ecological relationships such as tank storage under varying rainfall regimes, evaporation losses from tank water spread, groundwater storage, recharge rates under different soil and silt conditions, the pattern of water use, and so on. A tank manual should be prepared that could serve as a guidance document to tank management in the long run.

How could the tank modernisation be done in a cost-effective manner? How to make the funding mode more effective?

Regarding investment and cost sharing in tank modernisation, a one-time investment of a maximum of 15% for maintenance and management has to be allocated from the total modernisation budget, and the bank interest accrued out of this fund can only be used for tank maintenance and management on a regular basis. In the case of water acquisition, the cost calculations should be based on rupees per square kilometer (sq km) of catchment area for works in the catchment including feeder channel improvement.

Since budget constraints may surface out while going for a large-scale rehabilitation, it is important to examine the relevant co-financing options in tank modernisation programmes. Several funding agencies are funding the tank modernisation efforts, but mostly in a single agency mode. For instance, the European Economic Community (EEC), National Bank for Agriculture and Rural Development (NABARD), World Bank, and so on funded programmes are mostly done based on their concept note and work plan already agreed with the implementing government departments such as irrigation or agriculture departments. It is observed that in most of the tank modernisation programmes, technology adoption and capacity building aspects are weak resulting in poor performance of the modernised tanks over the years. Hence, co-financing with national or international funding agencies with different expertise in modernisation would enhance the benefits from modernisation. Thus, NABARD could consider co-financing options with the Asian Development Bank or World Bank to utilise their specific expertise. So, there is a win-win situation for both the funding agencies. Co-financing will also provide better opportunities for cross learning and mainstreaming the investment programmes in a better manner.

What is the kind of institutional setup needed for the future of the tanks?

Tank water users' association should be made mandatory for all the tanks. One single agency such as Public Works Department or Rural Development Department must be made as the nodal agency to coordinate with tank dependent farmers' associations. At the national level, a tank authority can be established mainly to coordinate and mobilise funds for tank investment and management by closely working with the states. The tank authority will ensure better convergence of different programmes by government departments, external funding agencies and corporate initiatives for tank improvements, and cross learning of tank management issues across states, prioritising of investment options and enhanced livelihood options in the rural sector.

In sum, given the climate change regime and the constraints in further expanding canal and well irrigation sources, irrigation tanks (both new and existing) offer the best investment strategy for stabilising the irrigation potential in the country, besides benefitting mostly small and marginal farmers and other rural households in the country.

Tank Irrigation in India: Future Management Strategies and Investment Options

1. Introduction

A tank is a low earthen bund formed across the shallow valley to hold the rainfall runoff from the catchment area above. Tanks may be either isolated or in a chain or cascade. Tank irrigation contributes significantly to agricultural production in large parts of South and Southeast Asia. Tanks are rainfall dependent and the majority of the tank systems are located in arid and semi-arid regions. There are about 0.25 million tanks in India irrigating about 1.7 million ha. The southern states account for about 60% of the tank irrigated area. Together, the tank irrigated areas of these states produce about 4.5 million tons of rice per year, that is, approximately 25% of the total rice production in these states.

In ancient days, tanks were considered to be the property of kings and rulers. The farmers paid a portion of the produce to the rulers. Farmers also were in charge of the maintenance of the tanks and supply channels. Zamindars (big landlords) ensured the proper maintenance of the tanks and channels, since they reaped the benefits of farming in large areas and also served as tax collectors for the rulers.

In many ways, tanks, even in their present decrepit state, are a socio-ecological, socio-economic and socio-engineering marvel. They perform many important functions; they help to collect, conserve and store the rainfall, thus, reduce soil erosion, provide low-cost flow irrigation to the crops, and recharge groundwater aquifers and stabilise well irrigation. Besides providing protection against the vagaries of rainfall, tanks complement other benefits such as fishery, social forestry and tank-bed cultivation, and provide silts that are the best organic manure to farmlands and enrich soil fertility. Overall, tanks enliven the aquatic environment in their surroundings and sustain local agrarian economies, as they serve as an important anchor for cohesive local communities. Above all, tanks provide all these benefits virtually free of cost. Neither their present users nor the government has made any capital investment to construct many of the tanks (Raju and Shah 2000).

Years of disrepair, neglect and lack of proactive management have adversely affected productivity and efficiency of tanks. Almost all tanks have suffered from silt build-up in the water spread area or tank bed. As a result, their storage capacity has declined. Siltation has occurred partly because of natural processes and partly because of changes in the land use in the upstream locations. Originally, the bulk of the tank catchment area was uninhabited and water demand in the catchment area was negligible, thus, facilitating free flow to the downstream tanks. After changes in land use and consequent siltation of the supply channels, the flow capacity of supply channels has been reduced. Further, siltation reduces the permeability of topsoil and impedes groundwater recharge.

Over the years, an increasing number of water harvesting and storage structures with changes in land use upstream of the tanks have further reduced the inflows downstream. With this, the free catchment available to the tanks has declined, and so has rainwater runoff. Further, beneficiary participation in all aspects of tank management starting from catchment management to field water distribution has reduced over the years. The above issues indicate that the irrigation department's lapses in maintenance works are only a part of the reason for their decline. An even more important reason is the dysfunctional social and village dynamics around the tanks (Raju and Shah, 2000; Palanisami *et al.* 2000). In sum, the potential of tanks seems to be sinking, and the productive capacity of most tanks has been reduced to a fraction of the potential because of the long neglect and disrepair.

1.1 Why Tank Systems should be Revived?

Given the constraints for the future expansion of irrigation under canals and groundwater, tanks are considered as neglected opportunities, as irrigation tanks have now re-emerged as some of the finest examples for extensive irrigation that spreads a given quantum of available water over as large an area as possible. This maximises the productivity per cubic foot of available water rather than per acre of land.

Land owned by resource poor farmers (owning less than 2 hectares) still account for the major share of tank irrigated areas in India. Marginal (less than 1 ha) and small farmers (1-2 ha) together account for about 55% and the large farmers account for 6%. This is also true across different states where tank irrigation has considerable presence even today (Narayanamoorthy, 2007; Narayanamoorthy and Suresh, 2016).

Expected climate change impacts in Asia in general and South Asia in particular will cause more intensive rains and floods in shorter periods and prolonged drought

Photo 1: Tanks with Long Bund, Tamil Nadu

spells for longer periods. During floods, tank systems offer more scope to store the excess water, and allow for both irrigation and groundwater recharge during times of water shortage. Because these tanks are distributed across the landscape, they capture more of the water and provide for more local control compared to a few large reservoirs. Hence, there is a considerable interest in tanks as the best adaptation strategy to climate change.

The present average cost of development of new major and medium (M&M) irrigation projects is about Rs. 8 lakh - Rs. 12 lakh per ha compared to Rs. 3 lakh - Rs. 4 lakh per ha for rehabilitation. Most of the potential sites for construction of M&M projects have already been developed. In the case of minor irrigation tanks, the cost of rehabilitation is around Rs. 60,000 - Rs. 70,000 per ha (at 2007 prices). If the hidden costs behind M&M projects are included, the M&M projects would prove even more costly. Thus, cost-wise, tanks offer more scope for future expansion in irrigation.

1.2 Why this Report?

So, on one side, we see the fast-deteriorating tanks, and on the other side, we see the increasing scope for tank restoration to meet the future water demand. There are emerging challenges (hotspots) and also opportunities (bright spots) that may spell out what can be done to revive the tanks in a sustainable manner. Now, a lot of interest is seen among the funding agencies to invest in tank rehabilitation and modernisation. But still one is not clear as to how to go ahead with tank rehabilitation investment, and what is the cross learning from the already done rehabilitation investment.

With this background, this policy report is structured to address the following issues: a) what are the spatial and temporal changes in tank related factors that hinder tank management, b) what are the major hotspots and bright spots and their impact on tank management, and c) what are the ways and means of effectively implementing tank improvement programmes?

The report heavily draws from the studies of tanks in India, and from the author's tank irrigation research and outreach activities done over the last four decades in several states of India and other countries. The report has five sections including the introduction. Section 2 deals with performance of tanks, section 3 deals with hotspots of tank irrigation, section 4 deals with tanks rehabilitation and modernisation, and finally, section 5 deals with future of tanks in India.

2. Performance of Tank Irrigation

In the absence of accurate data across all the states, the number of tanks and ponds in India are reported to vary from 0.2 million to 0.35 million (Asian Development Bank, 2006). The number of tanks in use assessed by the minor irrigation (MI) census in 2000-01 was 0.23 million in India. Besides, an estimated 42,955 tanks were not in use in 2000-01, which has gone up to 85,807 in 2010-11. Together, this estimates the number of tanks to be in the range of 0.3 million in India. The southern region accounts for 35% of the total tanks in use in India (2000-01), followed by West (20%), East (16%) and North (14%). East has the highest proportion of tanks not in use (21,471 out of 42,740 in 2010-11), followed by South (35,742 out of 1,02,991 in 2010-11), West and North (Reddy *et al.* 2018). The high density of tanks, both in use as well as in a decayed state, in South could be the reason for the focus that the region received for tank renovation programmes.

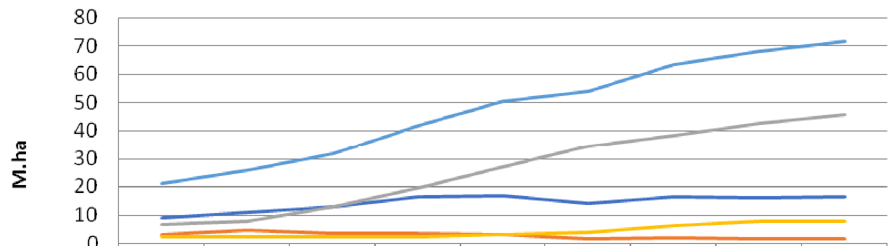
In terms of irrigated area, the tank irrigated area in India has declined from 3.3 million hectares (m.ha) in 1953 to 1.67 m.ha in 2018 (about 50% reduction)[1]. The share of tank irrigated area to the total irrigated area has also reduced from 15.6% in 1953 to 2.3% in 2018, whereas the share of groundwater irrigation has increased from

Table 1: A Comparison of Land Productivity under Tanks, Canals and Well Irrigation (t/ha in food grain energy equivalent units)

States	Land Productivity under (t/ha)			Compared to Tank Irrigation, Land Productivity Exceeds by (in %)	
	Well Irrigation	Canal Irrigation	Tank Irrigation	Well Irrigation	Canal Irrigation
Andhra Pradesh	5.7	3.4	2.1	185	70
Tamil Nadu	6.5	2.6	2.0	183	13
Karnataka	4.2	3.5	2.5	83	52

Source: Thacker (1999), quoted in Palanisami (2009).

Figure 1: Irrigation Source-wise Distribution of Net Area Irrigated, India (Figures in Million Hectares)



	1953	1963	1973	1983	1993	2003	2008	2014	2018
Canals	8.861	10.832	12.996	16.764	15.986	14.073	16.748	16.278	16.429
Tanks	3.303	4.781	3.619	3.533	3.179	1.811	1.973	1.842	1.668
Wells	6.521	7.649	12.964	19.392	26.92	34.354	38.361	42.438	45.75
Other Source	2.437	2.403	2.255	2.26	3.211	3.658	6.107	7.542	7.71
Total	21.122	25.665	31.834	41.949	50.296	53.897	63.189	68.1	71.56

Source: Directorate of Economics and Statistics, *Agricultural Statistics*, Ministry of Agriculture & Farmers Welfare, Government of India, New Delhi, Various Issues.

30.8% to 63.9% during this period (Figure 1). As a consequence of the decline in tank irrigation, the productivity of land under tanks is also observed to be low compared to other sources of irrigation. In Tamil Nadu, compared to land under tank irrigation, land productivity per hectare (ha) was 13% higher under canal irrigation and 183% higher under well irrigation (Table 1). The yield gaps under the tank irrigation are increasing over years due to poor tank management and water control. This calls for revival and improvement of tanks, so that tank irrigation will remain as a viable and sustainable irrigation source in the future.

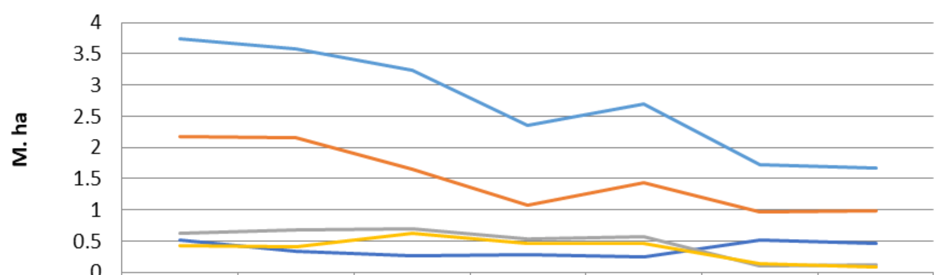
2.1 Status of Tank Irrigation Across Regions in India

The variations in the density of tanks across states are basically due to geo-hydrological, topography and rainfall patterns. Among the regions, southern India is noted for the intensity of tanks. Unlike in the northern region, rivers in the southern region are mostly seasonal and the plains are not very extensive. The local topographic variations have been effectively exploited to impound rainfall in tanks, which are used to raise irrigated rice crop and simultaneously serve as means of improving groundwater recharge in the command areas.

In order to get an insight in to the performance of tank irrigation across region, all the major states and union territories (UTs) in India are grouped under four regions (as per the Planning Commission), namely, South, North, East and West.[2]

Irrigated area under tanks has been declining since 1950-51, while that under all other sources have recorded an increase. Between 1973 and 2018, area under tank irrigation has steadily declined in the North and the South as well as at the all-India level, though there appears to be a sort of a revival between 2003 and 2018 (Figure 2). This could be due to the advent of tank rehabilitation programmes in some of the southern and eastern states. Over the last three decades, area under tank irrigation has declined by 1.0 m ha at the all-India level. Of this, more than 0.7 m ha of area is

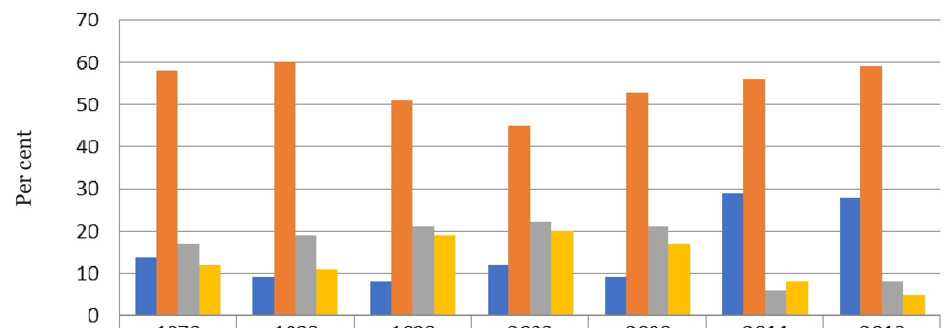
Figure 2: Region-wise Distribution of Area Under Tank Irrigation, India
(Figures in Million Hectares)



	1973	1983	1993	2003	2008	2014	2018
North	0.52	0.33	0.27	0.28	0.24	0.51	0.46
South	2.17	2.16	1.66	1.07	1.43	0.96	0.98
East	0.62	0.68	0.69	0.53	0.57	0.11	0.13
West	0.43	0.41	0.62	0.47	0.46	0.14	0.09
All India	3.74	3.58	3.24	2.35	2.7	1.72	1.67

Source: Same as Figure 1.

Figure 3: Region-wise Percentage of Area under Tanks, India (%)



	1973	1983	1993	2003	2008	2014	2018
North	14	9	8	12	9	29	28
South	58	60	51	45	53	56	59
East	17	19	21	22	21	6	8
West	12	11	19	20	17	8	5

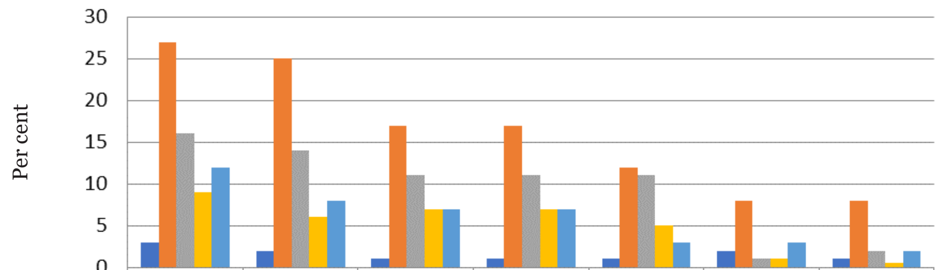
Source: Same as Figure 1.

from the southern region consisting of erstwhile undivided Andhra Pradesh, Tamil Nadu, Karnataka and Kerala. The share of different regions in the total area under tanks in India has changed between 1973 and 2018. In the South, it has marginally increased from 58% to 59% and in the North from 14% to 28%. In the East and West, it had reduced from 17% to 8% and 12 to 5%, respectively (Figure 3). On the other hand, the relative importance of tank irrigation to the total irrigated area has come down substantially over the years.

At the all-India level, the share of tank irrigation has declined from 12% in 1973 to 2% in 2018 (Figure 4). The importance of tank irrigation within the respective regions also declined substantially over these years. Tank irrigation, however, holds relatively greater importance in the South and the East, as these regions account for 8% and 2%, respectively, of the total irrigated area in the country. This could be one of the reasons for the attention that these regions get in terms of tank rehabilitation initiatives in the last few decades. In the case of other regions, tank irrigation accounts for 0.5% of the total irrigated area in the West and 1% in the North.

At the national level, a decline in tank irrigation from 12% to 2% was recorded between 1973 and 2018, indicating an urgent need for relooking the tank irrigation investment and management aspects. This will primarily look into the revival and

Figure 4: Region-wise Tank Irrigation to the Total Irrigated Area, India (%)



	1973	1983	1993	2003	2008	2014	2018
North	3	2	1	1	1	2	1
South	27	25	17	17	12	8	8
East	16	14	11	11	11	1	2
West	9	6	7	7	5	1	0.5
All India	12	8	7	7	3	3	2

Source: Same as Figure 1.

re-energising the tanks as a future investment opportunity for stabilising the irrigated area, especially in the South, East and West regions, where the higher tank density coupled with a large number of non-functional tanks exists.

2.2 Declining Tank Performance: Causes and Concerns

Even though the institutional arrangements such as tank water users' associations remained in place to protect and sustain these tank systems for several centuries, growing political interventions and changing socio-economic dynamics have resulted in their degeneration overtime. All this eventually started during the colonial period (early 19th century) when the investment and management priority shifted from minor irrigation (having irrigated areas less than 2,000 hectares) to medium irrigation (between 2,000 and 10,000 hectares) and major irrigation projects (more than 10,000 hectares). These shifts in policy focus was more on revenue generation from irrigation projects rather than protecting these traditional structures. As a result, the community ownership of the tanks deteriorated.

Historically, tanks have been constructed to store water in order to provide drinking water and protective irrigation during dry periods. Tanks and ponds have been the primary source of water for poor rural households in eastern India. Recent research shows that they are being converted into fish ponds by local communities or panchayats – tanks have been converted into fish ponds in the East and percolation ponds in the South mainly due to the declining viability of agriculture under tanks. Inflows into the tanks have declined substantially in recent years due to the catchment interventions such as watershed development programmes, urbanisation, etc. Though the tank systems have not fully been designed to facilitate all the multiple uses like domestic needs, fisheries, livestock and irrigation, the systems by default become multiple use systems due to anthropogenic pressure and changing tank hydrological parameters. While some of the unplanned uses may get absorbed by the system, other uses could damage it (Van Koppen *et al.* 2009). Often the competing water needs of the tanks results in conflicts between different users such as irrigators and fishermen, and also, domestic water or livestock water facing severe stress.

In most of the regions of India, especially in the drought-prone semi-arid tropics, declining tank irrigation and expansion of groundwater irrigation are observed over the years due to decline in benefits from community based tanks. Many studies clearly indicated that socio-economic changes, weakening of the tank based institutions and poor governance contributed significantly for the decline of tank irrigation (Von Oppen and Rao, 1980, 1980a; Reddy, 1995; Reddy, 2015, Mosse, 1999; Shankari, 1991; Sivasubramanian, 2006; Janakarajan, 1993; Reddy *et al.* 1993; Reddy *et al* 2018, Sakthivadivel *et al.* 2004; Palanisami, 2006, 2008; Palanisami, *et al.* 2011; Nehlin, 2016; Raju and Shah, 2000, 2002). The decline of traditional systems, therefore, is a cumulative effect of the policy and institutional neglect. As a consequence, other associated socio-environmental benefits such as groundwater percolation, retarding negative impacts of floods and droughts, community-led management and maintenance of tanks, and enriching biodiversity in the vicinity of the cascading tanks got collapsed, creating a considerable imbalance in the hydrological and ecological systems in most of the tank irrigated regions in the country.

In the case of eastern India, most of the tanks are small and used for irrigation, fishery, domestic needs and livestock management. About 90% of the tanks are used for irrigation, 68% for fishery, 59% for domestic use, 68% for livestock management, and 62% for both fishery and irrigation. None of the tanks are allowed for irrigation, if the pond depth is less than 3 feet (that is, 0.9 meter). Diesel pumps are also not allowed in most cases to drain water. Netting of fish is usually done in lean season, when there is no need for irrigation. Stocking of fish fingerlings in rainy season and harvesting in summer gives yield of 2-3 tons of fish per acre of water spread area. Supplementary irrigation provides scope for yield improvement and taking up a second crop after the harvest of first crop.

One of the main reasons for the decline of tank irrigation in the region is the deterioration in the physical condition of the tanks because of poor maintenance. Rift between different stakeholders (government, private, cooperatives, etc.) is contributing to inefficiency in tank irrigation. Furthermore, while tanks are still used for irrigation, livestock and domestic purpose, it has been observed that fishery, a sector which enjoys considerable government support, is emerging as the primary stakeholder of tanks in this region (Pant and Verma, 2009). This is increasing the scarcity of water for irrigation in the tanks, as a certain level of tank storage is required for fish production which otherwise would be available for irrigation. Competition between irrigation and fisheries is a factor contributing to a rift within the stakeholders and resulting in poor management of the tank systems. An optimal combination of irrigation and fishery would ensure the sustainability of tank irrigation. Not many studies have addressed these issues in detail in eastern India along with needed interventions, even though several studies have focused on these issues in the South Indian tanks (Sakurai and Palanisami, 2001; Kajisa *et al.* 2006, 2007; Ranganathan and Palanisami, 2004).

The declining tank performance can be summarised as follows:

Palanisami and Easter (1983, 1984, 1987, 1991, 2000) have mentioned a number of possibilities for the low level of tank irrigation. Firstly, the procedures used to calculate the water yield to tank storage are no longer applicable to the current situation, and can lead to an over estimation of water availability. Secondly, there has been a change in the rainfall patterns over time and changes in catchment characteristics due to abuses in the upper part of the watershed. Thirdly, encroachment in the tank foreshore and along the feeder channels, as well as siltation and tree planting in the tanks has reduced tank storage capacity. Fourthly, in several cases, the construction of dams and anicuts in upper watersheds has prevented the water supplies from reaching downstream tanks. Fifthly, low level resource mobilisation in the villages and low state budget allocations for operations and maintenance (O&M). Sixthly, community management of the tanks has declined due to conflicts between different groups in the villages. Seventhly, intensive groundwater development in tank command areas has

Photo 2: Tank with Siltation, Andhra Pradesh

caused tank management to decline due to diminished collective action. And, finally, the poor design of new tanks has resulted in a low level of performance.

Since the tank related issues are seemingly complex to comprehend due to the interplay of time and space, it is important to differentiate the issues relating to the decline in tank performance in terms of spatial and temporal scale, as many issues that are significantly affecting tank performance may be arising in the last three decades or so. Such an analysis would help to isolate the factors influencing tank management and highlight factors that may be important while dealing with tank improvement investments.

In spatial scale, the major factors contributing to the decline of tank irrigation in India and South India in particular are the following:

(a) System level: Erratic rainfall pattern and inadequate and unreliable water supply to the tank, encroachment of tank bed and supply channels by the government, public, and private people, silting of tank water spreads and supply channels, large-scale infestation of weeds, growth of trees and loss of grazing land in the tank bed, damaged sluices and weirs, dilapidated and weak tank bunds, delinked tanks in the tank cascades, and less investment on new tanks (Palanisami, 1990, 1991, 1993, 2000, 2005, 2006, 2013).

(b) Command area level: Unlined and damaged field channels, fast growing proposphis plants in the fields, inadequate tank water, declining groundwater levels in the wells, well abandonment, inappropriate crop pattern, poor crop yield, low income and lack of water management practices, pollution of urban tanks, and conversion of tanks into percolation ponds (Palanisami, 1993; Palanisami and Flinn 1988, 1989; Palanisami and Easter, 2000).

(c) Tank community level: Lack of community involvement in tank management and maintenance, non-functioning of tank based local institutions, meagre resource allocations for maintenance, out- migration of the potential labourers and farm family members for other jobs due to fast development of roads and communication facilities, expansion of urbanisation in the tank villages which are close to towns, and non-profitability of tank irrigated agriculture due to increased wages and input costs (Palanisami *et al.* 1997, 1998, 2008, 2010, 2011; Kajisa *et al.* 2006, 2007).

In temporal scale, the declining tank performance can be summarised under different phases as follows:

In the first phase (pre-independence to 1950), the declining performance has been related to the past governance of the tanks. During this period, institutional arrangements (such as *Dasabandam* and *Kudimaramat* of South India, *Aher-Pyne* systems of South Bihar, *Chandeli* tanks of Bhundelkh, and *Johads* and *Pals* of Rajasthan), were in place to protect these systems from decay. These institutional arrangements were nurtured by the benevolent local rulers, who were central to the development and sustenance of the tank systems over centuries. However, the policy shift towards major and medium irrigation during the British period, coupled with the changes in policy perception of irrigation development, that is, treating irrigation as a productive (revenue-generating source) rather than a protective source, has resulted in the degeneration of these institutions.

The second phase (1950-1980) of the declining performance is attributed to the government's investment priorities on medium and large-scale irrigation projects under the five year plans. Advent of the energisation of groundwater lifting mechanisms also contributed for mass expansion in groundwater irrigation. The benefits of tanks as common property have been transferred to individual beneficiaries as private prosperity and water markets begun to function, though they could not sustain in the long run. The new technologies in pumping systems introduced in the 1980s coupled with the benefits from the Green Revolution technology have resulted in an unprecedented expansion of groundwater development. Further, poor farmers were not in a position to adopt these technologies because of their capital-intensive nature, especially during the initial stages. The socio-economic changes in the village dynamics made the traditional tank associations non-functional. Population pressure with expansion of village roads and housing areas resulted in encroachment of tanks.

The third phase (1980-2000) of declining tank performance has been related to the growth and spread of socio-political set up in the villages, where regional political parties and local caste groups started strengthening their hold by attracting youths and dominant caste groups. Increasing well failure (including bore wells) in the tank commands had become a common phenomenon, thus, rendering both tanks and wells inactive in most of the periods. Further, several government initiated social security nets, such as fair price (ration) shops and Mahatma Gandhi National Rural Employment Guarantee Scheme (MGNREGS) had assured some food security and employment for the rural poor; and small scale industries, expansion of village roads, etc., facilitated the easy movement of the rural labour classes towards higher income earning options.

The fourth phase (2000 onwards) of the declining performance has been due to the climate change and the associated anthropogenic pressures related events where the intensive rains in few days and prolonged droughts for an extended number of days resulted in less water supplies to tanks in most of the years resulting in uncertainty in tank irrigation, thus, making the tank irrigated agriculture a non-profitable, risky and unsustainable livelihood option in the rural areas. Land owners slowly abandoned their agriculture and migrated to towns leaving their agriculture lands as fallow lands. Urban tanks witnessed a major fall during this phase where city expansion and increase in land values converted urban tanks into storage ponds with polluted waters. The temporal changes, as reported in Table 2, capture adequately the impact of several factors on tank management and its attributes.

Table 2: Temporal Changes in Tank Management and their Impact

No.	Phases	Factors Influencing	Major Impact on	Impact
1	Phase 1 (pre independence to 1950)	Policy shift and governance on irrigation investment	Tank system*:	
			a) Above outlet	Low
			b) Below outlet	Low
			c) Tank institutions	Low
			d) Village:	
			i) Farmers	
			• Well owners	Low
			• Non-well owners	Low
			ii) Labourers	Low
			iii) Others	Low
2	Phase 2 (1950 to 1980)	Emphasis on major and medium surface irrigation, Green Revolution, emphasis on groundwater development and energy use, crop production technologies.	Tank system*:	
			a) Above outlet	Medium
			b) Below outlet	Low
			c) Tank institutions	Medium
			d) Village:	
			i) Farmers	
			• Well owners	Low
			• Non-well owners	Medium
			ii) Labourers	Low
			iii) Others	Low
3	Phase 3 (1980 to 2000)	Socio-economic development programmes such as MGNREGS, population expansion, peri-urban influence, development of easy access roads and communication facilities, labour out-migration, village safety nets and poor functioning of tank based institutions	Tank system*:	
			a) Above outlet	High
			b) Below outlet	Medium
			c) Tank institutions	High
			d) Village:	
			i) Farmers	
			• Well owners	Low
			• Non-well owners	High
			ii) Labourers	Low
			iii) Others	Medium
4	Phase 4 (2000 +)	Climate change, changes in rainfall pattern with more drought years, population pressure, pollution of urban tanks, expanded well investment, new caste and political party based local groups, conversion of tanks - into percolation ponds.	Tank system*:	
			a) Above outlet	Very high
			b) Below outlet	High
			c) Tank institutions	High
			d) Village:	
			i) Farmers	
			• Well owners	Medium
			• Non-well owners	High
			ii) Labourers	Low
			iii) Others	Medium

Note: * Above outlet refers to tanks' hydrology components such as catchment area, foreshore, supply channel, water spread area and tank bunds, sluices and surplus weirs. Below outlet refers mainly to command area, field channels and wells.

Source: Palanisami *et al.* (2008a, 2010, 2011).

3. The Hotspots of Tank Irrigation

Among the four phases of tank management discussed, the current phase is experiencing several key issues and challenges that may threaten the future of tanks in India. These issues otherwise called as hotspots are worth discussing, as they may help to address the need for tank revival. However, the level of influence of these issues may vary from state to state and differ from other countries like Sri Lanka where tank irrigation is common (Box 1). In order to highlight exact influence of these factors, the experiences gained from South Indian tanks in general and Tamil Nadu tanks in particular are discussed here.

Box 1
Small Tank Irrigation in Sri Lanka - Continuity and Change

The exact number of tanks in Sri Lanka's dry zone is unclear. According to the Department of Agrarian Services (2006), there are some 11,260 small tanks with a total command area of about 2,20,000 hectares. The density of tanks declines from the heavily populated West to the uninhabited east. The social organisation of tank irrigation – which for centuries had combined a stylised land-use pattern, a system of highly differentiated property rights, and elaborate rules of community management of tank irrigation – has now been morphing in response to demographic pressures, urbanisation, market signals, technical change and modernisation. The hydraulic civilisation of the dry zone of Sri Lanka is in the throes of a transition. However, the resilience of the small tank system is explained by the synergy between the tank ecology, social capital and institutional structures, especially secured property rights to land and water that provided the community with the incentive to contribute resources, primarily labour, to operate and maintain these tank irrigation systems.

Source: Shah *et al.* (2013).

3.1 Rainfall Pattern and Tank Filling

One of the common phenomena attributed to the decline in tank irrigation is the changes in rainfall pattern and reduced water inflow into the tanks. Whenever there was a decline in rainfall, tank irrigated area also decreased, and irrigated area increased as rainfall increased. But after 1984, tank irrigated area generally decreased even though rainfall increased in certain years. During the 1960s, the area irrigated by the three major sources in this state, namely, canal, tank and well irrigations were

36%, 38%, and 24%, respectively. But now the area irrigated by tanks is only 18%, whereas the area irrigated by wells is three times higher than that of tanks.

During the years of deficit, the rainfall had been observed to occur with a changed pattern and less intensity. This had decreased the inflow into the tanks, and in turn, reduced the tank irrigated area. There are many more reasons for the reduction of inflows like encroachment of supply channels and tank beds, sand mining of supply channels, rural infrastructure development interfering with the natural inflows, and unplanned watershed development cutting off the supply to tanks.

Unlike the other states, Tamil Nadu receives rainfall from both Southwest monsoon (SWM) and northeast monsoon (NEM). Therefore, the nexus between the two has been studied not only by taking into account the annual (total) rainfall but also the seasonal (SWM and NEM) rainfall. The area under tank irrigation in Tamil Nadu has declined from 9.34 lakh hectares in 1963 to 3.22 lakh hectares in 2018 – a reduction of nearly 65%. The correlation analysis has also shown that there is an insignificant relationship between the level of rainfall and the area under tank irrigation. Between the two major seasons, the area under tank irrigation has a relatively stronger correlation (though statistically not significant) with northeast rainfall, which is understandable because the state normally receives higher rainfall during this season.

Ideally, one may not be able to study the relationship between rainfall and area under irrigation without analysing how the intensity of rainfall has changed over the years. At least 25 millimeters (mm) of rainfall should fall within one hour to have an effective runoff into a moderate catchment area. Unfortunately, owing to data constraint, it is difficult to study the intensity of rainfall while studying the nexus between rainfall and tank irrigation. Since the total rainfall of NEM plus SWM is crucial for increasing tank irrigation, it is expected that the rainfall share of these two seasons in the total annual rainfall would have a relatively stronger correlation with tank irrigated area. This suggests that even if the share of rainfall of the two main seasons increases, it is not going to make any significant increase in area under tank irrigation, unless the intensity of rainfall is higher.

3.2 Tank and Groundwater Development – The Nexus

There is a close link between well irrigation and tank storage especially in areas with confined aquifers with rock stratum. Tanks by storing the runoff water for longer periods help recharging groundwater, and so, the well owners have conflicting interests with the command area farmers (Palanisami and Ruth, 2001; Palanisami and Balasubramanian, 1998). In fact, groundwater irrigation in the tank commands is more reliable due to good recharge that may be available throughout the crop season. In most cases, tail end farmers rely on groundwater due to unreliable water supplies from tanks. It is argued that both tank irrigation and well irrigation should be used as complementary, rather than substitutes in order to maintain a hydrological balance and manage water resources sustainably in the long run. It also facilitates the functioning of localised water market within the tank systems (Palanisami, 2006, 2013; Palanisami *et al.* 2011)

3.2.1 Dynamics of a Tank–Aquifer Agro-ecosystem

Studies have indicated high returns from supplemental irrigation and stabilisation of the value of groundwater in the tanks (Palanisami *et al.* 2011). Because wells recharge directly from the tanks as horizontal percolation, the hydraulic relation between tanks and wells has been well-established over the years (Palanisami and Easter, 1991; Ranganathan and Palanisami, 2004; Palanisami *et al.* 2008; Palanisami *et al.* 2011).

Figure 5 depicts the interaction between tanks and wells in normal and deficit rainfall years. Groundwater augmentation is not proportional to the tank water deficits

Figure 5: Behavioural Relation between Tanks and Wells in different Tank Filling Years

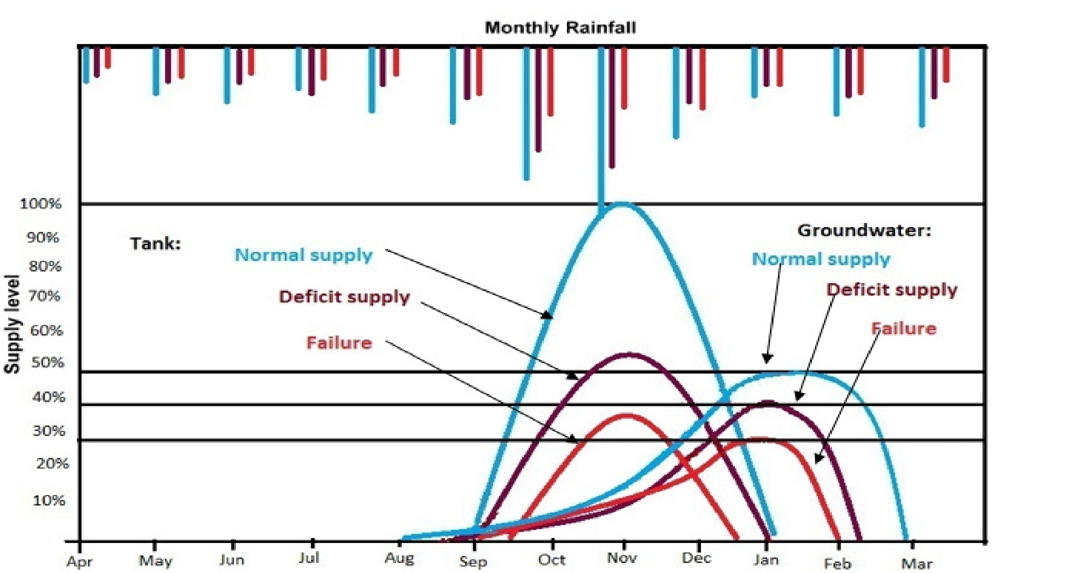


Table 3: Tank and Groundwater Use

Tank Water Supply (%)	Actual Groundwater Supply (%)		
	1990-2000	2000-2010	2010-2020
Normal year (>80)	5 (5)	20 (20)	30 (30)
Deficit year (50-80)	20 (30)	40 (50)	20 (60)
Failure year (<50%)	20 (40)	20 (60)	10 (70)

Note: Figures in brackets denote the required level.

in rain deficit and failure years. In fact, groundwater supply is much less when the tank storage falls below 30%. This raises important questions: Why do tanks not provide a platform for well investment? Why have more wells not come up? Data suggests that well density is less (0.46/ha of net sown area, NSA) in tank regions compared to non-tank (mostly well irrigated central) regions (1 well/ha of NSA) (Table 3). Among the tank-intensive districts of northern and southern regions of the state, the number of tanks and wells, and well and tank irrigated area had shown significant variations. The well density in the northern region is almost double that of the southern region, perhaps because of rainfall patterns that benefit mostly from SWM compared to NEM in southern regions, and the diversified soil types and cropping pattern that support the growth of wells. Over the years, well failure is also increasing in the tank regions, indicating recharge problems caused by poor tank storage management, as tank supplies are exhausted within two months of the start of tank season compared to the 3-4 months observed during the 1980s and the 1990s (Palanisami and Mohanasundari, 2020).

3.2.2 Determinants of Well Investment in Tanks

Past studies and the present status of the tanks elucidate that tank irrigation can survive in the future, provided that well irrigation through adequate groundwater development is ensured. Therefore, it is important to assess the scope for well development and the potential constraints, more specifically when expanding well irrigation in the tank commands.

In Tamil Nadu, it was observed that there is a potential to increase the number of wells by 25% in the tank commands, as currently only 15% of the farmers have wells (Palanisami and Amarasinghe, 2008). Despite the declining area under tank irrigation in recent years coupled with declining groundwater, conjunctive use of groundwater with tank water has not spread much. This is often due to the low productivity of agriculture resulting in low capacity of farmers to invest in bore wells.

Photo 3: Tank and Well Recharge in a Good Tank Storage Year, Karnataka

In addition to the location of tanks in the tank cascade, rainfall patterns, tank water supply availability, soil type and aquifer characteristics, factors such as overall tank performance, O&M expenditure incurred and revenues realised from tank's multiple uses also influence the well density in the tank command area. Tanks that perform better in terms of irrigating more command area in the registered command area and tanks that are able to spend larger O&M budgets on tank maintenance and also collect revenue (tax) from the multiple uses of the tanks have a positive influence on well development in the tank commands. Unusually, some tanks depend purely upon wells. These tanks have a low tank performance. They act as percolation tanks deriving tank benefits in terms of well recharge.

3.3 Conversion of Tanks into Percolation Ponds

Of the total tanks, about 1% is defunct or absent. About half are already performing as percolation tanks for recharging the groundwater. Therefore, those tanks that are not used for direct irrigation, or tanks that get less than 40% of tank storage in most years can be managed to enhance water storage by converting them into percolation ponds by deepening the storage area and by encouraging farmers to invest in private wells in the command area (Palanisami, 2005, 2006). Because getting electrical connections is the major constraint in well investment, necessary reforms in providing electrical connections or solar power pumps in rural areas can be considered. Some investment in creating watershed structures such as check dams and percolation ponds in tank intensive regions can be diverted to tank rehabilitation. Such investment can minimise the duplication of investment in water harvesting structures. Reports have argued that conversion of tanks into percolation ponds could raise crop productivity and income (Palanisami *et al*. 2003; Nandakumaran and Palanisami, 2012). The rate of growth in converting tanks into percolation ponds was about 1.3% over the last 10 years (Palanisami *et al*. 2008, 2010).

3.4 Temple Tanks

Tamil Nadu is rich in heritage temple tanks. Temple tanks are as ancient as temples itself, because the temple tanks are ponds dug for construction of temple. Temple tanks are used for domestic needs of the community, domestic demand of devotees, rituals connected with temple and performing float (*Theppam*) during float festival (*Theppa Thiruvizha*). The temple tanks are usually connected with water bodies such as irrigation tanks, rivers, irrigation channels and runoff from hillocks for feeding of water. Few natural springs in the vicinity of the temples are considered as holy and the water used for spiritual purpose (*Theertham).* The temple tanks are not sealed at the bottom, which allows the water to recharge the ground water aquifers (Dhan, 2018).

The pond was initially dug to fulfil the water demand for labours involved in construction and demand for soil for construction. Currently, the feeder channels of the temple tanks are polluted, encroached or destroyed which have eventually caused them to empty. This deteriorates the quality of water and prevents communities from accessing the water.

3.5 Tank Multiple Uses

Findings of a study in 1996-97 revealed that the multiple use value of tank services, including non-irrigation uses, increased the value of output that may be attributable to tanks by 12%. A repeat of that work in 2009-10 found that the multiple use values had declined to 6%, indicating a decline in the relative importance of tanks' multiple uses over the years. An even more dramatic change was seen in revenue mobilised from the tanks – the total taxes and fees from all uses were more than three times higher than the fees collected for irrigation in 1996-97, but were almost equal in 2009-10 (Palanisami and Dick, 2001).

Photo 4: Tank with Multiple Use Benefits, Bihar

It may, thus, appear that multiple use values were already low and dropped even lower, suggesting that they are relatively unimportant in understanding overall performance. However, it was non-irrigation uses that generated most of the government revenues from tanks. Even now at reduced water levels, these revenues account for about 50% of the total collection of Rs. 119/ha in 2009-10 and substantially larger than the government outlays on O&M (that is, Rs. 60/ha), and thus, create confidence about the resource generation potential of tanks.

It is widely known that declining tank storage is a common phenomenon in South India, and this might have contributed for the decline in intensity of multiple uses over years (Palanisami, 2000; Palanisami *et al.* 2011). Furthermore, reductions in tank storage directly affect the area irrigated and also the opportunities for multiple uses (Palanisami *et al.* 1997). To test the nature of this relationship and provide guidance to tank rehabilitation, a simple empirical relationship was developed between the estimated multiple use values and the tank storage levels. Based on the estimates, the optimum level of tank storage was worked out to be 71% for panchayat union (PU) tanks and 67% for public works department (PWD) tanks. The multiple user values and marginal multiple use benefits were also calculated for different storage levels.

The marginal impact on multiple use values for changes in tank storage decrease as storage approaches about 70% under PU tanks and about 65% under PWD tanks, as tank storage rarely exceeds this level in the normal course. Hence, restoring tank storage to these levels would have a higher payoff. Some non-irrigation uses in the study sites declined, as rural infrastructure had improved. For instance, when households were provided with alternative sources of domestic water supply, their reliance on tanks fell. In other cases, uses had declined as tank performance had declined, partly because the values of non-irrigation uses had not appreciated and captured. This highlights that it is important not only to consider existing non-irrigation values in evaluating irrigation systems and planning future directions, but also their potential in contributing to long-term performance.

Despite their multiple uses, tanks are often evaluated on just their irrigation performance, that is, in terms of area irrigated. However, it has been argued that the multiple uses of tanks should be taken into account in evaluating their performance. In fact, Palanisami and Dick (2001) observed that as much as 2% of the increase in the value of output was attributable to the multiple uses of tanks.

Alternative incomes provided by tanks will assume greater significance in areas with higher rates of poverty and where a large number of landless labourers or lease farmers exist. Landless rural labourers benefit indirectly from improved agriculture through greater employment, but may benefit more directly from non-irrigation tank use. While multiple use of tanks can increase overall economic returns, conflicts

Photo 5: Irrigation cum Fish Tank, West Bengal

Photo 6: Tanks with Social Forestry, Tamil Nadu

between various users can occur – between irrigation users (head users versus tail users), farmers with and without groundwater pumps, and fishers and irrigators (Kathikeyan and Palanisami, 2011).

In East India, while tanks are still used for irrigation, livestock and domestic purposes, fisheries are emerging as the primary beneficiary of tanks. Integrating fisheries, prawn farming and duck-keeping with paddy irrigation, and using local secondary reservoirs for water storage have enhanced households' income. Competition between irrigation and fisheries often creates a rift within communities resulting in management issues that directly contribute to the poor maintenance of tanks (Palanisami, 2013).

3.6 Population and Tank Irrigation

An intriguing subject in recent period is, whether increased urbanisation has any impact on the number of tanks and the area under tank irrigation. It has been observed that urban agglomeration appears to have a negative impact on the area irrigated by tanks, as population impact is more in urban tank regime without any irrigation sources. However, in several locations, in spite of no drastic reduction in the quantum of rainfall, the regions with higher urban population had experienced reduction in tank irrigated area, and this was mainly due to expansion of peri-urban habitation and delinking the tanks from the tank cascade through encroachment of the supply channels that connects the tanks in the cascade (Narayanamoorthy and

Suresh, 2016). Encroachment of the supply channels due to village expansion and industrial activities have been observed to have a determining effect on the tank performance (Palanisami, 2005, 2006). Due to urbanisation, tanks are getting less water and also prone for conversion into percolation tanks (Palanisami *et al.* 1998, 2008a).

3.7 Tank Silt and Agriculture Use

Application of tank silt to rainfed agricultural lands during off-season months is an age-old traditional practice to sustain the productivity of their lands. Many farmers used to transport tank silt and farm yard manure to their fields before the onset of monsoon, and this had helped to replenish the soil nutrients and improve the moisture retention capacity of the soil. This practice has resulted in periodical desilting of tanks and restoration of the water storage capacity of the tanks.

But this practice of applying tank silt to the agricultural lands has slowly vanished over the past four decades, which may be ascribed to the following reasons. All the bullocks and bullock carts have been replaced by a few tractors resulting in the silt removal by only small and marginal farmers. Restrictions imposed by the local revenue staff for taking silt from the tanks, as in many cases mining of the tank bed area for brick making are common (Palanisami and Easter, 2000).

Silt application has several advantages, such as soil moisture retention goes up by 4-7 days, improves water use efficiency (10%-20% higher than no silt application) and saves on chemical fertilizers ranging from Rs. 2,500 to Rs. 3,750/ha. Thus, application of silt has resulted in resilience to moisture stress in terms of crops yield. For the application of tank silt with soil moisture retainers, an estimated unit cost of Rs. 14,000/ha with 50% of it as farmer's contribution was adopted. Additional yield of about 15% in dry lands and about 25% in irrigated lands had been noticed by the farmers (Osman, 2009). Among the silt disposal, 35% of silt is used for bund strengthening, 15% as manure to the fields, 20% for brick making, and 30% for periphery and contour bunding (Palanisami, 1993).

3.7.1 Issues

In many parts of the state of Tamil Nadu, farmers consider the rainfed agriculture as an economically non-viable occupation, as their produce could not fetch a reasonable price in commensuration with the increasing prices of agricultural inputs and other commodities they use. Hence, many youths of the farm families opt for working as skilled or unskilled labourers elsewhere leaving their dry lands fallow. Tank farmers indicated that government department officials were not allowing taking out tank silt without proper permission from the revenue department officials in the locality. As per Rule No 6(1) of Tamil Nadu Minor Minerals Concession Rules 1959, "The public may be allowed to quarry free for bonafide domestic or agricultural purposes without obtaining permits for quarrying, provided that the dwelling place or the agricultural land of the person concerned and the quarrying place shall be in the same revenue village or in the adjoining revenue village".

Further, cost of maintaining the bullocks, etc., is very high, and most of the farmers could not afford to maintain them, when there was no work in the farm and the tank irrigation was not done due to water scarcity (Palanisami and Easter, 2000). The fast growth of *prosophis* trees in the farmer's fields because the land was left fallow continuously for 2-3 years also make the fields unsuitable for silt application.

Further, the present way of implementing the MGNREGS has made the farmers to believe that the scheme has caused an unrealistic increase in the wages of farm labour, and hence, it is perceived as a potential threat to tank agriculture. Further, the MGNREGS is implemented during the non-agricultural season coinciding with the season for tank silt application, and thereby, labour shortage and cost escalation of tanks silt application. This perceived threat of MGNREGS can be changed as an opportunity for desilting of tanks and silt application in dry lands, if it is implemented with an innovative approach.

3.8 Pollution of Tank Water

Water pollution, encroachments and urbanisation are eating into water bodies in general and tank irrigation sources in particular. It is roughly estimated that about 20% of the water bodies like tanks had become unsuitable for fishery, domestic and livestock use (Palanisami, 2000).

Tanks have been neglected for the past few decades. None of them works in isolation, and they are connected to a series of other channels. Today, that chain has been cut off due to encroachment for various purposes. It began with encroachment and pollution of smaller drains that connected these water bodies, affecting the latter eventually.

Further, due to encroachment and social forestry in the tank supply channels, foreshore and water spread area, water quality is affected by salt, sediments, nutrients and suspended organic matter, and in some cases, chemical pollutants. The transported sediments into the tank water spread area are responsible for the growth of algae and water borne weeds (Palanisami, 2006). Pollution of tanks, ponds and reservoirs has also led to pollution of groundwater. The latest available data shows that people in over 50% of the districts have access only to polluted water. The number of deaths due to water borne diseases is increasing every year.

3.9 Climate Change

The major impacts of climate change are likely to occur through water. Rainfall pattern is also likely to change in terms of distribution and intensity. While agriculture as a whole is expected to be mostly negatively affected, rainfed agriculture, where tank irrigation is concentrated in particular, is expected to be impacted differently by climate change (Intergovernmental Panel on Climate Change, 2007). Rainfed agriculture may have unexpected changes in its crop compositions and crop calendar, as the pattern and structure of climatic variables may change. These unexpected changes could sometimes be beneficial, when they are internalised. But mostly these impacts become cascading due to various socio-economic changes taking place in these regions. Increasing commercialisation, changes in gender and age composition of working farmers, lack of educated farmers in agriculture, increasing labour costs and declining labour productivity are some of the changes that complicate the situation on the ground. The cascading impact of all these changes accentuated by the climate variability seems to be driving the fortunes of the rainfed farmers. More importantly, the farming communities and institutions are unable to foresee these impacts and adequately prepare themselves to face the challenges.

In the context of increased temperatures, storage of water in sub-surface aquifers assumes importance to reduce evaporation rates. And, tanks need to be connected to canal systems wherever possible in order to face water shortages and severe droughts. On the other hand, interlinking of tanks (cascading) becomes critical in the event of excess precipitation and floods. This is possible only with a comprehensive approach of integrating the three sources of irrigation in a river basin or watershed context. Rainfall forecasts should be effectively used to predict the likely nature of tank filling. Non-systems tanks should be converted into system tanks by linking the canal and river systems wherever possible, so that surplus water during heavy rains can be diverted to the tanks easily. The tank chain should be restored to facilitate the diversion of water from upstream tanks to downstream tanks. In all the future government spending programmes on tanks, this should be made compulsory.

While an integrated approach is necessary across the country, the requirements of the systems could differ from region to region depending on the changes or expected changes in climatic conditions. For instance, the need for and extent of desilting and the need for conversion of irrigation tanks to percolation tanks may vary from region to region (Palanisami *et al.* 2010). Regular monitoring of climate as well as procuring hydrological data at appropriate scale is a prerequisite for sustainable resource management. Such information would help in identifying appropriate activities and investment in the context of climate change. For instance, partial desilting and increase in well density are observed to be more appropriate in order to cope with the impact of climate change in the future (Palanisami *et al.* 2010). Similarly, tanks connected to canals (system tanks) are expected to provide more opportunities for improvement compared to non-system tanks (Palanisami and Rosegrant, 1995 as quoted in Palanisami *et al.* 2010). Generation of technical information at an appropriate scale is a prerequisite for policy planning in the context of climate change.

Although there is considerable uncertainty in precipitation projections for future, it is likely that precipitation may increase in high latitudes and parts of tropics, and decrease in some sub-tropical and lower mid-latitude regions. More floods, droughts, decreases in agricultural and aquaculture productivity, displacement of millions of coastal dwellers due to sea level rise and intense tropical cyclones, and the degradation of mangroves and coral reef ecosystems are considered to be some of the likely consequences of climate change (Intergovernmental Panel on Climate Change, 2007). Indeed, heavy precipitation related floods, storm surges and relatively higher temperatures have led to devastating consequences in recent years.

Thus, the impact of the climate change is likely to be higher in rainfed regions, where tanks are often the major source of water storage and groundwater recharge. Hence it is important to address how best the tanks could be restored, so that they could act as better water storage structures. The tank ecosystem based benefits could also be revived, if tanks are restored with new vigour and commitment by the government and community. In locations where rainfall intensity is higher and where there are not many tanks, it is possible to invest in new tanks after examining the financial viability of such investment.

3.10 Tank Based Institutions

The important functions of any irrigation institution include water acquisition, water allocation and distribution, maintenance, decision making, enforcement of decisions and conflict resolution. The traditional irrigation institutions have well-defined rules regarding the role and responsibility of each member of the tank and village community. The source of water to the tanks is mainly rainfall, and the tanks can be either isolated or in a cascade. When the tanks are connected to a nearby river or stream, reliable water supply is assured. The priority of the irrigation institution is water acquisition in case of river fed and cascade tanks.

The traditional tank based institutions have well-defined conventions evolved over a long time such as the opening and closing of sluices, allocation of water to various locations in the tank command and allocation norms during water scarcity periods. Though based on customs and traditions, they are clear, specific, detailed and accepted by all tank farmers. Water management practices have been perfected over time by experience. The traditional institutions, based on their experience, involved the sequence of opening the sluices to have a minimum wastage of water.

Over years, these institutions have disappeared or have become non-functional due to several reasons, such as (a) splits among the farmer groups within the tank on the basis of caste, political affiliation, income status, education levels, etc.; (b) conflicts in water allocation due to periodical failure of tanks in providing assured water supplies to fields; (c) poor revenue generation for regular maintenance of the tanks; (d) declining interest in tank irrigation by the younger generation farmers due to risk in farming; (e) out-migration of labour force from farm and non-farm families within the village for earning higher income in the towns and cities; (f) government programmes such as social forestry in tank foreshore, tank modernisation and rehabilitation, etc., implemented without involving tank associations; and finally, (g) several agencies and departments such as local village panchayats, PWD, revenue, fisheries, forest and mining interfere with tank related management issues (Palanisami and Balasubramanian, 1998). Studies have already identified these issues and recommendations have been made to make these institutions sustainable.

Tank management as a local common property has experienced a lot of challenges due to the decline in the performance of the local institutions at tank level (Sakurai and Palanisami, 2001; Kajisa *et al.* 2007).

4. Tank Rehabilitation and Modernisation

Given the existing as well as emerging challenges (hotspots) in tank irrigation, it is important to examine how best the tanks should be restored to the extent possible and to sustain their function. Indeed, there are many suggestions for improving tank irrigation systems through tank modernisation incorporating both technical and management interventions. Broadly speaking, the tank modernisation strategies can work to save water and extend the surface irrigation or increase recharge and conjunctive use of groundwater, or both. Hence the tank modernisation is considered as an appropriate measure to address the future of the tanks.

Earlier review of India's irrigation sector, World Bank (1998) notes, 'There is a need for a major shift in India's irrigation strategy. There is a need for shift from the past near exclusive reliance on irrigation expansion to a strategy emphasising improving the performance of irrigation and irrigated agriculture'. There are compelling reasons for giving much greater attention and resources to small scale surface irrigation schemes (Vaidyanathan, 1999). The reported decline in area under this category of works is a reflection of the past neglect. These works had not received much attention under the five year plans, and investment in this category had been meagre in relation to the magnitude of the problem. Substantial investment in system improvement are necessary for improving the quality of surface irrigation, and this must be given priority over the construction of new systems (Vaidyanathan, 1999).

The rationale for tank modernisation is valid not only from the equity and stability point of view but also from the economic angle, where unit costs of modernisation are marginal compared to investment costs in creating new irrigation systems. Moreover, most of the river basins are approaching their irrigation potential, and any further expansion in area under irrigation has to come from rain water harvesting (Asian Development Bank, 2006). Further, irrigation tanks are more equitous. Research on costs and benefits of rehabilitating irrigation tanks made it clear that benefits outweigh costs in all situations irrespective of tank size, though benefits are proportional to the size of the tanks (Palanisami, 2005; Reddy and Bhagirath, 2009a,b; Kumar, *et al.* 2011).

Recharging of groundwater appears to be one of the most pressing reasons for tank restoration, given the fact that groundwater is the single largest source of irrigation in most parts of India. It is observed that in the absence of replenishing mechanisms like tanks or canals, water supply available from wells is much limited. In most regions, open wells have dried up, and water levels go down rapidly in the deep bore wells in the absence of well managed tanks in the vicinity, especially during the low rainfall years (Reddy *et al.* 2018). The stabilisation value of groundwater in the tank systems is about 15% to supply value, which further justifies that wells are value added to tank ecosystem[3] (Palanisami *et al.* 2011). This not only emphasises the rational for the revival of tanks but also points out to the need for conjunctive use of surface and groundwater resources. In this context, a review of the past rehabilitation and modernisation activities would help arriving at an appropriate model for tank modernisation.

Tank rehabilitation started about four decades ago since the early 1980s with the primary objective of physical rehabilitation somewhat had a sole aim of increasing agricultural productivity. Though bilateral agencies like European Economic Community (EEC), World Bank and Ford Foundation have supported the rehabilitation programmes in states like Tamil Nadu, non-government organisations (NGOs) such as Professional Assistance for Development Action (PRADAN) and Tarun Bharat Sangh (TBS) in Rajasthan, Gram Vikas in Karnataka, Development of Humane Action (DHAN) Foundation in Tamil Nadu and Andhra Pradesh, and Society for Promotion of Wastelands Development (SPWD) in different states had also initiated programmes to revive these traditional systems. State governments have partnered in these large initiatives and have also initiated large tank renovation programmes on their own with the support from bilateral agencies like World Bank. During 2004-05, tank rehabilitation got the specific attention at the national level only after two decades of efforts in various states. A pilot scheme for Revival, Restoration and Rehabilitation (RRR) of water bodies to augment the storage capacities and to recover or extend irrigation potential was initiated at the national level. A Working Committee of the Planning Commission recommended about Rs. 70,000 million ($ 2,333 million). The pilot scheme envisaged a plan outlay of Rs. 3,000 million ($ 100 million) to be shared by central government and state governments in the ratio of 3:1 and covered the water bodies with an irrigation potential of 40 ha to 2,000 ha. Initially, the scheme was for a short period of two years, though there was a plan to link it with the programmes like National Rural Employment Guarantee Programme (NREGP) and the *Bharat Nirman*.

Tamil Nadu, Karnataka, Andhra Pradesh, Maharashtra, Odisha and Rajasthan are among the first states to undertake rehabilitation and reforms with the help of national and international aid.

Tamil Nadu state has piloted one of the first tank rehabilitation programmes, aimed at desilting and strengthening the bunds and weirs, with the financial support from Ford Foundation. In 1984, EEC and the Government of India had signed an agreement to rehabilitate 210 tanks. The Phase I of the programme was completed in 1989 and the Phase II in 1996 covering about 44,000 ha of command area (Asian Development Bank, 2006). The World Bank had supported rehabilitation of 620 tanks under its Water Resources Consolidation Project (WRCP). The National Bank for Agriculture and Rural Development (NABARD) also provided support for 109 tanks in two phases. Altogether 11,034 tanks have been rehabilitated under different programmes in Tamil Nadu.

Karnataka has its Community Based Tank Management Project (KCBTMP). Started in 2002, the KCBTMP aimed to rehabilitate 2,000 irrigation tanks through community participation on a pilot basis. The Government of Karnataka constituted an autonomous body called the Jala Samvardhane Yojana Sangha (JSYS) to oversee the entire task (Asian Development Bank, 2006). The project had three components: (i) providing enabling environment for the sustainable and decentralised tank management systems; (ii) strengthening community based institutions to take up development and management activities; and, iii) undertake system improvements. The purpose was to rehabilitate the tanks and hand them over to the tank water user associations. A significant number of women and traditionally marginalised communities were involved, and represented in the project (Thinksoft, 2006).

Andhra Pradesh is the first state to initiate irrigation sector reforms in India. Under these reforms, all the tank systems with more than 45 ha of command area were brought under Water User Associations (WUAs), which were expected to rehabilitate and manage the systems. However, since the reform focus was not tank rehabilitations, tank WUAs suffered due to limited funding available for rehabilitation (Reddy *et al.* 2018.). A new initiative named 'The Andhra Pradesh Community Based Tank Management Project' (APCBTMP) envisaged rehabilitating around 3,000 tank systems with an estimated command area of about 2,50,000 ha. The ultimate development objective was to improve tank system based livelihoods and strengthen community management of the selected tank systems. The main components of the project include: (i) strengthening community based institutions for system improvement and management; (ii) livelihoods support services for tank system users; and, (iii) post implementation project management. National framework guidelines have been used to select the tanks for rehabilitation. The criteria include: (a) tanks irrigating 75% of the area, and (b) incidence of poverty at the *Mandal* level and having cropping intensity of less than the state average. In the case of tank cascades, the entire cascade was to be taken up for rehabilitation (Thinksoft, 2006).

The Maharashtra government has undertaken a similar project called the Maharashtra Minor Irrigation Project (MMIP). The project envisaged improvements to minor irrigation tanks, weirs, diversion weirs, storage weirs (*bhandars*) and lift irrigation schemes, with participation of farmers in management and operation. The project components provided support for institutional reforms and capacity building in water resources management (WRM), irrigation service delivery and complementary investment in improving and modernising physical assets. *Pani Panchayats* would be established in the post-implementation phase to ensure equitable water distribution among the farmers (Thinksoft, 2006). The Maharashtra state also designed and implemented a specific programme for desiltation known as 'Gaalmukt Dharan, Gaalyukt Shivar Yojana' (GDGS) (that is, silt free water reservoirs and silt applied farms) policy since 2017. It has set up a 'Desilting Policy Committee', which recommended that 31,459 small dams and water tanks be desilted in the state. The revised state water policy in 2019 promotes GDGS as an important strategy for drought mitigation.

The Odisha Water Resources Consolidation Project (OWRCP) was initiated with World Bank assistance in 1996. Its components included scheme completions, systems improvement and farmer participation, basin planning and environmental action plan, water resources research and agricultural intensification, institutional reorganisation and strengthening, resettlement and rehabilitation and development plan of the indigenous people. *Pani Panchayats* were created to deal with tank level issues like water distribution, conflict-resolutions, etc., (Thinksoft, 2006). The OWRCP was a part of the major water sector reforms in the state. The European Union has provided support for rehabilitating 47 tanks in 997 with a focus on repairing distribution channels, apart from some support funding from NABARD (Asian Development Bank, 2006).

In West Bengal, there are different programmes under which minor irrigation development in the state is being currently implemented. It includes mainly Rural Infrastructure Development Fund (RIDF), Accelerated Development of Minor Irrigation (ADMI), Accelerated Irrigation Benefit Programme (AIBP), Rashtriya Krishi Vikash Yojana (RKVY), Command Area Development and Water Management (CADWM) programme, etc., (Government of West Bengal, 2012). In response to the emerging challenges of the time, the state government has initiated three strategies: (i) large scale harvesting of rain water; (ii) *Jal Dharo - Jal Bharo* (rainwater harvesting) programme on multiple platform; and, (iii) increasing the efficiency of water use in every operation. The objective of *Jal Dharo - Jal Bharo* programme was to harvest rainwater in all kinds of water bodies, namely, ponds, reservoirs, canals and underground aquifers. The programme also aims at building citizen's awareness towards rain water conservation and efficient water use in irrigation (Government of West Bengal, 2012).

Rajasthan also has initiated tank rehabilitation, known as Water Resources Consolidation Project (WRCP), along with its water sector reform project supported by the World Bank. Another project supported by the German Bank for Development Reconstruction (KFW) envisaged rehabilitation and modernisation of 1,198 large tanks over a period of 10 years. Like the Andhra Pradesh model, in the irrigation reforms in Rajasthan also, tank users' associations were organised to facilitate (a) improved utilisation of potential created, (b) better operation and maintenance of the systems, and (c) equitable, reliable and efficient distribution of water etc., (Raju and Shah, 2000).

The Telangana state has embarked on an ambitious tank rehabilitation programme, known as '*Mission Kakatiya*'. Under this programme, it is planning to restore 9,306 tanks (that is, 20% of the total tanks) every year with an eventual target of restoring all 46,531 tanks in 5 years in a phased manner in order to bring 0.45 million ha into command. Main activities include de-silting, repairing of sluices and weirs, strengthening of tank bunds, repairing the feeder channels, and re-sectioning of irrigation channels.

4.1 Cost of Tank Rehabilitation and Modernisation Programmes

A study by Asian Development Bank has indicated that the present investment strategy is skewed toward physical rehabilitation, and very little was provided toward institutional development, maintenance and management (Asian Development Bank, 2006). With the available average value of the catchment area, water spread area and the command area of the 875 tanks studied, the tentative cost per unit was worked out as follows:

Catchment area	: Rs. 20,000 per ha
Water spread area (improving tank bund, sluices, weirs, desilting)	: Rs. 30,000 per sq km
Command area development	: Rs. 5,000 per ha

This cost physical rehabilitation cost was to constitute 75% of the total project cost. The remaining 25% of the cost toward institution, maintenance and management was to be arrived and added to get the total project cost.

Allocation of the total project cost:

Institutional development	: 10%
Physical rehabilitation	: 75%
Maintenance and management	: 15%

Using this allocation for typical tanks, the cost per ha of the command area worked out to be Rs. 34,000 at 2005 prices or Rs. 1,02,000 at 2021 prices.

The focus of rehabilitation in the future is to be more on water acquisition. Hence, it should be based on rupees per sq km of catchment area for works in the catchment including feeder channel improvement. For tank storage improvements, it should be based on rupees per ha of water spread area. And for the command area, it should be based on rupees per ha of command area (Asian Development Bank, 2006).

In the case of World Bank funded tank modernisation programmes completed recently in four states, the cost structure has changed depending upon the projects (World Bank, 2014, Annexure 1). The composition of the costs is as follows[4]:

Total number of water bodies/tanks covered	: 12,523
Average total project cost /ha of command area (The cost at 2021 price was about US$ 1330)	: $ 933

Allocation of the project cost:

Infrastructure	: 66%
Agriculture	: 16%
Institutional support	: 12%
Project management	: 6%

4.2 Relooking Tank Modernisation: Changing Dynamics

Until the 1990s, not much emphasis was given for alleviating poverty by generating employment opportunities, engaging local communities for institutional development, and considering tanks cascade system as a whole instead of an individual tank. Starting from the early 2000s, focus has shifted to alleviating poverty coupled with enhanced agricultural productivity. This shift occurred as a result of experiencing more advantages while augmenting structural treatments under semi-arid or dry conditions in the cascading tanks against the individual tank (non-system tank). For instance, canal lining for provisioning of water supply to attain last mile connectivity in the cascading network has resulted in water conservation by about 21% (Asian Development Bank, 2006).

The past experiences on tank modernisation reveal that a successful programme of tank rehabilitation has to work on the invidious tank village dynamics and create a socio-technical system that is able to align the interests of all users with the sustainability of the tank management. A robust, self-managing tank water users' organisation is a necessary condition for better tank management. However, the difficulty in designing an effective modernisation project aimed at management regeneration is that there are no such working models of sustainable tank management, as sustainability is a key parameter of better tank management. However, the scope for deriving a working model for each region given the proactive stakeholder groups, resource availability, and livelihood enhancement of the local groups and stability of the tanks in getting adequate supplies still exists. Although NGOs are acting as catalysts in promoting local tank level organisations, their roles mainly depend on continuous external financial support. Hence there is a win-win situation for both the NGOs and the WUA.

Once the modernisation process is initiated, it needs to assess the wider impact of proposed rehabilitation work on the entire array of its stakeholders, including the command area farmers, petta (foreshore) cultivators, groundwater users, livestock owners, fish culturists, pastoralists and other non-agricultural users like domestic households, particularly rural women. Similarly, investment in rehabilitation needs to be assessed and justified on grounds of multifarious economic, social and environmental costs and benefits of rehabilitation. An ABC analysis of sorts needs to be done with farmer participation to evolve a medium or long-term programme of rehabilitation, beginning with low-cost-high-pay-off repair works and building up to more expensive items of physical structures. The cost curves for each of the modernisation options proposed need to be drawn to get meaningful inferences on investment.

Contrasting the techno-economic perspective (structural components) with a socio-ecological perspective (structural and managerial aspects) leads to a different understanding of the role tanks play in the lives of the people around them. It may also result in a radically different notion of the kind of rehabilitation that will enhance the relevance and overall social value of tanks. It will also produce new insights into the strategy of tank management by the user groups, that is likely to make sense given the diverse interests and varied stakeholder participation in the village. Available evidences show that multiple uses of tanks result in different levels of tank performance than just merely targeting only on irrigation benefits, as is done in most of the impact evaluation studies (Palanisami *et al.* 2010). Hence, enhancing the benefits from multiple uses of tanks is highly warranted, and future modernisation strategies need to consider this option as well, in order to sustain the benefits from tank systems.

4.3 Tank Modernisation – Time-tested Measures

Heavy rains in different regions of the country in the recent years have ensured that storage and management of the rainwater are more relevant for tanks. Once the tanks are full, assured groundwater recharge would be possible, and feasible number of wells in the tank command area can be calculated based on the annual groundwater draft. This will act as an upper limit for well expansion. Using the experience of Tamil Nadu as a case, future tank modernisation activities are suggested under the following six options (Table 4).

Option 1: Desilting only in selected locations in the tank water spread area. Normally it covers from 20% to 30% of the water spread area.

Option 2: Desilting the entire tank water spread area to a given depth.

Option 3: Converting the tanks into percolation ponds by closing the sluices, when the tank water storage is less than 40% of the last 5 years.

Option 4: Providing 1-2 fillings to the tanks during the tank season from the near-by canal, anaicut and river systems.

Option 5: Development of full groundwater in the command area by working out the feasible (optimal) number of wells in the tank command area using annual groundwater draft. It is expected that in the tank commands, about 20% increases in the number of wells will be possible.

Option 6: Adopting sluice rotation (opening and closing the sluices in alternate weeks) so that ground water and tank water will be simultaneously (conjunctively) used throughout the crop season.

Photo 7: Solar Pumps in Tank Commands, Andhra Pradesh

Table 4: Aquifer-tank Ecosystem Development Options and their Impact

Indicators of Change	Tank partial desilting	Tank full scale rehabilitation	Tank into percolation ponds	Converting non-system into system tanks	Tank with full groundwater development	Conjunctive use
Water supply increase	5%	12%	6%	10%	15%	20%
Multiple use enhancement	30%	35%	15%	40%	25%	25%
Financial viability	Low (IRR<5%)	Low (IRR= 5%-7%)*	Medium (IRR=7%-10%) (for limited tanks)	High (IRR=10%-15%) (for limited tanks)	High (IRR=10%-15%)	Very high (IRR= 15%-20%)
Unit cost	Moderate (Rs. 10,000 /ha)	High (Rs. 60,000 /ha)	Low (Rs. 7,500 /ha)	Medium (Rs. 30,000 /ha)	High (Rs. 100,000 for wells & Rs. 2.5 lakh with solar power)	Medium (Rs. 20,000 /ha)
Sustainability of aquifer-tank ecosystem	Medium	High	Medium	High	High	Very high
Increase in no. of wells	5%	10%	15%	10%	20%	20%
Groundwater externality	Positive	Huge positive	Negative	Huge positive	Negative	Positive
Tank ecosystem/ multiple use benefits	Medium	High	Low	Very high	Low	Medium
Role of active WUAs and quantum increase in tank benefits	Medium and 20%	High and 25%	Low and 5%	High and 30%	Medium and 35%	High and 35%
Social benefits	Medium	High	Medium	High	Low	High

Notes: 1) IRR stands for internal rate of return and WUA stands for Water Users' Association. 2) Multiple uses enhancement refers to the quantum of benefits from multiple uses expected, when the particular modernisation option is implemented. This is more or less correlated with tank ecosystem benefits. 3) Quantum increase in tank benefits due to active WUAs refers to the role of WUAs in managing the water allocation during scarcity periods and also managing the tank structures with minimal water losses. 4) Social benefits refer to the overall benefits to the village community in terms of on farm and off–farm employment and other livelihood options to the tank based households and institutions.

* IRRs are low because costs are additive and benefits are non-additive. Furthermore, tank-storage-based benefits are not uniform in all years.

It could be seen from Table 4 that most of the options are possible to implement depending upon the tanks and the budget availability. These options are not mutually exclusive. Option 3 (converting into percolation ponds) and Option 4 (converting into system tanks) will have lesser applicability compared to other options, as these options can fit only to those tanks with lesser storages and those close to or within the canal and anaicut systems. Once the groundwater development in the tank commands is completed, it is possible to manage the conjunctive use through sluice rotations as a possible strategy to sustain the tank irrigation in the long run. Also, among the system and non-system tanks, the rate of return to modernisation is higher with system tanks, due to their adequate water supply in 3 out of 5 years, than with non-system tanks, which have adequate supplies mostly 1-2 years out of 5 years (Palanisami and Amarasinghe, 2008).

5. Future of Tanks in India – A Way Forward

Tank rehabilitation had undergone many notable changes over the years in terms of their objectives and focus, funding pattern and funding sources, physical components prioritised for rehabilitation, implementation pattern, and institutional changes. Looking at the past rehabilitation performance and needs of the future, it is important that, given the increased benefits and equity considerations, improving the livelihood of the rural community by increasing the total benefits from tank multiples uses should be the objective of future tank rehabilitation programmes. In this context, it is important to examine how the future of tank irrigation could respond to the emerging hotspots.

5.1 Emerging Hotspots – Key Questions and Policy Suggestions

Given the above issues and challenges, it is important to examine what questions need to be answered and what policy suggestions could address these questions adequately. The list of key questions and the policy suggestions are summarised below (Table 5).

Once the hotspots are appropriately addressed through policy interventions, it is important to bring in the bright spots of tank irrigation to make sure that tanks will be sustainable irrigation structures in the near future. The following big ticket questions will help locate the bright spots in tank modernisation.

Table 5: Hotspots – Key Questions and Policy Suggestions

No.	Hotspots	Key questions	Suggestions
1	Rainfall pattern and tank filling	The weak relationship that exists between the rainfall and area under tank irrigation leads to a genuine question: do other factors influence area under tank irrigation more than the level of rainfall?	a) Any improvement in the level of rainfall is not going to make a perceptible increase in area under tank irrigation, unless adequate arrangements are made to improve the storage capacity as well as the flow of water supply into the tanks. b) Even in normal or good rainfall years, several tanks could not get adequate tank filling, and many of the tank farmers reported that there was no adequate rains in the tank catchments and officials relied on nearby station rainfall data for quantifying the runoff into tanks. Currently, the rain-gauges are available in the block offices only and periodical measurement of rain fall intensity is not followed. Hence, installation of rain-gauge stations at different locations of tank cascade to measure rainfall intensity and estimate the exact relationship between tank storage and rainfall is suggested.
2	Tanks and groundwater development	Which type of tanks (system vs. non systems, PU vs. PWD) have more potential for expansion of well irrigation? What will be the optimum number of wells in the tank command area?	a) Tank management will be complementing the well development, and hence, strategies that help to improve the tank performance need to be identified and implemented. Water markets at tank command area can help to supplement the tank irrigation, benefitting non-well owners. b) Using the annual groundwater draft, the feasible number of wells in each tank command needs to be worked out for optimal use of tank and groundwater. c) Conjunctive use of tank and groundwater will enhance the water use efficiency of both tank and groundwater.

(Contd....)

Table 5: Hotspots – Key Questions and Policy Suggestions *(Concluded)*

No.	Hotspots	Key questions	Suggestions
3	Change in village socio economic dynamics	How the changes in socio economics profile of the households influence tank management? What measures will ensure sustainable tank management?	a) Increasing socio political changes among the village households hinder effective tank management. Hence, encouraging SHGs with micro finance options will ensure better livelihood options and out-migration of the labour households can be prevented. Further, village support programmes like livestock and poultry development programmes, social forestry protection and fishery development programmes can be encouraged in the tanks for better multiple use benefits among the stakeholders.
4	Climate change and impacts	What exactly is the impact of climate change on tank water storage and getting supplemental irrigation for crops? What kind of climate smart practices are likely to support tank-based agriculture? What kind and type of tanks are the most affected by climate change?	a) Tank modernisation could help to improve supply channels leading from catchment, increase and stabilise storage capacity of the tanks, thereby, providing scope for storing more rainwater during heavy runoffs. It is important to restore the original storage capacity of tanks by desilting. In some cases, as a least cost option, increasing the bund height may help to store more flood water provided no submergence in the catchment. Tanks with short bunds may be good to implement this. Also, this will help to recharge groundwater in the tank commands. Since more dry spells will be common due to climate change, groundwater supplementation with solar pumps for groundwater pumping, Climate smart agricultural and water management practices, and changes towards less water consuming crops could help to address the emerging climate change influence in agriculture. b) A tank manual should be prepared for all the tanks in the cascades.

Photo 8: Improved Rice Crop Management and Transplanting Practices in Tanks, Tamil Nadu

5.2 Future of Tank Modernisation – Ways and Means

What will be able to address the tank modernisation in future? What will be the key components of tank modernisation? How could the modernisation options be prioritised in the tanks? What are the factors that would make tank modernisation sustainable? How could the tank modernisation be done in a cost-effective manner? What kind of modernisation cycle could be followed in the long run to cover all the tanks in the region/state? What kind of institutional mechanisms will safeguard the tanks and efficient irrigation management?

The facts that may help to address the above questions are discussed below:

What will be able to address the tank modernisation in future?

Climate change will affect the water supplies in South Asia, where floods and droughts with high intensity are expected in the future. Increasing water storage is a key adaption response. The experiences of irrigations tanks, water harvesting structures dating back centuries across much of peninsular India, illustrate both the potentials and challenges of this adaptation response. Analysis of climate and hydrological data at an appropriate scale should be given high precedence. Further, instead of focusing purely on financial gains, providing livelihood to all including the landless should be the key focus of future modernisation.

What will be the key components of tank modernisation?

Tank modernisation should primarily comprise catchment treatment, foreshore plantations and creation of dead storage for community and livestock use, improvement

Photo 9: Tank Improved Sluice Control, Karnataka

to supply channels, improvement to tank structure, on-farm development works, crop and water management, and provision of community wells wherever feasible. Rehabilitation focus should be on distribution of water based on crop demand and adoption of crop and water management practices through on-farm development.

The rehabilitation budget should be allocated in the ratio of 10%, 75%, and 15%, respectively, to institutional development, physical works and maintenance. A one-time investment of 15% for maintenance and management activity has to be allocated from the rehabilitation funds, and this amount should be deposited in a bank. The interest accrued out of this fund can be used only for maintenance and management. Capacity building of SHGs and vulnerable groups is a built-in component of the tank rehabilitation project. There should be a subcommittee in the tank user groups to do social audit of the water distribution to ensure equity among the users.

How could the modernisation options be prioritised in the tanks?

Although tank modernisation is seemingly a good option for reviving the tank irrigation as a whole, a major criticism observed in the past rehabilitation works is its focus as a single-time activity. Also, most of the modernisation programmes followed a standard package (blue print) approach, and the same package was applied for all tanks irrespective of their major attributes such as location in the cascade, command area, water storage and physical structures. This approach resulted in poor post rehabilitation activities with many of the rehabilitated tanks becoming degraded. In several tanks, impact of tank modernisation did not yield benefits as expected (Palanisami *et al.* 2008a). Also, lack of effective involvement of those stakeholders, for whom the tank is still the primary livelihood, especially in the process of planning, implementation, cost sharing, operation and maintenance of the rehabilitated tanks, is still a major problem. Therefore, there is a need to relook the tank rehabilitation packages in terms of modernisation package to sustain the benefits from tanks. For greater cost effectiveness, it is important to identify selective (customised) modernisation strategies to suit different tank typologies. For example, in the East and West regions, the key attention of tank rehabilitation is still on increasing agricultural productivity, where the benefits remain conferred on the landowners (landlords), while the landless remains merely as labourers. In most of the South region, focus is given for improving livelihood opportunities; wherever the household in the village received benefits in one way or another from tanks' multiple uses, it instilled a sense of confidence for their participation in tank management.

In the case of construction of new tanks and rehabilitation of the existing tanks, it is always important to see the suitability of the sites for new tank construction along with hydraulic particulars such as rainfall runoff, terrain characteristics, etc. Based on the experiences, it is suggested that in the case of the eastern region, where small tanks and ponds are common, construction of new tanks and ponds can be an attractive investment option. But it is always economical to invest in rehabilitation of the existing tanks in other regions, where already a large number of tanks are existing and where watershed programmes are competing for rainfall storages.

What are the factors that will make tank modernisation sustainable?

The focus of rehabilitation in the future will be more on water acquisition, storage and distribution.

The cascade approach should be followed in restoring tanks, if the full benefits of harvesting the runoff from a micro watershed and effective groundwater recharge are to be realised. All tanks in the cascade, small and large and irrespective of the size of their command area, have to be renovated by restoring the link canals between them on top priority.

In this entire process of designing tank rehabilitation, capacity building is the core without which sustainability could not be attained. It should start before planning rehabilitation, considering all stakeholders including SHGs and the landless. The first part of the capacity building should focus on strengthening the tank user groups, creating awareness and introducing income generating sources to SHGs. Then, their subsequent involvement in rehabilitation activities can be facilitated through the local NGOs. The second part of training can start during the implementation of the rehabilitation works focusing mainly on the crop and water management and operation maintenance aspects of tanks. Once the rehabilitation works are completed, the third part of the training can start focusing on managing tank and tank irrigation under the guidance of WUAs. This will cover at all levels of tank hierarchy, namely, tank, tank cascade and tank federation. The foremost driver behind modern day rehabilitation programmes observed is the engagement with stakeholders under a decentralised governance system.

The MGNREGA manpower can be better used in tank improvement works, so that the impact of the MGNREGA labour could be measurable. The available labour in the villages can be listed out and the work schedule can be prepared accordingly to engage them in the tank related works including agricultural operations.

Integration of tank and groundwater system: It is important to manage the conjunctive use of tank and ground water through appropriate water management strategies. For example, sluice rotations are considered as a possible strategy to sustain the tank irrigation in the long run, wherein the stabilisation value of groundwater will be high compared to current practice of using tank and groundwater separately, that is, tank water in the first few months and then groundwater in the later months. This practice results in over-use of tank water in the initial periods and under-use of groundwater in the later periods due to inadequate groundwater, thus, resulting in crop yield reductions. The hydraulic interaction between tank and well water is high, when both are used conjunctively. This will ensure availability of tank water for longer period, and thereby, facilitate direct irrigation as well as groundwater recharge. The TankSim model developed has demonstrated the impact of this strategy in terms of higher rate of return among other modernisation strategies (Palanisami and Easter, 2000).

Integration of tanks and social forestry: Social forestry plantations (mainly *Acacia nilotica*) occupied the tank water spread area, prohibiting the desilting process by the farmers. Current popular debate is that the social forestry should be removed from the tank and tank desilting should be undertaken in the entire water spread. Also, there is an increasing pressure from the farmers that the plantations should be removed, as they consume more tank water. A study by Palanisami (2006) on the water consumption by trees has shown a linear increase in uptake and utilisation with the age of the trees with a correspondingly increase in the biomass production. But there is no significant loss in tank water compared to tanks without the social forestry plantations, as the tree cover prevented the evaporation of water from the tank. The efficiency in utilisation of water by the tree also improved: young trees utilise more water, but yield little biomass (131.16 kg/ha/cm) because more water is spent maintaining the plants and fresh growth rather than developing building blocks. A maximum water use efficiency of 150.93 kg/ha/cm was registered by 25 years old trees, due to more photosynthesis and conservation of biomass. While analysing the economics of water consumption and biomass value, the cost of water consumed by trees increased from Rs. 825/ha/year for 5-year-old trees to 6099/ ha/year for 25-year-old tress, with corresponding increase in the value of biomass from Rs. 13,603/ha to Rs. 1,16,639/ ha. However, only the tank foreshore area can be permitted to go for social forestry, as this will prevent the foreshore encroachment and also the extensive growth of *prosophis* tress that have less economics values. The revenue should go to the tank maintenance funds.

As part of the modernisation process, the database on tanks in the cascade can generate information that can be used to analyse a variety of technical, socio-economic, and ecological relationships such as tank storage under varying rainfall regimes, evaporation losses from tank water spread, groundwater storage, recharge rates under different soil and silt conditions, the pattern of water use, and so on. Also, there is a need to explicitly document conflicts of interests between various groups of stakeholders. Approaches to handle such conflicts to create win-win strategies should be planned periodically at cascade level. All these will ensure sustainability of the modernisation activities undertaken.

How could the Tank modernisation be done in a cost-effective manner? How to make the funding mode more effective?

Regarding investment and cost sharing in tank modernisation, a one-time investment of a maximum of 15% for maintenance and management should be allocated from the total modernisation budget, and the bank interest accrued out of this fund could only be used for tank maintenance and management on a regular basis. The modalities to draw the interest from bank for tank related works need to be worked out in consultation with the stakeholders where the provision for a matching grant from WUAs will be assured. A higher level of contribution from the WUAs will be an added advantage to help mobilising more funds from government and other funding agencies.

In the case of water acquisition, the cost calculations should be based on rupees per square kilometre (sq km) of catchment area for works in the catchment including feeder channel improvement.

Given the fiscal constraints, the issue concerns the balance between creating new works and making better use of the already existing tanks. If the existing thousands of tanks and ponds are rehabilitated in a cyclic manner, it will contribute significantly to not only increasing food production but also to providing a variety of livelihood options to the rural poor, especially women. And also, these rehabilitated tanks will act as a buffer to store more flood water due to climate change induced heavy rains. This appears to be the best cost-effective option than creating new irrigation works.

Since budget constraints may surface when going for large scale rehabilitation, it is important to examine the relevant co-financing options in tank modernisation programmes. As such, several funding agencies is financing the tank modernisation mostly in a single agency mode. For instance, the EEC, NABARD, World Bank and so on funded programmes that are mostly done based on their concept note and work plan already agreed with the implementing government departments such as irrigation or agriculture departments. Some agency might be having all expertise to implement both structural and non-structural investment options, and many may not have the technical expertise. It is observed that in most of the tank modernisation programmes, technology adoption and capacity building aspects are weak resulting in poor performance of the modernised tanks over years (Palanisami and Mohanasundari, 2020). Hence, co-financing with national or international agencies with different expertise in modernisation will enhance the benefits from modernisation. For example, NABARD could consider the co-financing options with ADB or WB for specific expertise. So, there is a win-win situation for both the funding agencies. Co-financing will also provide better opportunities for cross learning and mainstreaming the investment programmes in a better manner.

What kind of institutional set is needed for the future of the tanks? How could the tank farmers associations and other tank- based institutions be revived?

Tank water users association should be made mandatory for all the tanks. One single agency such as PWD or Rural Development Department must be made the nodal agency to coordinate with the tank farmers associations. This will facilitate efficient fund flow from government departments to the tank management. Also, revenue generated from tank multiple uses should be shared with tank farmers associations though appropriate government norms or acts. At the national level, a tank authority can be established to coordinate and mobilise funds for tank investment and management by closely working with the states. A tank authority will ensure better convergence of different programmes by government departments, external funding agencies and corporate initiatives on tank improvements, and cross learning of tank management issues across states, prioritising of investment options and enhanced livelihood options in the rural sector.

The role of government (funding agencies), NGOs and tank user groups at the tank, cascade and federation levels are increasingly important in achieving these enhanced livelihood options through effective modernisation.

In sum, given the climate change regime and the constraints in further expanding canal and well irrigation sources, irrigation tanks (both new and existing) offer the best investment strategy for stabilising the irrigation potential, besides benefitting mostly small and marginal farmers and other rural households in the country.

Notes

1. The number of tanks and the area irrigated by tanks vary over years due to the addition of small water bodies like ponds, etc., Hence, the actual area irrigated by tanks may vary between states, and the total area under tanks in the country may be around 2 m ha. However, this report used the available data to mainly analyse the trends in tank irrigated area among the regions.

2. Northern region covers Jammu and Kashmir, Punjab, Haryana, Himachal Pradesh, Delhi, Uttar Pradesh, Uttaranchal, Madhya Pradesh and Chhattisgarh. Eastern region covers Bihar, Jharkhand, Orissa and West Bengal. Western

region covers Maharashtra, Goa, Rajasthan and Gujarat. Southern region covers Andhra Pradesh, Tamil Nadu, Karnataka, Kerala and Pondicherry. North-eastern states are not included here, as tank irrigation in this region accounts for a negligible percent of the total tank irrigated area in India, and also not much information is available on tank related aspects.

3. The groundwater first augments the total water supply for irrigation and then stabilizes the fluctuations in the supply of irrigation water to the crops. The total value of groundwater is, thus, the sum of the above two groundwater generated benefits. The benefit generated by the variability reducing function of the groundwater is called the stabilisation value of groundwater.

4. Based on the averages of the 12,423 tanks covered in four states under four major such as KCBTMP in Karnataka APCBTMP in Andhra Pradesh, OCTMP in Odisha and Tamil Nadu Irrigated Agriculture Modernisation and Water-bodies Restoration and Management (TN-IAMWARM) Project in Tamil Nadu.

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Annexure 1: An Overview of Main Efficiency Measures – Planned Vs. Actual

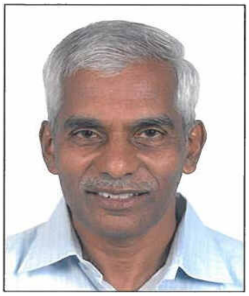
Particulars	Units	APCBTMP Planned	APCBTMP Actual	KCBTMP Planned	KCBTMP Actual	OCTMP Planned	OCTMP Actual	TN-IAMWARM Planned	TN-IAMWARM Actual
Project closing date		31/12/12	31/12/16	31/01/09	31/01/12	31/08/14	30/06/16	31/03/13	30/06/15
Total Project costs	USD (in mil)	204.7		138.47		127.8		515.06	
Component costs:									
Infrastructure	USD (in mil)	150.6		82.15		60.6		282.83	
	% of total	74%		59%		74%		55%	
Agriculture	USD (in mil)	25.2		8.95		11		166.22	
	% of total	12%		6%		13%		32%	
Institutional support	USD (in mil)	16.4		33.88		5.1		57.69	
	% of total	8%		24%		6%		11%	
Project management	USD (in mil)	12.5		13.49		5.7		8.32	
	% of total	6%		10%		7%		2%	
Number of water tanks	No.	3,000	3,000	2,000	3,503	900/320	320	5,700	5,700
Total command area	Ha	250,000		145,997		120,000		403,410	
Average total project cost per ha of command area	USD	819		948		687		1,277	
Average infrastructure cost per ha of command area	USD	602		563		505		701	
Average agriculture cost per ha of command area	USD	101		1		92		412	
Irrigated area – WOP	Ha	180,000	-	109,267	-	64,320	-	-	-
Irrigated area – WP	Ha	225,000	0	32,829	0	-	0	-	0
Increase of irrigated area	%	25%		22%					
Total number of beneficiary farmers#	No.	108,000		194,811		82,400		677,650	
Internal Rate of Return	%	23.6		19	17	20.8		20.4	

Notes:
1. KCBTMP stands for Karnataka Community-based Tank Management Project.
2. APCBTMP stands for Andhra Pradesh Community-based Tank Management Project.
3. OCTMP stands for Orissa Community Tank Management Project.
4. TN-IAMWARM stands for Tamil Nadu Irrigated Agriculture Modernisation & Water-bodies Restoration & Management Project

\# In APCBTMP and OCTMP, they are farmers benefiting from agricultural component; in KCBTMP, they are based on average farm size of 0.75ha (command area); and in TN-IAMWARM, they are farmers in project area.

Source: World Bank (2014): Review of Tank Projects in India, FAO - World Bank Cooperative Programme, Draft Report – 24, (unpublished), World Bank, New Delhi.

About The Author



K. Palanisami is an international agriculture and water expert with specialisation in Agriculture economics and water policy and climate change. He was a visiting professor at the University of Minnesota, United States (1982-84, 1990); visiting fellow at Khon Kaen University, Thailand (1984-85); visiting researcher at Waseda University, Japan (2000); and Research Institute for Humanity and Nature, Kyoto, Japan (2004). He worked at International Rice Research Institute (IRRI), Philippines (1986-1988), and served as expert consultant for the United Nations/FAO for East African Countries (1997) and for International Fund for Agricultural Development projects in seven Asian Countries. He was also one the high-level experts for preparing a water master plan for Abu Dhabi Emirate in 2007. He was the director of the Water Technology Centre and Centre for Agricultural and Rural Development Studies, Tamil Nadu Agricultural University (2000-2008). He was the director of the IWMI-Tata water policy programme and also principal researcher at International Water Management Institute (IWMI), South Asia Office, Hyderabad (2008-2014). He also served as a consultant to several World Bank and ADB projects in India and abroad.

He has written 20 books on water management and published 45 papers in leading international journals. He is a leading expert in tank irrigation, and has handled several research projects on tank irrigation with the University of Minnesota, USA; Linkoping University, Sweden; University of Newcastle, and BGS, UK; Khon Kaen University, Thailand; Waseda University, Tokyo; and Kyoto University, Kyoto, Japan. He handled a major research programme on tank irrigation for the Australian Council for International Agricultural Research (ACIAR), Australia covering eastern Indian states and Nepal.

He was the recipient of the Indian Council for Agricultural Research (ICAR) junior and senior fellowships, the best scientist award from the Tamil Nadu State Council for Science and Technology, best water technologist award from Tamil Nadu Agricultural University, junior and senior Fulbright fellowships (USA), Robert McNamara Fellowship (World Bank, USA) and JSPS fellowship (Japan), GLOBE AWARD from WELLCOME Trust UK, Best water Practice/technology award by the United Nations in 2013, and IWMI recognition award in 2014. He was awarded the fellow of the National Academy of Agricultural Sciences (NAAS) in 2015. He is currently working as an emeritus scientist of the International Water Management Institute (IWMI), and also serving as an agricultural expert to the Inter-state Water Resources Department, Government of Telangana and as agricultural Modernisation expert, Asian Development Bank.

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Department of Economic Analysis and Research
NATIONAL BANK FOR AGRICULTURE AND RURAL DEVELOPMENT
Plot No. C-24, 'G' Block, BKC, Bandra (E), Mumbai - 400 051