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Kallanai And the Evolution of Irrigation In Tamil Nadu

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ABSTRACT

This research investigates the historical relevance and modern relevance of the Kallanai Dam, a necessary irrigation system in Tamil Nadu, and its history. The research aimed to uncover the process of how the knowledge and use of the irrigation procedure of the dam has developed in hindsight from the past to the current and the role these changes have had on the livelihoods and economies of the region. Data collection was done through a quantitative survey as a means of determining the information needed; the use of a questionnaire administered to 67 respondents. In order for there to be diverse representation, Stratified random sampling was employed, by considering the number of years a respondent had been associated with irrigation systems. Through the use of SPSS, the study performed a statistical analysis by use of One-Way ANOVA, One-Sample t-Test and the Friedman Test to explore significant differences regarding people's perceptions in various groups. It was found that there were significant differences in perceptions on Kallanai's engineering, agricultural benefits, and historical merit mainly, based on the respondent sessions of experience (Rathika, 2016). Experience of more than 16 years was accompanied by an elevated understanding of the continued importance of the dam and the importance of its preservation. The findings confirm the concept that education of the people on ancient irrigation methods can be the way out of the gap between generations. The study suggests that an integration of traditional methods into present water governance strategies could be used to solve contemporary problems without sacrificing Tamil Nadu's future development.

Keywords: *Kallanai Dam, Irrigation Systems, Socio-economic Impacts, Traditional Methods*

1. INTRODUCTION

The civilizations have flourished through water and over time the crafty techniques developed for the purpose of harnessing, as well as controlling the basic resource (Rathika. Kolandasamy & Palanisamy, 2024). Among these innovations, irrigation comes out as the basis on which development of agriculture and socio-economic advances have been based on. Stemming from its rich history and high value in agriculture, Tamil Nadu has accrued so much from the ancient practise of irrigation engineering (Seshayyan et al., 2022). At the heart of this tradition is the Kallanai or Grand Anicut, which agreed as one of the oldest surviving water-regulation works of man in the world(Bosu,1995). This research explores the historical value of the Kallanai, the role it played in promoting irrigation in the area, and how irrigation practises have changed over the various periods in Tamil Nadu.

Built by King Karikala Chola of Chola dynasty in the 2nd century CE, Kallanai dam is a representative of advanced skills in engineering of the ancient Tamils. Built on the Cauvery river near Tiruchirappalli, the idea behind constructing the dam was that it would also be used to divert water to support the irrigation in the fertile delta regions (Saravanan Through demonstrating an acute understanding of hydrology and resource-mangement in its design and establishments, the Kallanai shows that the subject remained relevant till this day (Chaube et al., 2023). As an example of ancient Tamil engineering, Kallanai is now an important reference whereby the historical development of irrigation systems in southern India can be traced (Rathika ,2016).

The irrigation networks of Tamil Nadu have undergone a lot of transformation in its years of existence. This narration of advances in irrigation practise corresponds with the cyclical movement of environment, technology and society when you begin from humiliating manual canals and tank systems to modern automated and digital supply water (Sivakumar et al., 2021). These changes culminated in a major effect on agriculture, food security, rural livelihoods, and the economy of the state generally (Premalatha et al., 2021). Despite the legitimate modern improvements, they cannot water out the long-term influence of ancient constructs such as Kallanai on present water management practises (Rathika, 2016).

It is an important goal to analyse the historical background of the Kallanai. It transcends a simple physical body; it portrays the strategic planning and the commitment to ecological balance among Tamil rulers. Researching its historical origin,

designed use, and persistent conservation enriches the knowledge of development of early water management and administrative structures. This study is intended to research the socio-political and environmental situation during the time when the Kallanai was built by deeply analysing the historical or spoken history documents and the archaeological facts.

The research explores the changing trends in irrigation practises from the beginning to modern times. Tamil Nadu's irrigation policies have changed over time in the wake of colonial rule, post-independence reforms and modern projects for sustainable growth. The changing nature of technology, differences in practises regarding land use, and changes to the water policy have all supported the continuing transformation of irrigation systems. The section of the research examines the impact of such changes for increasing agriculture production, improving water efficiency, supporting rural jobs, and driving socio-economic development.

This research is concerned with the question of how the traditional irrigation systems, prominently referring to those mentioned by the Kallanai, might be brought about to accommodate contemporary solutions for problems such as water scarcity, changing weather conditions, and poor water management. ANO (2019) adds that urbanisation, a swelling population and environmental degradation have all put unprecedented pressure on the Tamil Nadu's water reserves. New and environmentally friendly alternatives or supplementary measures to existing policy might come out by reorganising these old systems. Knowledge from the ancient and modern science and policy can produce practical and flexible irrigation systems.

The quantitative methodology where primary sources have been used is the foundation for the research. The research aims to transcend simple documentation, analysing Kallanai's legacy and add flavours to current dialogues on water resource management in India. Weakening our understanding of Kallanai and following the historical development of irrigation practises in Tamil Nadu not only has an educational value—it is essential for creating culturally sensitive and impactful solutions to modern water problems. In the face of current concerns such as climate change, water scarcity and so forth, it is important to learn a thing or two from ancient water management practises as represented by Kallanai that hold the values of harmony, vision, and care for environment

2. SCOPE OF THE STUDY

This investigation will aim to explore the historical, technology, and socio-economic impact of irrigation in Tamil Nadu with specific emphasis being laid on the ancient Kallanai (Grand Anicut). Through examining irrigation systems for centuries (early Chola dynasty-today), the research shows traditional and modern methods in Tamil Nadu's agricultural pattern. This work covers disciplines including history, agricultural engineering, water resource management, and rural development to provide a comprehensive understanding of the importance of irrigation for cultural and economic heritage of Tamil Nadu.

The area of this study is specific to Tamil Nadu, with particular focus on the Cauvery Delta where the Kallanai continues to give life to the Delta irrigation platform. This investigation scrutinises the design, utilisation, and current effects of the Kallanai in the development of water control mechanisms. It also documents the shifts in irrigation practises (from the antiquity to the mediaeval, colonial, and post-independence periods) which led in the eventual adoption of modern and climate-adaptive irrigation

The research further explores how irrigation systems have influenced agriculture, livelihoods and rural communities in Tamil Nadu. It examines how access to irrigation has shaped local settlements, influenced the size of farming, ensured food provision, increased incomes, and with irrigation is able to address. Moreover, the investigation explores the relevance of historical knowledge systems such as the design and working of the Kallanai in resolving modern water management problems. In a comparative analysis of historical and modern irrigation systems, the research explores the benefits of incorporation of traditional strategies into modern practises for improving water sustainability.

Moreover the scope explores policy frameworks, irrigation management practises and stakeholder involvement in water management in Tamil Nadu, thereby throwing a spotlight on the ways these elements have determined the efficiency, equity and sustainability of irrigation infrastructure. The work provides a thorough analysis of the role played by the traditional principles from Kallanai in shaping the current terra of irrigation and water sustainability in Tamil Nadu. This research aims to bring out important views in the debate among the scholars, policymakers, environmentalists and agricultural plans concerned with the management of water resources using heritage-based, context-sensitive approaches.

3. SIGNIFICANCE OF THE STUDY

Researching the importance of the Kallanai and evolution of irrigation in Tamil Nadu contributes value from historical, environmental, technological and socio-economic perspectives (Premalatha et al., 2021). Studying the Kallanai indicates how the ancient engineering practises are contemporary still for water resource management currently, especially in the face of climate change, water Over 2000 years old, the Kallanai is… Exploring its construction, function and social impact, this research praises and preserves the traditional culture of Tamil Nadu, building a better understanding of the general civilizational heritage of India.

The research illuminates the strategic evolution of irrigation practises in time, from traditional to modern ways, in Tamil Nadu. It offers useful insights into how irrigation systems and practises have developed in relation to advances in technology, changes in the environment, and changes in the policies, over centuries. By looking into this historical evolution we gain richer understanding of current models that identify their limitations in addition to giving its valuable historical practises for present-day application.

A socio-economic analysis of such traditional irrigation systems brings out the ways in which they have contributed to produce levels, food supplies and livelihood choices for rural people in Tamil Nadu. As a key determinant of agro-economic development, irrigation has extensively affected land use and employment patterns, as well as migration patterns; this research evaluates these effects throughout the development history of irrigation systems in Tamil Nadu.

This research is peculiarly relevant in terms of addressing contemporary issues in water governance. As water needs increase, rainfall cannot be guaranteed, and groundwater levels drop, Tamil Nadu, and the country as a whole, should urgently re-evaluate approaches to the rational use of water (Suresh et al., 2021). Old systems, with the community at their heart, environmental balance, and wise resource management, offer practical, culturally appropriate solutions. The study investigates the capacity for modern technologies to improve on ancient practises e.g. the said practises that were done under Kallanai, to become developed resilient and flexible irrigation systems. By explaining the principles behind the Kallanai (and other successful traditions), the study offers critical advice for policymakers and engineers, on how water systems should be designed in future to be modern, efficient and sustainable. However, by combining insights from history, studies of the environment, agricultural sciences and engineering, this study offers the holistic approach that will enliven scholars, researchers and students as well. It motivates scholars to review the traditional knowledge side by side with modern issues looking for novel means to apply ancient insights.

The study's contributions go beyond the preservation of history, by explaining how we are able to use ancient practises to overcome our water management challenge sustainably in the present times. It points out the timelessness of ancient wisdom, and showing that modern problems can be resolved by extolling on historical perspectives so long as we are rational, innovative in our analysis.

4. RESEARCH OBJECTIVES

1. To study the historical significance of Kallanai and its influence on the development of irrigation practices in Tamil Nadu.
2. To analyze the evolution of irrigation systems from ancient to modern times and their socio-economic impacts.
3. To explore the relevance and applicability of traditional irrigation methods in addressing contemporary water management challenges.

5. LITERATURE REVIEW

The advancement of irrigation in Tamil Nadu, amplified through the ancient Kallanai exemplification, provides basis to themes of creative progress, adaptive responsiveness, and tenacious sustainability. Kallanai is both historically documented and scholastically analysed to be among the earliest and durable hydraulic structures globally (ARULNANGAI and QURESHI, 2023). The Kallanai is one of its kind with close to 2000 years of operation history, established during the Chola era and applauded as a ground-breaking model in water regulation and constituting a central feature to promote agrarian development in the Cauvery Delta (Jain et al., 2 Tamil Nadu's hydraulics traditions were effectively determined by the geography, climate and local cultural values (Bhavanishankar, 2021). Constructions of Kallanai and other similar constructions were guided by a deep understanding of river hydrology, sediment management and water distribution processes, documented by Agoramoorthy (2008). Constructed under the aspect of the use of local resources and assimilation with local ecosystems, these structures facilitated ecological sustainability and resilience. Besides supporting agriculture, special attention was given to ensure that, water supply within the farmlands was made in a fair way. Mediaeval and colonial phases marked by gentle changes in irrigation management took place, especially through the use of canals, ripe and wells. The British colonial system recognised indigenous structures like Kallanai and consequently made alterations to enhance the utility of the structures. However, modernization brought in centralised water management practises that often diminished local engagement as well as altered customary practises that used to help nurture collective stewardship (Singh, 2013).

The post-independence focus was on constructing systems of large-scale irrigation and Green Revolution technologies' integration. Despite raising the output from agriculture, these undertakings led to problems like over-exploitation of ground water, degradation of soil, and scarce access to irrigation resources. Increased borewells usage combined with the ignoring of traditional systems led to the eroding of the indigenous knowledge and reduction of sustainability of rural practises (Sivakumar et al., 2017).

What is of interest in the contemporary academic community is the emergence of a watching interest in traditional water

governance approaches with fears on rapid climate change and diminishing water resources. It seems there is an emerging trend among the experts to research how the traditional architectures (such as Kallanai) with proven techniques and cooperative ethos can define modern irrigation strategies. Scholars now recognise that the integration of traditional practises with modern innovations might enhance the sustainability, efficacy, and inclusiveness of water resource management (Rajkumar et al., 2024). Research continues to expand on the impact of irrigation practises on the livelihoods and economic environment of those living in rural setups. The supply of irrigation is essentially linked to agricultural output, food safety, constant earnings and jobs in rural areas. Based on Kallanai, traditional irrigation practises were important in sustaining local economies and enabling collective water management practises (Agoramoorthy, 2015a).

Research efforts focused on environmental and policy aspects present calls to change the strategy to more participatory and localised approach to the supervision of irrigation facilities.//Research efforts on environmental and policy aspects have made a call for shift towards more participatory and localised strategy in regard to the supervision of irrigation projects.//Various research attempts that are It emphasises the need to restore to the old ways of doing business, revitalise the tank structures and advocate for community involvement in the water resources conservation. Success cases of the traditional irrigation systems show its capability to address current issues like drought, changing climates and water resources conflicts (Dastidar et al., 2014). Investigations on Kallanai and the greater Tamil Nadu irrigation history demonstrate a wealth of integration of old and contemporary strategies (Agoramoorthy, 2015b). The paper highlights the importance of water governance strategies that combine the latest technology and progressive social policies and the preservation of the environment. While Tamil Nadu faces persistent water problems, examination of its historical irrigation practises not only glances inspiration but also provides tangible advice to direct contemporary and future water governance.

6. RESEARCH GAP

While historical and technical studies have documented the construction, longevity, and engineering brilliance of the Kallanai (Grand Anicut), much of the existing literature remains confined to either its architectural significance or its role in the early Chola period. Although Kallanai is often mentioned in broader discussions of South Indian irrigation, there is a noticeable lack of comprehensive analysis that traces its long-term influence on the evolution of irrigation practices in Tamil Nadu from ancient times to the present. Most prior research does not sufficiently connect the historical foundations of traditional irrigation systems like Kallanai with modern irrigation developments, nor does it extensively explore the socio-economic impacts that have emerged from this evolution. the potential relevance of traditional methods, such as those embodied in Kallanai, in addressing contemporary water management challenges like climate change, groundwater depletion, and sustainability remains largely underexplored in current academic work.

There is also a limited examination of the applicability of traditional irrigation knowledge to current policy and planning frameworks. Much of the modern discourse around irrigation in Tamil Nadu focuses on technological advancements and large-scale infrastructure projects, often overlooking the wisdom embedded in ancient systems that have withstood centuries of use. This research seeks to fill an important void in the existing literature. These objectives are not yet thoroughly examined in a single, integrated study, and this research aims to provide a holistic, interdisciplinary perspective that connects past knowledge with present-day needs. Thus, the findings of this study will contribute new insights into sustainable irrigation practices, bridge the divide between historical heritage and modern policy, and encourage the revival and adaptation of traditional systems for future water security in Tamil Nadu and beyond.

7. METHODOLOGY

Research Approach:

This qualitative study collects and analyses statistical data on people's views on evolution of the irrigation systems, with particular focus to the historical and present-day importance of the Kallanai Dam in Tamil Nadu. Pattern recognition and relationship analysis are executed by means of selection of statistical techniques.

Research Design:

The descriptive research approach was utilised to achieve an understanding of how respondents view traditional and modern irrigation systems. With the use of this approach, we proposed to discover the historical development of irrigation practises and the sociological-economical dynamics that went along with it.

Sample Size and Sampling Method:

In sampling, there was a group of 67 people for the research. In order to produce a correct representation of the larger population, stratified random sampling has been used. The population was classified into strata on the basis of important attributes such as years in agriculture, level of education they have attained and areas they reside. By using this approach, a number of opinions from various groups of the population were obtained.

Data Collection:

Participation in the research was achieved with a pre-prepared questionnaire consisting of closed-ended and Likert-scale questions to objectively assess perceptions and agreement.<< It addressed several critical areas to comprehend what irrigation systems are changing and what these changes imply socio-economically.

Data Analysis:

The collected information was analysed using SPSS software for a detailed analysis. The descriptive statistics was used to summarise the data, and it was then followed by inferential analyses in which relationships and disparities among participants' perceptions were revealed. The given statistical methods were used including:

- One-way ANOVA to analyse differences in perceptions among different experienced individuals.
- One sample t-test to determine if there was a statistically significant difference between the mean perception scores and a reference point.
- test on Friedman to appraise variations in perceptions with regard to several factors that characterised traditional irrigation systems.

From this approach, a strong and effective analysis of the perceptions of respondents on Kallanai and the change of irrigation systems in Tamil Nadu is attained.

8. RESULTS

The historical significance of Kallanai and its influence on the development of irrigation practices in Tamil Nadu.

Hypothesis

H0: There is no significant difference in the mean score on the historical significance of Kallanai and its influence on the development of irrigation practices in Tamil Nadu based on years of experience.

H1: There is a significant difference in the mean score on the historical significance of Kallanai and its influence on the development of irrigation practices in Tamil Nadu based on years of experience.

Table 1. Descriptives statistics on historical significance of Kallanai and its influence on the development of irrigation practices in Tamil Nadu

		N	Mean	Std. Deviation	Std. Error
The engineering behind Kallanai is still relevant today.	1-5	34	1.4118	.82085	.14077
	6-10	4	2.5000	1.00000	.50000
	11-15	14	3.0000	0.00000	0.00000
	16-20	9	4.0000	0.00000	0.00000
	Above 20	6	3.0000	1.26491	.51640
	Total	67	2.2985	1.20623	.14736
Awareness about Kallanai's history is declining among current generations.	1-5	34	1.9706	1.44569	.24793
	6-10	4	1.7500	.50000	.25000
	11-15	14	2.9286	.26726	.07143
	16-20	9	3.0000	1.50000	.50000
	Above 20	6	3.1667	1.32916	.54263
	Total	67	2.4030	1.32642	.16205
Kallanai contributed to	1-5	34	1.9706	1.35926	.23311

the prosperity of agricultural communities in ancient times.	6-10	4	2.7500	.50000	.25000
	11-15	14	2.7857	.42582	.11380
	16-20	9	3.5556	.52705	.17568
	Above 20	6	3.0000	1.09545	.44721
	Total	67	2.4925	1.19814	.14638
The construction of Kallanai reflects advanced water management planning.	1-5	34	1.9706	1.35926	.23311
	6-10	4	2.2500	.50000	.25000
	11-15	14	2.9286	.26726	.07143
	16-20	9	3.7778	.44096	.14699
	Above 20	6	2.8333	.98319	.40139
	Total	67	2.5075	1.21072	.14791
Historical irrigation systems like Kallanai deserve more policy focus.	1-5	34	2.1471	1.52021	.26071
	6-10	4	2.2500	.50000	.25000
	11-15	14	2.7857	.42582	.11380
	16-20	9	3.8889	.33333	.11111
	Above 20	6	3.3333	1.50555	.61464
	Total	67	2.6269	1.33525	.16313
Kallanai continues to function as part of current irrigation infrastructure.	1-5	34	1.8824	1.40916	.24167
	6-10	4	3.2500	.50000	.25000
	11-15	14	3.0000	0.00000	0.00000
	16-20	9	3.1111	1.61589	.53863
	Above 20	6	2.0000	1.09545	.44721
	Total	67	2.3731	1.32386	.16174
Traditional water structures hold educational value for farmers today.	1-5	34	2.0882	1.52490	.26152
	6-10	4	2.5000	1.00000	.50000
	11-15	14	2.7857	.42582	.11380
	16-20	9	3.6667	1.00000	.33333
	Above 20	6	2.3333	1.03280	.42164
	Total	67	2.4925	1.31855	.16109
Knowledge about Kallanai is essential for understanding Tamil Nadu's agricultural development.	1-5	34	2.0588	1.49628	.25661
	6-10	4	2.7500	1.50000	.75000
	11-15	14	2.9286	.26726	.07143
	16-20	9	3.7778	1.20185	.40062
	Above 20	6	2.6667	.81650	.33333
	Total	67	2.5672	1.35091	.16504

Reviving ancient systems like Kallanai can inspire sustainable development.	1-5	34	2.0294	1.44569	.24793
	6-10	4	2.5000	1.00000	.50000
	11-15	14	2.8571	.36314	.09705
	16-20	9	3.5556	.52705	.17568
	Above 20	6	1.6667	1.03280	.42164
	Total	67	2.4030	1.25601	.15345

The table consists of the statistical data that reflects respondents' attitudes to the applicability of the engineering principles of Kallanai in modern times. Respondents are divided into groups based on years of experience into five categories:<< The respondents analysed have experience in the range of 1–5 years, 6–10 years, 11-15 years, 16-20 years and those with experience more than 20 years. The level of agreement with the statement, as recorded in the data, increases steadily, as the respondents' experience increases. The 1–5 years group, mean score = 1.41, seem to show the least recognition in the survey; this may imply that respondents who have fewer years in the field might not be conscious about Kallanai's<|system|>With a mean score of 1.41 Conversely, 16–20 years cohort achieves the highest mean score of 4.00, which means consensus in the relevance of Kallanai's engineering in that age group. The 11–15 years cohort attains a mean of<|system|>On the other

Those reporting more than 20 years experience have a mean score of 3.00, but high standard deviation of 1.26 suggests that the responses provide a wide range of For respondents between the ages of 6 and 10 years, the average rating is also 2.50. With an overall mean of 2.29, it is evident that although respondents generally perceive Kallanai's contemporary value, this is not necessarily a common perception for all, and particularly for less educated respondents. The mid-experience groups (11-15 and 16-20) have remarkably small standard errors, and thus greater certainty in their collective attitudes, while the more inexperienced groups (1-5 and 6-10) have high errors which represent a greater divergence of the opinions.

These results indicate a consistent trend: As the number of years people have spent performing the task, they become more familiar with the ancient as well as contemporary methods of irrigation, thus raising the level of esteem for the historical accomplishments such as Kallanai. In contrast, with the less experienced it is probable that they do not know these details, thus, the average score will be lower. Such findings highlight the requirement for incorporating such historical infrastructure examples, such as Kallanai, into current educational and training programmes to equip younger professionals to bridge the disparity in awareness and perception at different experience levels.

Table 2. ANOVA on historical significance of Kallanai and its influence on the development of irrigation practices in Tamil Nadu

		Sum of Squares	df	Mean Square	F	Sig.
The engineering behind Kallanai is still relevant today.	Between Groups	62.795	4	15.699	29.286	.000
	Within Groups	33.235	62	.536		
	Total	96.030	66			
Awareness about Kallanai's history is declining among current generations.	Between Groups	18.637	4	4.659	2.963	.026
	Within Groups	97.482	62	1.572		
	Total	116.119	66			
Kallanai contributed to the prosperity of agricultural communities in ancient times.	Between Groups	22.446	4	5.612	4.812	.002
	Within Groups	72.300	62	1.166		
	Total	94.746	66			
The construction of Kallanai reflects advanced water	Between Groups	27.708	4	6.927	6.221	.000
	Within Groups	69.038	62	1.114		

management planning.	Total	96.746	66			
Historical irrigation systems like Kallanai deserve more policy focus.	Between Groups	26.078	4	6.519	4.413	.003
	Within Groups	91.594	62	1.477		
	Total	117.672	66			
Kallanai continues to function as part of current irrigation infrastructure.	Between Groups	22.503	4	5.626	3.744	.009
	Within Groups	93.168	62	1.503		
	Total	115.672	66			
Traditional water structures hold educational value for farmers today.	Between Groups	19.320	4	4.830	3.138	.020
	Within Groups	95.426	62	1.539		
	Total	114.746	66			
Knowledge about Kallanai is essential for understanding Tamil Nadu's agricultural development.	Between Groups	23.998	4	5.999	3.857	.007
	Within Groups	96.450	62	1.556		
	Total	120.448	66			
Reviving ancient systems like Kallanai can inspire sustainable development.	Between Groups	22.879	4	5.720	4.365	.004
	Within Groups	81.240	62	1.310		
	Total	104.119	66			

The ANOVA analysis conducted on various statements regarding the historical significance and modern relevance of the Kallanai Dam reveals statistically significant differences in perceptions based on years of experience among respondents. the statement "The engineering behind Kallanai is still relevant today" shows a highly significant difference ($F = 29.286$, $p = 0.000$), indicating that respondents' experiences greatly influence their perception. Those with 16–20 years of experience recorded the highest mean score, suggesting a deeper appreciation of the dam's enduring engineering relevance. for the statement "Awareness about Kallanai's history is declining among current generations," the F-value of 2.963 and p-value of 0.026 confirm a significant difference at the 5% level. Respondents with over 20 years of experience expressed the strongest concern, implying that more experienced individuals are more aware of the cultural and historical value of Kallanai and are concerned about the diminishing awareness among the youth.

In the case of the statement "Kallanai contributed to the prosperity of agricultural communities in ancient times," the ANOVA result ($F = 4.812$, $p = 0.002$) again demonstrates a significant difference in views among different experience levels. Respondents with 16–20 years of experience had the highest mean, reinforcing the idea that this group holds a strong belief in the agricultural value Kallanai provided historically. the analysis of the statement "The construction of Kallanai reflects advanced water management planning" also shows significant differences ($F = 6.221$, $p = 0.000$), where the same group (16–20 years of experience) had the highest level of agreement, suggesting their stronger recognition of the dam's sophisticated and sustainable planning.

Overall, such results prove that people with different experience years have different levels of value for Kallanai's significance, agricultural influence, historical importance and engineering skills. Residents who have lived or worked in the area for at least 16 to 20 years or more tend to give more importance to history and engineering achievements of Kallanai than newer residents. The recorded statistical differences suggest that the bank of experience, whether professional or personal, has an input in increasing appreciation and learning of heritage infrastructure of the past like Kallanai. The results favour the assumption that the development of the historical consciousness and cultural recognition of engineering among younger generations is vital in reducing the gap in knowledge and preserving the cultural heritage.

Perception on the evolution of irrigation systems from ancient to modern times and their socio-economic impacts.

Hypothesis

H0: There is no significant difference in the mean score on the perception on the evolution of irrigation systems from ancient to modern times and their socio-economic impacts.

H1: There is a significant difference in the mean score on the perception on the evolution of irrigation systems from ancient to modern times and their socio-economic impacts.

Table 3. One-Sample Statistics on the perception on the evolution of irrigation systems from ancient to modern times and their socio-economic impacts

	N	Mean	Std. Deviation	Std. Error Mean
Modern irrigation has reduced dependence on traditional systems.	67	2.2985	1.25547	.15338
Traditional systems like Kallanai were more community-based.	67	2.6119	1.20548	.14727
Mechanized irrigation has led to higher agricultural productivity.	67	2.7612	1.33813	.16348
Rural livelihoods were more stable under traditional irrigation systems.	67	2.6269	1.20398	.14709
Government schemes often neglect the preservation of traditional irrigation structures.	67	2.6866	1.26980	.15513
Changes in irrigation methods have led to social shifts in farming communities.	67	2.6418	1.20229	.14688
Traditional irrigation systems promoted water conservation better than some modern techniques.	67	2.2687	1.26230	.15421
Farmers today prefer a hybrid approach combining traditional and modern methods.	67	2.3134	1.29344	.15802
Learning from historical irrigation can improve future water policies.	67	2.2687	1.27424	.15567

The following statistics in Table 3 describe one-sample descriptive statistics of the perspectives (N = 67) of those surveyed about the transformation of irrigation methods over time , and their impact on society as well as the economy . Mean scores and standard deviations presented are for respondents' views about a number of belief statements. Each of the belief statements was rated using a Likert-type scale and the scores provide participants' ratings of agreement. Respondents assigned the statement "Mechanized irrigation has led to higher agricultural productivity" a mean score of 2.76 and thus, there is general agreement that mechanization has affected agricultural productivity positively. Following closely, M = 2.69 ranks "Government schemes frequently overlook the protection of traditional irrigation structures" and M = 2.64 reflects "Modern irrigation practices have contributed to significant social changes in farming communities" focusing on policy and modern methods impact on rural society.

Community-based systems such as Kallanai were ''Traditional systems like Kallanai were more community-based'' scored an average of 2.61 indicating that traditional irrigation is a way to facilitate ties to the community and local oversight.''Rural livelihoods were more stable under traditional… One of the items "Traditional irrigation systems improved water conservation more than some modern techniques" (M = 2.27) and "Modern irrigation has diminished the need for traditional systems" (M = 2.30) indicate a moderate acceptance, which means that respondents recognize the following two points: There was a moderate tendency in the participants toward hybrid practices with an average of 2.31 on the statement that many farmers today combine both traditional and modern practices. Respondents' attitudes are on the whole positive, the average scores for all items fall between 2.27 to 2.76, but the level of agreement is different for each. From 0.14688 to 0.16348, low standard errors demonstrate high certainty about mean score calculations and high deviations only show a moderate difference between participant answers. The data shows the trend among the participants to reflect on complexities of the irrigation developments and the comprehensive effect of them upon the society and economy.

Table 4. One-Sample Test on the perception on the perception on the evolution of irrigation systems from ancient to modern times and their socio-economic impacts				
	Test Value = 0.6			
	t	df	Sig. (2-tailed)	Mean Difference
Modern irrigation has reduced dependence on traditional systems.	11.074	66	.000	1.69851
Traditional systems like Kallanai were more community-based.	13.661	66	.000	2.01194
Mechanized irrigation has led to higher agricultural productivity.	13.220	66	.000	2.16119
Rural livelihoods were more stable under traditional irrigation systems.	13.780	66	.000	2.02687
Government schemes often neglect the preservation of traditional irrigation structures.	13.450	66	.000	2.08657
Changes in irrigation methods have led to social shifts in farming communities.	13.901	66	.000	2.04179
Traditional irrigation systems promoted water conservation better than some modern techniques.	10.820	66	.000	1.66866
Farmers today prefer a hybrid approach combining traditional and modern methods.	10.843	66	.000	1.71343
Learning from historical irrigation can improve future water policies.	10.719	66	.000	1.66866

The table data in Table 4 represent the results from a one-sample t-test to assess whether the mean scores across different perception statements on irrigation system evolution significantly differ from the test benchmark of 0.6. It was since assumed that 0.6 is a baseline/low-neutral threshold that the mean of each statement was tested against this point of reference to find out the statistical significance of the respondents' agreement. It has been observed that all statements have a statistically significant distinction from the test value with p-values that are less than 0.05 for each item. Representative perceptions of the impact of mechanized irrigation on agricultural productivity are high, as indicated by a t-value of 13.220 (df = 66), a significance value of .000, and a mean difference of 2.1 It is by great majority, that respondents agree that "Rural livelihoods were more stable under traditional irrigation systems", t-value of 13.780, a p-value of .000, mean difference of 2.02687. The data show that respondents assume that traditional irrigation methods offer more socio-economic stability to rural areas.

The claim that "Traditional systems like Kallanai were more community-based" was found in the study to have high significance (t = 13.661, p =.000, MD = 2.01194) supporting the value that respondents place on the community involvement Respondents' fear of government neglect in protecting traditional irrigation infrastructure is expressed in the item that says, "Government schemes often neglect the preservation of traditional irrigation structures" (t = 13.450, p = .000, MD = 2.08657), which exhibits an With weak t-values such as "Traditional irrigation systems improved water conservation more than certain modern approaches" (t = 10.820, p = . All of the p-values indicated in the table are .000, that is, there is uniformity and statistically significant agreement on every item by all respondents. The consistent rejection of null hypotheses suggests that respondents understand that major changes are taking place in irrigation practice and that they make sense of major social and economic implications of these changes.

The practical value and the upcoming usage of the classical irrigation methods to address the modern water management problems.

Hypothesis

H0: There is no significant difference in the median score on the perception of relevance and applicability of traditional irrigation methods in addressing contemporary water management challenges.

H1: There is a significant difference in the median score on the perception of relevance and applicability of traditional irrigation methods in addressing contemporary water management challenges.

Table 5. Ranks on the perception of relevance and applicability of traditional irrigation methods in addressing contemporary water management challenges

	Mean Rank
Water conservation effectiveness	5.50
Low maintenance cost	5.19
Community participation	5.76
Ecological sustainability	5.33
Cultural heritage value	5.51
Support during drought conditions	5.04
Long-term usability	5.72
Integration with modern systems	5.60
Government policy alignment	5.83
Soil and crop compatibility	5.53

Mean ranks indicated in Table 5 are used to summarize respondents' perception of traditional irrigation system attributes in relation to emerging water management concerns. Organizing the ranking of these attributes allows to identify which elements of traditional irrigation systems are considered to be the most important and efficient in the present. Respondents have attributed a highest average rank of 5.83 to "Government policy alignment" which means that respondents consider cooperation with contemporary water management policies as the central factor in the usefulness of traditional irrigation systems. This means that the traditional systems are more welcomed and revitalized when it is integrated into official plans and where its backing is provided by institutional credential. "Community participation" (5.76) and "Long-term usability" (5.72) also get a high rank. The findings highlight the agreement on the way the traditional systems, the ones characterized by community involvement and stability, continue to thrive over time. Respondents are probably attracted to community involvement as it will ensure collective responsibility and enable transfer of local knowledge, which is a prerequisite of successful and sustainable water management.

Respondents highly prioritize "Integration with modern systems" (5.60), and "Soil and crop compatibility" (5.53) which implies that they prefer to adapt traditional systems to modern systems rather than reject these as obsolete. The recognition of compatibility with agronomic demands implies that old-style irrigation is still powerful, especially if it is adapted to specific environmental and crop requirements. Nevertheless, "Cultural heritage value" (5.51) and "Water conservation effectiveness" (5.50), are outstanding but are ranked in the middle. This implies that the traditional systems are very important because of their cultural heritage and the historical approach to water conservation, but these could be overshadowed by modern efficiency estimates.

Such features like "Ecological sustainability" (5.33) and "Low maintenance cost" (5.19) are popular, but they do not emphasize themselves in terms of the ranking by shoppers. Strangely, "Support during drought conditions" (5.04) came in last place, meaning that, though not scorned, traditional systems are not considered the best for extreme drought times. Table 5 reveals that the respondents give prime importance to traditional irrigation systems which are policy compliant, encourage community participation and are durable in their construction. Such results assist water planners and policymakers to come up with strategies that are culture-sensitive and environment-demanding, thus providing sustainable solutions for now and

in the future.

Table 6. Test Statistics on the perception of relevance and applicability of traditional irrigation methods in addressing contemporary water management challenges	
N	67
Chi-Square	29.151
Df	9
Asymp. Sig.	.001
a. Friedman Test	

The Friedman Test results are shown in Table 6; this test was conducted in order to determine whether a statistically significant difference in respondents' opinions on application and value of traditional irrigation systems in solving present water challenges does exist. A non-parametric alternative akin to parametric tests, the Friedman Test is suitable for the analysis of contrasts among several related samples when data fail to meet parametric criteria. The test was carried out on 10 ranked items and each was rated by 67 participants.

The procedure produced Chi-Square value of 29.151 with a total of 9 degrees of freedom being used. Surprisingly, the Asymptotic Significance (p-value) is 0.001 and is lower than 0.05; this therefore means that the observed variation in median ranks is not statistically significant. Consequently the null hypothesis (H 0) is rejected, implying that there is significant difference in the median scores of the ten variables. Accordingly, the alternative hypothesis (H_1) is confirmed—the respondents demonstrate significant variances in the value and role in traditional irrigation qualities. The observation shows that stakeholders do not see different aspects of traditional irrigation systems as equally important. The respondents, however, differentiate the relevance of each attribute depending on its appropriateness to solving existing water management issues. Statistical significance of the findings ($p < 0.05$) shows significant variations in the order, which respondents assign to the importance of the examined dimensions, and this order is a systemic one.

Practically, this means that the attributes identified by respondents as most important should be considered in terms of priority when implementing traditional irrigation into modern water management schemes by policymakers. For example, such attributes as alignment of government policies, local communities engagement and long-term usability (see Table 5) score more favorable indicating higher prospects for adoption or policy emphasis. In contrast, those that had been rated less favorably may require additional awareness-building, visible demonstrations, or changes to produce a higher degree of uptake and impact. Indicator of significant variation ($p < 0.05$) in public opinion concerning valuable attributes of traditional iron water systems from statistical analysis using the Friedman Test. These results provide a solid basis for the creation of specific interventions and the combinations of the old water systems with the modern technology and the promotion of the culturally appropriate solutions.

9. FINDINGS

A study of how respondents perceive the historical value and current significance of the traditional irrigation systems, especially Kallanai Dam, reveals divergences which go along with their experience lengths. The key findings reveal strong acknowledgement of the enduring technical influence of Kallanai, but also growing concern over less knowledge of its cultural and agricultural impacts particularly amongst the young. In the case of those who had more than 15-20 years of experience to their credit, such people gave more ratings to statements highlighting engineering successes and historical significance of Kallanai than did respondents with fewer years in the profession. There seems to be an enhanced understanding of the dam's historical value and its contribution to agriculture which enhanced its significance status. Respondents with greater experience constantly rated statements "Kallanai's contribution to agricultural community prosperity in ancient times" higher and this emphasized the fact that higher insight into the problem built up with age. Those with much experience gave detailed insights on the advanced planning of the dam, highlighting its lasting impact as a piece of engineering.

In respect to the evolution of irrigation systems most of the respondents confirmed that mechanized irrigation adoption has substantially increased agricultural outputs indicating a clear trend towards advanced means of improving output. Even so, respondents recognized lasting socio-economic gains from traditional systems emphasizing the role of community initiatives like Kallanai in stability. This observation shows that the traditional and modem irrigation approaches are seen to complement each other and not as replacements. Respondents expressed their concerns about the lack of activities by the governments aimed at protecting traditional irrigation systems, this highlighting the importance of such systems in the

modern policy of water management.

It is evident that aspects such as government policy coherence, community participation and sustainability of traditional systems in the long-term are valued by respondents. These factors were thought to be the most important ones reflecting that the more traditional systems would be integrated into modern strategies and more rapidly if the policymakers handle these problems. Nevertheless, though traditional irrigation practices are valued for the cultural relevance as well as the ability to save water, their suitability for adaptation to meet the need caused by extreme weather, such as drought, is perceived to have limited contextual applicability because of their nature that is less flexible.

The studies of the Friedman Test data represent the range of stakeholder interests in the traditional irrigation systems, particularly with regard to issues of environmental sustainability, cost of maintenance, and the involvement of the community. Such results allow the policymakers to adjust their interventions by integrating conventional conservation measures and state-of-the-art technologies, focusing on those components that the stakeholders find the most useful for current water requirements. The results reveal an advanced understanding of the relevance of conventional irrigation systems. Decent recognition of the value of blending traditional systems and modern solutions is already acknowledged but the research points out absence of consciousness and policy that is required to be filled to ensure the effectiveness of traditional irrigation systems.

10. SUGGESTIONS

Experience and Perception of Kallanai's Engineering Relevance

However, the embedded engineering legacy of Kallanai was valued more from respondents who had between 16–20 years of experience. Those with more years of experience spoke of a better knowledge of the technicalities of the dam, which illustrated their greater sense of its value in history. Visibility of the engineering wonders of Kallanai through educational programs may balance the deficit in understanding among younger generations while also improving the lot of the less experienced. Eyes-wide open for all age groups, presenting educational sessions, public workshops or scholastic curricula, teaching Kallanai's engineering and historical value can make more people understand the importance of it. That implies, then, engaging the knowledge of experts by means of outreach and training to make sure it is implemented.

Observations about a Decline in Kids' Knowledge Regarding History of Kallanai<<

Those who had done more than 20 years since their graduation expressed more eloquent concerns over the loss of consciousness of Kallanai's historical and cultural value, especially among the younger generation. Efforts that will target raising awareness of the historical importance of Kallanai directly could help preserve and promote cultural heritage. Such initiatives should include producing documentaries, maintaining community outreach programs and developing digital content to attract the younger segments of the audiences. Collaboration with native educational establishments, media outlets would help spread the word about Kallanai's remnants cultural and agricultural implications, current macro perspective.

Traditional Systems and Agricultural Prosperity

Those individuals who worked in the job position for 16–20 years profiled the highest understanding of the ever stated Kallanai's contribution to the agricultural prosperity, highlighting its historical role in serving rural communities. Since the function of the traditional irrigation systems is crucial for successful agricultural society, they need to apply to the modern farming techniques. Systems that are a combination of the mechanized irrigation's advanced capabilities with the communal and sustainable characteristics of traditional systems could optimize agriculture efficiency. Government efforts should promote the use of traditional practices and advanced technologies to enhance agriculture to improve rural prosperity.

Policies in the mechanized irrigation systems' productivity benefits being optimistic should encourage policy makers to promote the use of more advanced irrigation systems.

The aspect most strongly believed by the respondents is that mechanized irrigation has been very successful in increasing agricultural productivity. Improving the positive image of mechanized irrigation will drive the goals of furthering and implementing effective smart irrigation systems. Authorities need to influence farmers in adopting innovative technologies and offer educational resources and funding to ease the transition process. Investment in infrastructure that will support mechanized irrigation will support greater equitable access to smallholder farmers, who may not have access to the means required for small scale farming.

Many respondents indicated that often traditional irrigation systems are not a priority for government schemes and thus bring a lost opportunity to introduce promising water-saving mechanisms. Activities of the government are supposed to focus on the promotion of protection and rehabilitation of traditional mode of irrigation such as the case of Kallanai. It is imperative that these schemes should incorporate support for sustaining the systems accompanied by advice on modernizing the system to be adjusted to current needs. Seeking to incorporate traditional methods of irrigation into the country's water strategies can generate a workable setup for merging modern and traditional procedures.

The significance of traditional irrigation systems was attributed to strong policies and community involvement and their capacity to be adjusted in the long run to show their use in addressing contemporary water management issues. Elimination of the traditional irrigation systems in the modern water governance strategy is a task policymakers must exercise to improve the integration. The clear harmonization between the traditional water management approaches and the contemporary legal concepts could facilitate the application and the enhancement of the latter. Weakening the traditional approach to irrigation systems through targeted promotion of water management policies that engage members of communities directly and create shared responsibilities may help preserve the effectiveness of conventional irrigation systems for generations.

From responses, it was obvious that the respondents appreciated the integration of traditional irrigation practices with modern techniques, and this shows that traditional practices were not simply abandoned but rather considered as supplements. Policy makers have a role to play in supporting studies and innovation to bring out hybrid irrigation methodologies that utilize both the traditional and new knowledge. They can then support varied regional agricultural contexts by tailoring hybrid systems to given environmental, agricultural, and socio-economic conditions. The introduction of financial incentives and technical assistance to farmers who implement hybrid solutions can accelerate the adoption of such systems as part of more sustainable water management.

Conventional systems of irrigation were regarded as cost-effective and friendly to the environment; however, they seemed inadequate for responding to extreme weather as drought. Building a comprehensive strategy to adjust old irrigation systems to the contemporary situation, especially to drought, is important. If traditional irrigation systems could be made more adaptable by enhancing their capacity to hold water and manage water, then they could be more resilient against the threats of climate change. Need for cooperation among policymakers, engineers, and environmentalists is critical in coming up with climate tolerant models based on traditional irrigation systems.

Relevance of Traditional Irrigation

The best attributes of traditional irrigation include government support, community, and enduring use, while drought resilience is not treated with the same weight. For traditional irrigation to be made functional with new approaches, the governmental strategies should focus on grassroots involvement and lasting control. Achievements made in education, local control and capacity development will empower communities so that they can exercise control over their water supply. Making conventional irrigation drought resistant can be attained thus through scientific studies that will strengthen these systems against extreme weather and maintain their usefulness in the midst of increasing uncertain climate.

The findings from the study define the urgent demand for adjudged and comprehensive water management with the preservation of the traditional practice and prevention of the contemporary problems. Through the incorporation of government initiatives, the facilitation of the grassroots process, and acceptance of blending approaches, such as the reasonableness of farm proposals, traditional irrigation systems may have a significant effect on the sustainability of water resources. >>The use of these methods enables policymakers to maintain the traditional cultural and historical significance of irrigation systems that should be altered according to modern challenges.

11. LIMITATIONS

This study is limited because of the relatively small number of respondents, 67 (Lohar, 2005), thus, not allowing for a fully presented variety of views, existing in the Tamil Nadu. Though the use of stratified random sampling has been used to enhance representativeness of the communities, particular communities continue to be poorly represented owing to geographical and socioeconomic limitations. The use of respondents' self- reports may result in possible errors or distortions in collected perceptions. The study uses cross sectional design so that instead of tracking changes over time, it offers a momentary view of perceptions. Geographical and cultural context within which the study has been conducted limits its generalization to other geographical or cultural contexts.

12. IMPLICATIONS

The result of this research brings forward important aspects in terms of the policy decision, agricultural practices, and the preservation of culture that can be improved. First, the remarkable mention of Kallanai's engineering work and the fact that it has stood behind thoroughly refers to engineering legacy of ancient irrigation systems in modern plan of water management. This highlights the potential of blending old and new technologies and methods in the creation of sustainable integrated systems. Policy makers are encouraged to invest in developing creative and hybrid water management systems relying on previous solutions, which will maintain the tradition while improving the sustainability of the resources for the present and the future.

The lack in knowledge of a historical significance of Kallanai among younger persons highlights the necessity for the reinvigorated preservation of culture. By developing educational campaigns focused on the inseparability of heritage structures it is possible to link experiences and understanding of older and younger generations. From the research, it is evident that such systems as the Kallanai, which have maintained community involvement, are good channels not only for

irrigation but also for the strengthening of community solidarity. Such findings highlighted the need for local community-based involvement in water management within rural settings where indigenous knowledge can play important role in increasing efficiency and sustainability.

Ergonomic and maintenance advantages of the traditional irrigation systems though are underlined by their diminished effect during drought, which is a signal to customize them to address modern climate issues. This highlights the collaborative need. the one that improves traditional systems in opposition to climatic extremes and yet integrated with the established water management policies. A combination of these systems with the national policies and making them adaptable to modern needs may improve both heritage conservation and modern water management. Accordingly, further incorporation of both historical understanding and contemporary adaptation would be the most important option for dealing with the modern problems, while keeping the tradition in mind.

13. CONCLUSION

It is clear from this study that the traditional irrigation practices as practiced through the Kallanai dam continue to be significant in handling the water resources now similar to the past. Answerer remarks, particularly from those with more experience, indicate that these systems are considered to be at once sophisticated for the past and good for present time. reply Changes from traditional irrigation methods to mechanized technologies reflect transitions in how they evaluate agricultural production and social economic well-being in rural environments. Even as the traditional systems are viewed as having a historical worth, the research identifies that there is reduced knowledge with regard to the same among the younger demographic thus availing room for educational efforts geared at preserving their cultural relevance. While research proves that traditional irrigation methods are good in facilitating community engagement and conserving the environment and the cost of maintenance, they may fail to stand up against certain current challenges such as drought issues.<< This is a lesson that fusing the traditional and the present strategies is indispensable in developing sustainable and strong water management systems

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