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Sustainable Water Management Through Pani Panchayats: Stakeholder Perspectives from Angul and Dhenkanal Districts of Odisha

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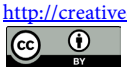

Abstract

This study evaluates the impact of the Pani Panchayat initiative, a community-based water management program, in the Angul and Dhenkanal districts of Odisha. Utilizing a mixed-methods approach, we gathered qualitative and quantitative data through structured interviews with diverse stakeholders, focus group discussions, and surveys. The findings indicate that the Angul district exhibited higher levels of fair elections and improved water access due to better canal maintenance, while the Dhenkanal district faced challenges from industrial water usage. The study also examines the potential of technological advancements, such as real-time water monitoring, to enhance governance. By identifying synergies and gaps with existing water policies, the research provides policy recommendations to promote sustainable water management in alignment with the Sustainable Development Goals 2030.

Keywords

Water Policy, Pani Panchayats, Impact Assessment, Social Inclusion, Sustainability, Technology

1. Introduction

Water is indispensable for life, driving economic growth, promoting social well-being, and ensuring environmental sustainability [1]. In a country like India, with its diverse and growing population, managing water resources effectively is increasingly critical [2]. Policymakers have long been concerned with the availability and equitable distribution of water, leading to various national and state-level policies and initiatives [3]-[5]. To fully grasp the research context, it is essential to

examine India's Water Budgeting, the National Water Policy, and the Odisha State Water Policy. These frameworks guide water management and governance in the country and in Odisha [6].

The water budgeting system is vital for assessing water availability and meeting demands across agriculture, domestic, and industrial sectors [7]. Using data collection and modelling techniques, this system accurately assesses water availability and sector-specific needs. It involves collecting data on rainfall, river flows, groundwater levels, and sector-specific water consumption, compiled by the water resources department. This data builds a comprehensive water balance model, determining the availability and demand of water resources in each sector. The allocation process prioritizes domestic and agricultural needs over industrial ones [8]. The water budgeting system effectively addresses regions with severe water shortages, ensuring equitable distribution and promoting water conservation through target setting and meticulous monitoring [9]. It raises public awareness of prudent water usage and encourages effective management practices. The implementation of this system has been crucial in identifying water-scarce regions and allocating resources appropriately, thereby fostering a sense of responsibility towards sustainable water management [10].

India's National Water Policy, first formulated in 1987 and revised in 2002 and 2012, provides broad guidelines for water resource planning and development [11]. The policy emphasizes an integrated and holistic approach to water management, considering both surface and groundwater [12]. It highlights the need for fair water distribution, prioritizing domestic and agricultural uses over industrial ones. The policy also advocates for stakeholder engagement, including local communities, in decision-making and the implementation of water conservation and demand management strategies [13].

The Odisha State Water Policy, introduced in 2007, aligns with the National Water Policy and addresses the state's specific water-related challenges [14]. This policy focuses on sustainable and fair management of water resources, emphasizing rainwater harvesting, groundwater recharge, and local community involvement in water governance [15]. A key aspect of the Odisha policy is the establishment of Pani Panchayats, community-based organizations managing local irrigation water distribution and maintenance [16].

Recognizing the critical importance of water resource management, the Government of India developed the National Water Policy to govern water resource planning, development, and optimal utilization. The policy, first adopted in 1987 and updated in 2002 and 2012, includes various key features and recommendations for effective water management. It treats water as an economic good and promotes its conservation and efficient use, prioritizing essential needs like safe drinking water, sanitation, food security, and ecological requirements. The policy addresses climate change impacts on water resources and recommends developing benchmarks for water use, water footprints, and water auditing. It suggests establishing a Water Regulatory Authority, incentivizing water recycling and reuse, granting statutory powers to Water Users Associations, and reducing urban-

rural water supply disparities. The policy emphasizes community participation in water projects and services, with provisions for private sector participation in a public-private partnership model. Adequate grants to states for technological advancements, planning, and management practices are also recommended [17].

The Odisha State Water Policy of 2007 addresses the state's unique water challenges, such as droughts and floods, with sustainable development, participatory governance, and integrated water resource planning. It emphasizes the role of Pani Panchayats in water management, supported by capacity building and financial assistance. The Odisha Pani Panchayat Act of 2002, amended later, provides a legal framework for community participation in water resource development. The policy aims to transfer the operation and management of irrigation projects to Farmers' Organizations, supported by capacity building and financial assistance, with norms for water rights and cost recovery established. Periodic evaluations will guide future measures. Overall, the Odisha State Water Policy aims to ensure sustainable water management through active stakeholder participation and cost recovery mechanisms [18].

Despite these policies, gaps often exist between objectives and implementation. This research identifies challenges faced by Pani Panchayats in the Angul and Dhenkanal districts of Odisha and explores potential strategies to address these challenges. By examining India's Water Budget, the National Water Policy, and the Odisha State Water Policy, this study aims to enhance policy approaches and the effectiveness of Pani Panchayats.

2. Overview of Pani Panchayats

The idea of Pani Panchayats/Water User Associations originated in Maharashtra in the year 1762, when Maharashtra was severely affected by droughts affecting nearly 4 lakh people. Vilasrao Salunkhe, popularly known as Pani Baba after completely assessing the rural landscape concluded that total participation of the community is necessary for ecological and social sustainability. On a plot of 40 acres on the hillside of Naigaon village in Purandhar block, he started watershed development. Contour bands were raised to trap water and check soil erosion. A gradual increase in crop productivity and income. Similar strategies were ready to be duplicated in different parts of the state by forming Gram Gaurav Pratishan (GGP) concluding everyone has equal access rights to water and should be treated as a common property [19]. Watershed development is connected with land ownership and redistribution efforts, energy utilization and sustainable agricultural practices. To achieve the desired goals, communities of innovators join together to work towards the goal of achieving sustainable livelihoods [11].

Initially during the implementation of any major, medium and minor irrigation projects, the dept. of water resources had sufficient staffs to look after the functioning and maintenance of the canal irrigation system. The classification of the types of irrigation projects is shown in **Table 1**. But, after the completion of projects, due to resource crunch, the maintenance activities could not be looked upon efficiently. In 1995, the Government of Odisha launched four pilot Participatory Irrigation

Management (PIM) initiatives, funded by the World Bank under the Farmers' Organization and a turnover component of the OWRCP[1]. Due to the success of the pilot projects and behavioural changes in farmers, the Govt. of Odisha passed the Pani Panchayat Act in the year 2002. The major objective was to ensure Participatory Irrigation Management by involving farmers who would look after the irrigation systems ensuring efficiency in terms of utilization, maintenance and productivity. The Odisha Pani Panchayat Act, of 2002 was implemented in 2003[2].

Table 1. Types of irrigation systems in Odisha (placeholder 1).

Total Ayacut Area	Type of Irrigation
Greater than 10,000 ha	Major Irrigation
2,000 ha - 10,000 ha	Medium Irrigation
40 ha - 2000 ha	Minor Irrigation
Less than 40 ha	Lift Irrigation

Source: Dept. of Water Sources, Govt. of Odisha.

2.1. Formation of Water User Associations

Reservoirs are constructed on rivers to fulfil the demands for irrigation, hydroelectricity, drinking water, and industrial usage and ensure flood control. Canals are artificial waterways constructed to divert water for major irrigation purposes. The main canal then divides into Branch Canal which then divides into the distributary canal. From distributary canals, minor, and Sub-minor canals are formed. Several outlets on the minor, sub-minor canals carry water to the irrigation fields [20]. The typical layout of the canal irrigation system is displayed in **Figure 1**.

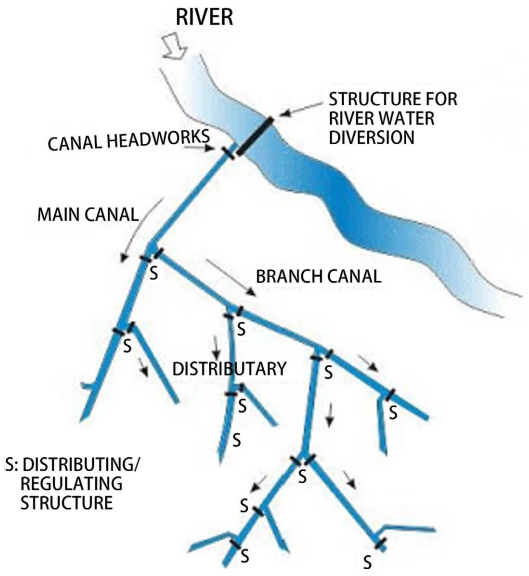

Figure 1. Typical layout of canal irrigation system.

[1]Department of Water Resources, Participatory Irrigation Management, Annual Report, 2009-10

[2]The Odisha Pani Panchayat Act was amended twice in 2008 and 2014.

At the last outlet point (chaka) of the minor/sub-minor canal which supplies water for irrigation, a chaka committee is formed by electing 3 farmers from the Upper Reach, Middle Reach, and Lower Reach of the ayacut of the outlet. The General Body of Pani Panchayat includes all the landholders or the members nominated by landholders who elect their representatives. Similarly, elections are conducted at chaka levels for all the outlets present in the entire region of Pani Panchayat. The elected members form the Executive Body of the Pani Panchayat. The election of the President, Secretary and Treasurer of the Pani Panchayat is conducted by Executive Committee. According to the Pani Panchayat Amendment Act of 2014, half of the members of the executive committee hold office for a term of 3 years and the remaining half of the elected members and members elected after 3 years shall hold office for a term of 6 years so that half of the members retire after every 3 years. The terms of the members are decided by the committee (Govt. of Odisha, 2008). The Superintending Engineer of the allotted irrigation division is responsible for the smooth conduct of the elections. A Distributary Committee is formed for every distributary area, which consists of the President, Secretary and Treasurer of the Pani Panchayats in the distributary area forming the general body of the Distributary Committee. The general body further elects its President, Secretary and Treasurer under the supervision of the Chief Engineer. The President, Secretary and Treasurer of different Distributary Committees form the general body of the Project Committee, and similar to the lower level of election, the Executive committee comprising of elected President, Secretary and Treasurer is carried out under the supervision of the Chief Engineer. At the top of the hierarchy, a State Level Committee is formed comprising the presidents of Project Committees limited to a maximum of 10 members [21]. The organizational structure of Water User Associations is highlighted in Figure 2.

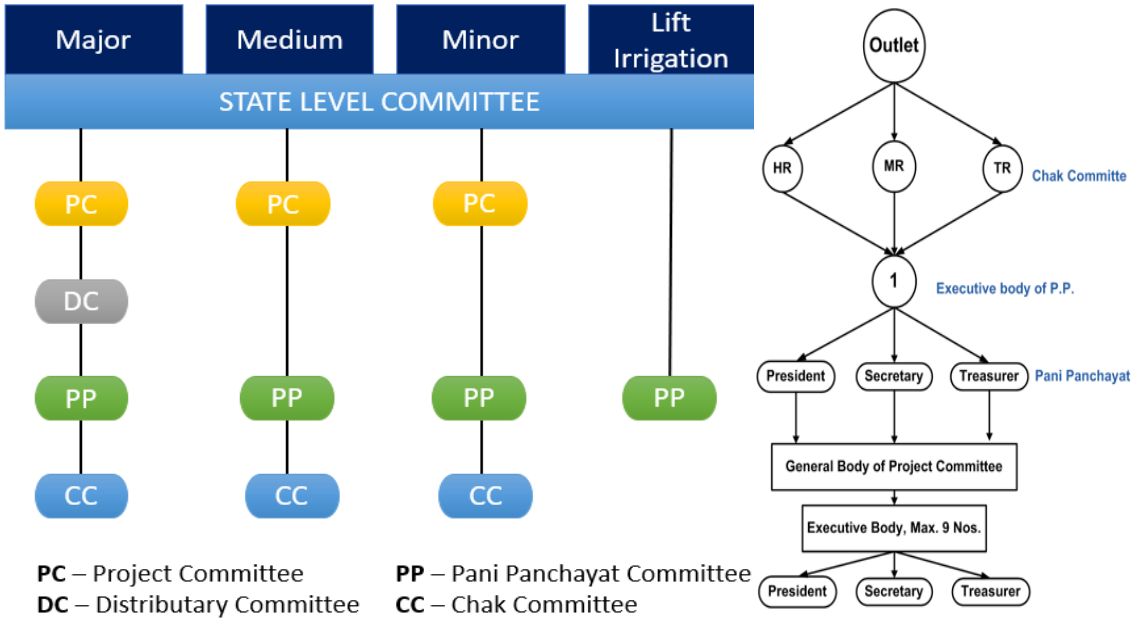

Figure 2. Organizational structure of water user associations.

2.2. Functions of Water User Associations

2.2.1. Pani Panchayat

- Preparation of cropping program for kharif and rabi seasons considering the agro-climatic factors.
- Preparation of a plan for cleaning and maintenance of irrigation systems at the end of each crop season by utilizing the Pani Panchayat funds.
- Maintain records of landholders, members, and minutes of general body meetings, inventory of irrigation system and funds allocation and utilization.
- Resolve disputes between the members, assist in the conduct of elections, regular conduct of general body meetings, social audits, and water budgeting.
- Collection of fees when required for maintenance works.

2.2.2. Distributary Committee

- Preparation of operational plan based on, cropping pattern, entitlement area, and soil at the commencement of each irrigation season adhering to the Project Committee's operational plan.
- Plan and execute maintenance work at the end of every crop season of the distributaries and field drains with the committee funds.
- Regulate water use between Pani Panchayats, resolve disputes if any and promote economic water uses.
- Maintain & audit accounts, hold general body meetings and records, and support for conducting executive body elections.
- Promote avenue plantations in operation area, conduct periodical water budgeting and social audit.

2.2.3. Project Committee

- Approves operational plan and maintenance plan of the canal irrigation system.
- Conduct and maintain records of annual audits, and general body meetings.
- Resolve disputes and conduct regular social and water budgeting.
- Pani Panchayat at the primary level, Distributary Committee at the secondary level and Project Committee at the project level together comprise the Farmers' Organization. Along with the above individual functions, they additionally supply fertilizers, seeds, and Agri-inputs and sell the Agri products at rates fixed by the general body. Every year Pani Panchayat Fortnight is celebrated from 16 Jan – 30 Janto sensitizes farmers of Pani Panchayat and makes them aware of various schemes of Agriculture, Horticulture, Fisheries, Animal Husbandry, Watershed and Water Resources depts. The best-performing PPs are awarded at district and state levels and provided additional financial support to carry out O&M works. Water and Land Management Institute (WALMI) present at Pratapnagar, Cuttack provides capacity building and sensitization training to the members of Pani Panchayats (Climate Change Cell, 2018). The major sources of funds are from any financing agency undertaking economic development projects in the area of operation, fees collected by the Farmers'

Organization, and amounts received from any govt. schemes, M.L.A Local Area Development Fund, M.P. Local Area Development Fund etc. According to the data available on the eCAD portal, in Odisha, 37,293 Pani Panchayats have been formed to date. Lift Irrigation systems constitute 47.50% of the total Pani Panchayats, minor irrigation systems constitute 22.51% and major/medium irrigation systems constitute 10.16%. Farmers don't pay any water tax to the Govt. for using canal water for irrigation but water tax is levied upon industries that opt to utilize water from canals.

To identify best management practices and generate competition among Water User Associations, several indicators are established as mentioned in Table 2.

Table 2. Performance indicators of Pani Panchayat.

Domain	Performance Indicator
System Performance	Water delivery capacity index
	Total annual vol. of irrigation water supplied/delivered (m^3/year)
	Field application efficiency
	Annual Relative Irrigation Supply Index
	Annual Irrigation Water Supply per unit of Command Area (cum/ha)
	Annual Irrigation Water Supply per unit of Command Area (cum/ha)
Agricultural Productivity	Output per unit of Command Area (Rs./ha)
	Output per unit of Irrigated Area (Tons/ha crop wise; (Rs./ha)
	Output per unit of Irrigation Supply (Rs./cum)
	Output per unit of crop water demand (Rs./cum)
Financial Aspects	Cost recovery ratio
	Total O&M cost per unit area (Rs/ha)
	Total cost per person employed on O&M Works (Rs/person)
	Revenue collection performance
	Revenue per unit volume of irrigation water supplied (Rs/cum)
	Maintenance cost to revenue
	Staff numbers for O&M per unit area (persons/ha)
	Total O&M cost per unit of water supplied (Rs/cum)
Environmental Aspects	Average depth to water table (m)
	Land Damage Index
	Water Quality: Ph/Salinity/Alkalinity Index
	Salt Balance (Ions)

Source: Dept. of Water Resources, Govt. of Odisha.

2.3. Role of Technology in Institutionalizing Pani Panchayats

The COVID-19 pandemic posed significant challenges to the functioning of Pani Panchayats (PPs), hindering decision-making, resource allocation, and overall effectiveness. The absence of PP elections during the pandemic led to dysfunctional PPs, impeding their ability to manage water resources. Slow and invalidated manually sourced data, along with the lack of real-time data tracking, further hindered decision-making and resource allocation for O&M/GIA. Additionally, the absence of gender-segregated data and the quantification of women's participation

limited their representation in decision-making. The democratic disposition of grassroots farmers' bodies within PIM was not adequately assessed. Moreover, the misalignment of data with revenue boundaries prevented sourcing funds from programs like MGNREGS.

Hence, the Government of Odisha has developed a robust single-window portal called eCAD (Pani Panchayat MIS) to facilitate digital transformation within the water resources department. This application is designed to handle large volumes of data, enabling multiple users to access and verify information simultaneously. To streamline data entry and verification processes, eCAD will ensure end-to-end verification and align data with the water resources department's goals. The application package serves as a comprehensive tool for managing Pani Panchayat data, contributing to efficient data management, and advancing the government's objectives in the water resources sector.

The introduction of a comprehensive digital platform has revolutionized the management of Pani Panchayats (PPs) by providing a centralized database. This platform enables real-time tracking of PP elections and their functionality, along with monitoring higher bodies' constitutions and functioning. Moreover, it has facilitated the active participation of women in water governance and decision-making processes. This digital intervention ensures a seamless flow of data from the grassroots level to the highest level, empowering stakeholders to make prompt and well-informed decisions. With this transformative digital solution, the management of PPs has been significantly enhanced, leading to improved efficiency and effectiveness in water resource management.

Associated Technical Challenges

The department also encountered several challenges in mapping projects, basins, circles, divisions, sub-divisions, and sections. Additionally, embedding intricate processes and data into a user-friendly application proved to be a daunting task. The department also faced the challenge of providing capacity-building initiatives to functionaries at different levels and verticals, which was met with resistance as many individuals struggled to adapt to the changes. Overcoming these obstacles required innovative approaches and dedicated efforts to ensure the successful integration of complex information into a simplified application, as well as providing comprehensive training programs to enhance the skills and understanding of the department's personnel.

With a strong focus on data security, this system incorporates advanced security features such as GIS-based tagging, session timeout, cross-site request forgery protection, and an audit trail of user login history. Additionally, to ensure transparency, the solution provides a comprehensive view of data, allowing for real-time updates through a responsibility matrix. The project also includes a centralized portal to automate CAD & WM processes and introduces an interactive analytical dashboard for monitoring in real-time. Furthermore, the department has integrated a grievance platform and ERP system to enhance efficiency and achieve better results.

To enhance stakeholder engagement, the department has strategic plans to implement a mobile application-based transaction system for a seamless interface with the government. This initiative aims to streamline processes and facilitate convenient interactions. Furthermore, the department intends to disseminate Information, Education, and Communication (IEC) and Social and Behaviour Change Communication (SBCC) content among stakeholders. This will promote awareness and knowledge regarding efficient water usage, and agricultural practices, and encourage the adoption of best practices. Additionally, the department is committed to implementing innovative mechanisms for grievance redressal, ensuring effective resolution and addressing stakeholder concerns promptly and efficiently. Through these measures, the department strives to foster meaningful engagement with stakeholders and achieve sustainable water resource management goals.

In the face of increasing water scarcity, the implementation of the eCAD platform has proven instrumental for the water resources department in determining the necessary capacity-building measures for stakeholders, particularly farmers in the region. The department successfully achieved its objectives of promoting efficient water usage, implementing sustainable agricultural practices that minimize water consumption, resolving water-sharing disputes, and facilitating the adoption of modern techniques and technologies to maximize productivity while empowering women through participation in decision-making. Through the implementation of this innovative approach, the Water Resources Department of Odisha has effectively provided irrigation facilities throughout the state. This initiative has had a significant impact on all beneficiaries involved and has the potential to greatly enhance the agricultural economy of Odisha.

3. Case Studies from Angul and Dhenkanal Districts of Odisha

In this paper, we have focussed on the Pani Panchayats formed in the Angul and Dhenkanal districts of Odisha, which are irrigated through the Rengali Right Bank Canal (Division-II), originating from Samal Barrage on Brahmani River. It is the second largest river flowing in Odisha formed by the confluence of Sankh and Koel near Rourkela industrial town of Sundergarh District. It passes through Sundargarh, Deogarh, and Dhenkanal. Angul, Cuttack, Jajpur, and Kendrapada districts of Odisha.

The Rengali Right Bank Canal flows from the Samal Barrage present in Angul district and targets to facilitate irrigation in agricultural lands of Talcher, Banrapal blocks of Angul district and Dhenkanal Sadar, Odapada, Gondia blocks of Dhenkanal district. The total length of the canal constructed was 483.2 km till Sept. 2022. The land irrigated in Kharif 2022 was registered to be 12986.257 Ha against a target of 17606.06 ha by the Rengali Right Canal Project (Division II). Thirty Pani Panchayats have been formed to date under this division. One Pani Panchayat each from Angul and Dhenkanal districts has been discussed in detail [22].

The satellite image of the Samal Barrage, from where the right bank canal

originates is shown in Figure 3.

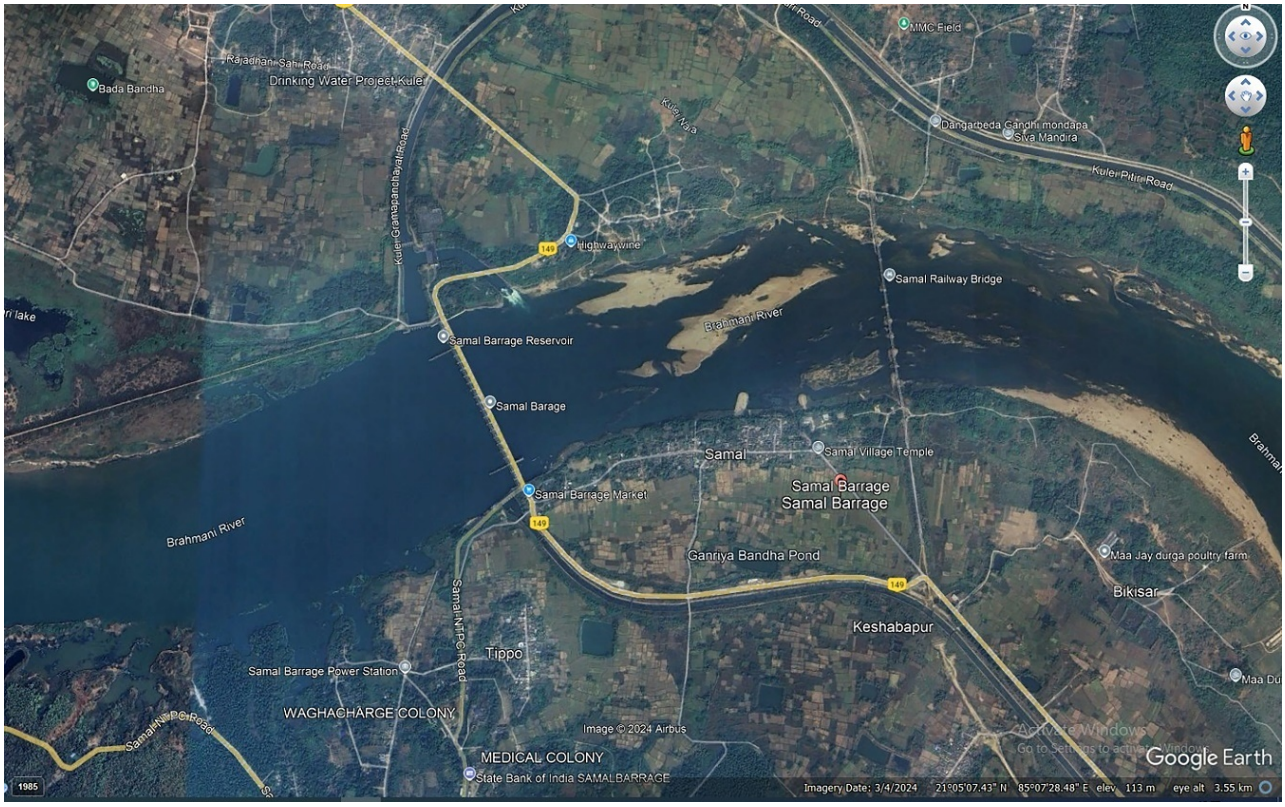

Figure 3. Satellite view of Samal Barrage.

Table 3. The total no. of outlets and CCA corresponding to the Pani Panchayats of Rengali Right Canal Project (Division II).

Sl No	Pani Panchayat	Total no. of outlets (chaka)	Total CCA (in Ha)
1	PP-1	68	405.92
2	PP-2	112	659.86
3	PP-3	63	370.793
4	PP-4	53	433.771
5	PP-5	69	522.865
6	PP-6	56	526.242
7	PP-7	43	347.945
8	PP-8	45	425.21
9	PP-9	41	271.778
10	PP-10	63	584.437
11	PP-11	71	756.809
12	PP-12	132	1087.609
13	PP-13	56	537.941
14	PP-14	94	825.029
15	PP-15	52	374.074

Continued

16	PP-16	54	754.606
17	PP-17	69	677.2
18	PP-18	43	434.099
19	PP-19	29	304.562
20	PP-20	42	362.144
21	PP-21	43	351.018
22	PP-22	64	594.052
23	PP-23	19	144.435
24	PP-24	92	975.424
25	PP-25	102	660.998
26	PP-26	23	436.703
27	PP-27	52	494.916
28	PP-28	60	737.982
29	PP-29	25	316.56
30	PP-30	38	344.445
	Total	**1773**	**15719.427**

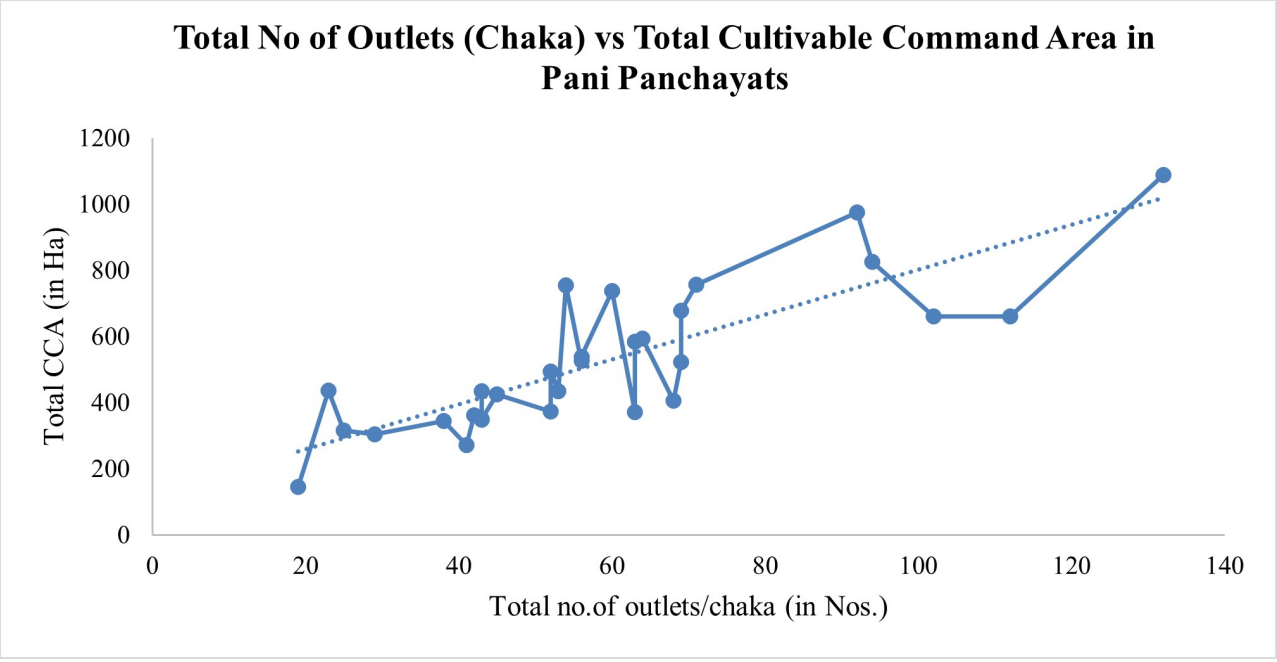

Figure 4. Total no. of outlets (chaka) vs Total Cultivable Command Area present in Pani Panchayats of Rengali Right Bank Canal—Division No. II.

The details of total No. of Outlets and CCA corresponding to the Pani Panchayats is shown in **Table 3** and the graphical representation of the total no. of outlets (chaka) and Cultivable Command Area of 30 Pani Panchayats of Rengali Right Bank Canal Division No. II is shown in **Figure 4**. The above figure shows that with

an increase in no. of outlets (chaka), the cultivable command area (CCA) also increases. Some deviations can be observed due to the diversion of canal waters for industrial usage and the lack of canal maintenance activities.

3.1. Kusaleswara Pani Panchayat: Angul District

Kusaleswara Pani Panchayat (PP-2), located under Talcher Sub Division, is a prominent water management organization responsible for handling and monitoring irrigation activities in 18 villages encompassing a cultivable command area of 659.859 hectares. This was formed on January 18, 2016, and comprises a total of 5248 members, including 4853 males and 395 females. In June 2019, after a three-year gap, the first election was held within them, with the subsequent election held in June 2022. Gayatri Sahoo is currently elected as the President of PP-2, by receiving unanimous support from the members. Initially, the farmers of this Pani Panchayat faced challenges in ensuring effective irrigation practices and reducing the high costs associated with diesel pumps for agriculture. The majority of them relied on renting diesel pumps for irrigation, resulting in significant expenses and limited profitability. This situation led to a decline in dual cropping, with farmers hesitating to cultivate their land during the Rabi and summer seasons. Recognizing the need for change, the water department consultants began visiting the members of PP-2 to raise awareness and motivate them to contribute towards sustainable irrigation practices. Despite initial doubts, the consultants' efforts were successful in building confidence among the farmers. With the implementation of a comprehensive plan, the Pani Panchayat established a group funding mechanism that facilitated quality civil work for irrigation infrastructure. As a result, the cost of irrigation decreased significantly, now accounting for only 20% of what farmers previously paid for diesel pump rentals. This significant reduction in irrigation costs has instilled confidence among the farmers, encouraging them to cultivate their land during the Rabi and summer seasons. Moreover, the availability of reliable and affordable irrigation has enabled the cultivation of high-value crops such as vegetables, supplementing the traditional paddy cultivation practices. The transformation in irrigation practices has not only boosted agricultural productivity but also improved the income generation potential of the villagers. The cultivation and sale of vegetables and other cash crops have become regular practices, ensuring sustainable livelihoods for the community.

3.2. Trinatha Pani Panchayat: Dhenkanal

Trinatha Pani Panchayat (PP-3) in Odapada block of Dhenkanal district has been formed by members from 10 villages under 3 Gram Panchayats in the year 2019. Asanabahali, Sibapur, Charadagadia, Kochilamada, Kangelpal, Bhanupada, Nimabahali, Galpada, Rangathali, Upparapalaare villages that benefit from 41 chaka (outlets) present in this Pani Panchayat. The major source of livelihood for 7000 residents of this region belonging to the farmer community/caste is farming and agriculture-related activities. Before the formation of Pani Panchayat, farmers were dependent on lift irrigation methods and monsoons to irrigate their lands. With

the failure of the lift irrigation system, the entire productivity was hampered by negligent farm activities for 10 - 12 years. The residents suffered from extreme poverty during that period. The locals of Bhanupada village a low-lying region state that people from other villages wouldn't marry their daughters in their village due to the absence of Goddess Lakshmi (wealth). However, after formation, it became relatively easier for them to increase productivity due to a consistent water supply. Also, they observed an increase in the groundwater table after the canal started running as ponds and wells wouldn't dry up during summers. There is a presence of small and marginal farmers in this region engaged in different varieties of paddy (Puja, Kala Champa, and Swarna), Groundnut, moong, and biri cultivation.

The last election was held in 2019 and the members are serving a tenure of 6 years. The elected chaka committee consists of 49 members out of which 15 are women. Initially, women were unwilling to be a part of Pani Panchayat as they were sceptical about stepping outside their homes and managing irrigation canals. However subsequent policy changes that mandated 1/3rd of seats for women in Pani Panchayats and awareness among the farmers enabled women to empower themselves by becoming a part of the decision-making process and representing their people as leaders. They have elected their President, Secretary and Treasurer who manage the overall operation and maintenance of the canal system. The area irrigated during Kharif 2022 was 77 ha against a target of 130.603 ha. The target could not be achieved since the canal water was diverted to Tata Steel Ltd., Meramandali for industrial purposes. Fair distribution of water supply is ensured by the members of the Pani Panchayat Committee. The general body meetings are conducted 3 - 4 times a year during the commencement and end of the crop season. The Pani Panchayat is funded with Rs 3 - 4 lakhs/annum (subject to requirement) for carrying out the O&M works. The members also have their annual collection to suffice the needs for operation work. Currently, the supply of fertilizers, seeds, and Agri-inputs is not facilitated by the Govt. and a facilitating center will be set up soon. Also, the proposal to set up new canal lines to the nearby villages has been sent to the Dept. of Water Resources for approval so that poor farmers can reap the benefits.

3.3. Framework, Data & Methodology

To understand the effectiveness of the Pani Panchayat a survey of 30 farmers from Pani Panchayat, 2 of Angul district and 30 farmers from Pani Panchayat, 9 of Dhenkanal district was conducted. The survey was conducted by referring to the model questionnaires depicted in Table 4.

3.4. Observations

Figure 5 conveys that the election/selection process is fairer in Angul district than in Dhenkanal district. Sometimes, lottery methods or directly nominated candidates are selected.

Figure 6 suggests that women should be members of the executive body of Pani Panchayat and should be involved in Pani Panchayat activities. We observe a 5%

difference between Dhenkanal and Angul districts, with the higher acceptance rate in Dhenkanal.

Cultivable Command Area (CCA) is the area that can be irrigated for agricultural activities. Figure 7 reflects that an improvement in CCA improves Agricultural Production. In the Dhenkanal, district since the canal waters are supplied for industrial usage, the available water for irrigation is less and the CCA is less affecting agricultural productivity.

Table 4. Field survey responses from farmers of Pani Panchayats in Angul & Dhenkanal Districts of Odisha.

Sl No	Questionnaire	Options	Response from PP-2, Dhenkanal (in %)	Response from PP-9, Angul (in %)
1	Election/selection of Pani Panchayats (PP)	a. Fair	62%	85%
		b. Unfair	38%	15%
2	Maintenance of irrigation canals by PPs after the formation	a. Same	4%	5%
		b. Worse	0%	0%
		c. Distinct improvement	96%	95%
3	Changes in Area irrigated after PP formation	a. Yes	100%	100%
		b. No		
4	Suggestion for controlling water distribution	a. Installation of shutters	87%	92%
		b. Disciplinary action		
		c. No control	13%	8%
5	Your method of preference for irrigation	a. PP	52%	67%
		b. Irrigation Dept. Personnel	48%	33%
6	Whether women should be members and involved in PP activities	a. Yes	78%	73%
		b. No	22%	27%
7	Are you aware that Govt. has mandated that 1/3rd of members of PP should be women	a. Yes	95%	96%
		b. No	5%	4%
8	Are you aware of formal PP functioning in your village	a. Yes	97%	98%
		b. No	3%	2%
9	Are you aware of the PP leaders (President, Secretary and Treasurer)	a. Yes	100%	100%
		b. No	0%	0%
10	Were you informed regarding PP meetings and did you attend them	a. Informed and attended	56%	61%
		b. Informed but not attended	35%	28%
		c. Not informed	9%	11%
11	Availability of water	a. Sufficient	76%	83%
		b. Insufficient	24%	17%
12	Has the formation of PP improved access to water	a. Yes	92%	95%
		b. No	8%	5%
13	Has the Cultivable Command Area improved due to PP	a. Improved	83%	85%
		b. Reduced	13%	15%
14	Effect of PP on agricultural yield	a. Improved	92%	91%
		b. Reduced	8%	9%
15	Did you notice any improvement in the water table after the formation of PP	a. Improved	95%	92%
		b. Deteriorated	5%	8%
16	Is water diverted for industrial purposes?	a. Yes	88%	3%
		b. No	2%	81%
		c. Not aware	10%	15%

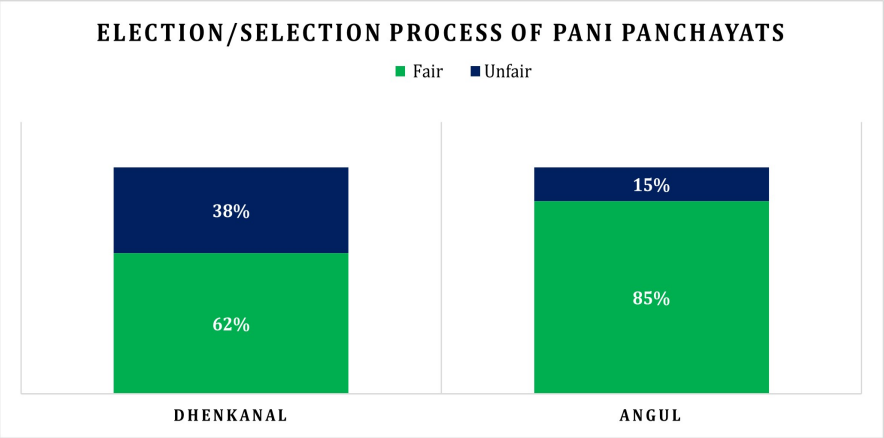

Figure 5. Comparison of election/selection process of Pani Panchayats in Dhenkanal & Angul District.

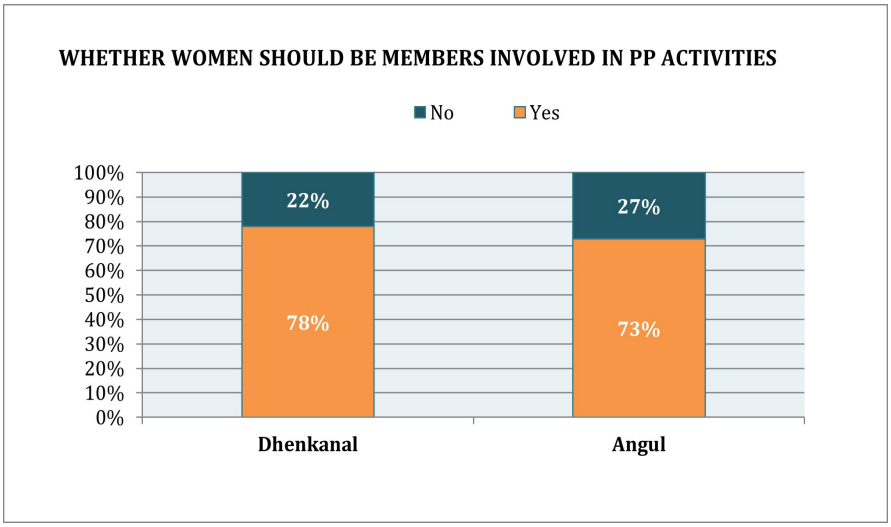

Figure 6. Comparison of acceptance of women as leaders in PPs in Dhenkanal & Angul Districts.

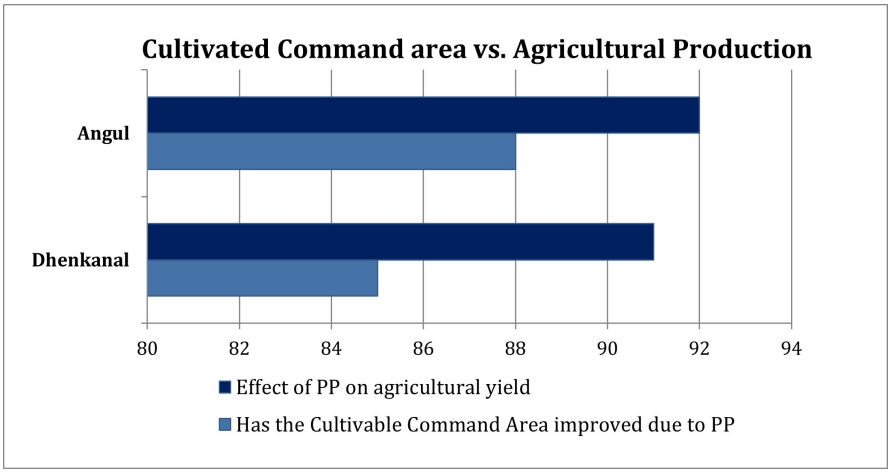

Figure 7. Comparison of effect of cultivable command area on agricultural productivity in Dhenkanal & Angul Districts.

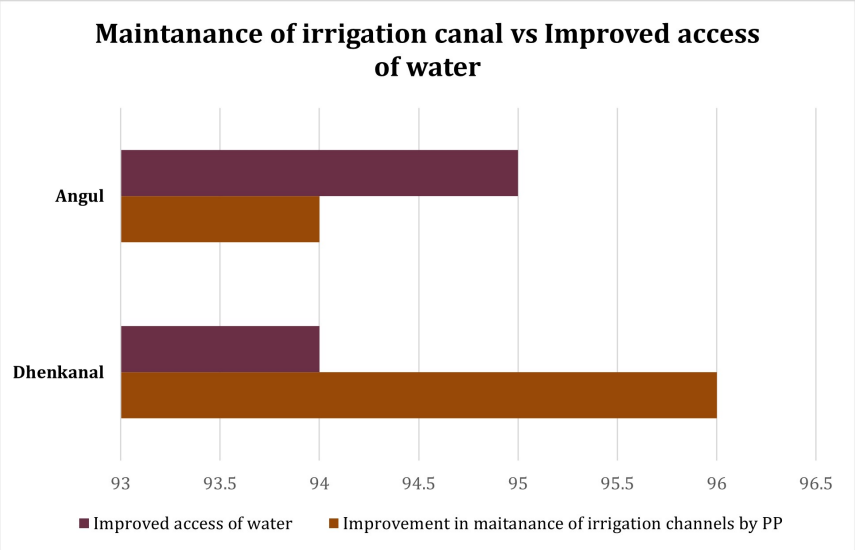

Figure 8. Comparison of how maintenance of the canal has improved access to water in Dhenkanal & Angul Districts.

Figure 8 depicts that in the case of Angul, the maintenance of irrigation channels is benefitting the farmers as they can now have better access to water. However, in the case of Dhenkanal, as shown in the graph, despite channel maintenance, the farmers have less water access due to the diversion of water for industrial usage.

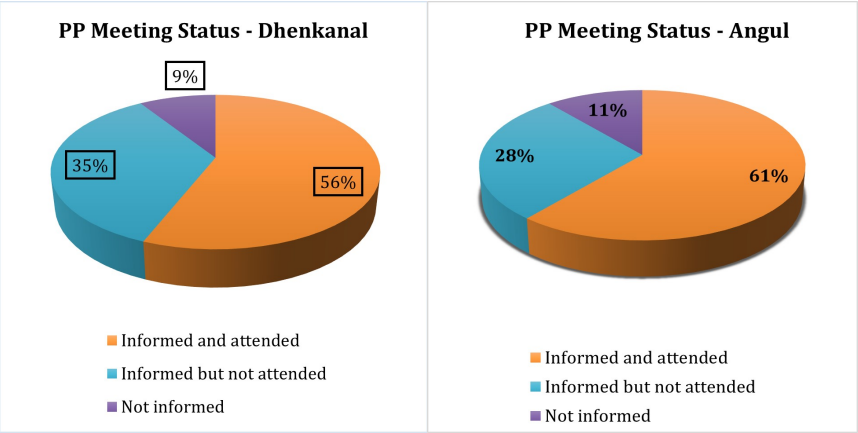

Figure 9. Comparison of attendance in Pani Panchayat meetings in Dhenkanal & Angul Districts.

From **Figure 9**, We conclude that more than 50% of the members attend the meetings regularly, and around 30% prefer not to attend due to transportation inconveniences and family emergencies. Around 10% of the members are not reachable before the meeting date.

4. Challenges

4.1. Behavioural & Social Aspects

A major challenge observed according to the Pani Panchayat executive members

is motivating the people to be a part of Participatory Irrigation Management to carry out the operation and maintenance works of the canal. The farmers even today have the notion that O&M works should be performed by the Dept. of Water Resources, and they are just mere recipients of water [23]. With regular sensitization programs, this issue has been addressed to a certain extent but is still prevalent in many PPs. It is noticed that farmers are often reluctant to come together to form an association due to homogeneity based on caste and class [24]. The lack of sufficient funds from the government for carrying out O&M works is also another factor for the reluctance of poor farmers to join the initiative as they have to incur the expenses personally. Several Lift Irrigation points are defunct, and the O&M is quite expensive on the farmers' side. Quite often it is observed that farmers due to their negligence block the canal passage during the harvest season by dumping the post-harvest waste into the canals. This behaviour poses a threat during the next water supply season.

4.2. Lack of Skilled Resources

Additionally, the absence of skilled manpower to execute operations presents a significant challenge. Occasionally, members of PPs do not receive prompt information to manage canal regulators when water is discharged from dams, leading to canal damage. Electricity theft is another issue that requires attention. Without a guard or staff to monitor water levels at the regulator, electricity theft becomes a concern as well [25].

4.3. Diversion of Water for Industrial Usage

According to the requirement of water for industries, occasionally water is diverted to fulfil water demand in the manufacturing sector, which affects the poor farmers' productivity.

4.4. Lack of Awareness& Facilities

Numerous farmers in the newly established Producer Partnerships (PPs) are unaware of various government schemes, which hinders their ability to access benefits such as seeds, fertilizers, agricultural inputs, and farm machinery. Inadequate awareness about the PP's objectives, functioning, and benefits is another challenge [26].

4.5. Climate Change

The adverse effects of climate change affect the hydrological cycle which eventually hampers prevalent agricultural practices. Rapid evaporation due to extreme temperature reduces the availability of available irrigation water in the canals. Increased flash flood frequency due to high intensity of rainfall results in the transport of debris through the canals blocking the water supply pathways.

4.6. Legal Limitations

The current process of conducting elections every 3 years for retiring half of the

members of the executive committee of Pani Panchayat is quite cumbersome for the authorities and members. Water is a state subject as per the Constitution of India, several water disputes between States on major rivers affect the quantity of water released in canals, subsequently affecting agriculture.

5. Sustainability and Way Forward

The major objective of the Pani Panchayat system is to ensure equitable water supply to the poor and marginal farmers so they can sustain their livelihood through agriculture and allied activities. With the recent adverse climate change impacts, the sustainability of Pani Panchayats would contribute to mitigating those issues through water conservation strategies at local levels. Furthermore, several suggestions from a policy perspective are highlighted in the areas mentioned below aligning them with Sustainable Development Goals (SDGs). Livelihoods are considered "sustainable" when they can withstand and recover from stress and shock, and protect or restore resources and assets without damaging natural resources. In terms of basin development, it is based on the creation of sustainable livelihoods, social and financial rights and access to clean water.

5.1. Institutional Structure

The Govt. of Odisha has framed the hierarchy of the committees involved in Water User Associations with their roles and responsibilities. Forming a State Level Committee which has not been formed yet would strengthen the system further. Democratic decision-making processes have been ensured in the management of water quality, particularly on the cost and distribution, maintenance, and expansion of water resources, resulting in social inclusivity and agricultural sustainability in the region [14]. Fair and regular elections must be conducted to ensure the inclusion of women and homogeneity in the entire member composition. Every member should have an equal voice in the decision-making process in water management. Pani Panchayats can work collaboratively with PRIs to work on the 19 LSDGs (Local Sustainable Development Goals under the theme "Water Sufficient Village" to ensure equitable water supply. The "Gender Equality" and "Reduced Inequalities" goals should be focused on ensuring equal representation of women and marginalized communities in the Pani Panchayats Executive Committee [27]. The line depts. should work like water resources dept., agriculture and allied depts. in convergence to achieve the optimum desired results. Fair and regular elections could be conducted by including women and members of all communities. The process of conducting elections should be eased, instead of retiring half of the members every 3 years, the tenure of the Pani Panchayats members can be revised to 5 years to align with the general PRI elections.

5.2. Effective Engagement of Communities

Regular Pani Panchayat meetings ought to be held ensuring that each member has an equal chance to voice their concerns and propose solutions to current issues.

Records of these meetings and financial expenditures should be kept, and yearly plans should be established to fortify the existing committee. Additionally, numerous awareness campaigns, such as the Pani Panchayat Fortnight, should be organized to inform farmers, particularly those in remote regions, about the advantages of establishing Pani Panchayats and various government schemes [28].

5.3. Capacity Building & Skill Development

Several workshops, design thinking sessions, exposure visits, SDG goals, digital literacy, and financial inclusion training can be conducted so that community members and leaders can function effectively and respond to problems tactfully. Also, a cadre of mechanics can be created at the cluster level by building collaborations with skill development institutions to impart training on the operation and maintenance of canals, adoption of modern and efficient irrigation systems minimizing wastage of water, modern agricultural methodologies, organic farming, etc.

5.4. Financial & Infrastructural Support

Annual budget planning and provision through grants, loans, and schemes should be provided to the Pani Panchayats for effective O&M of the irrigation systems. This would encourage the farmers to participate in the activities proactively. Prepaid meters can be installed to check power theft.

5.5. Assessment of Water Resources

Timely and regular assessment of water availability, water quality, supply, and demand at local levels should be conducted by adopting modern technologies like remote sensing, and GIS and making a digital database on the eCAD portal. This will help in understanding the resources of water and usage patterns of the region and contribute to designing the desired policy interventions.

5.6. Monitoring and Evaluation

A robust monitoring and evaluation mechanism for the Pani Panchayats should be established. Regular audits should be conducted to assess the performance and identify areas for improvement. The PPs should be assessed on categories like System Performance, Agricultural Productivity, Financial Aspects and Environmental Aspects on (Teamwork, technology, transparency, transformation, and time limit) framework of Govt. of Odisha. This will ensure the accountability and functioning of the institutions as intended.

5.7. Adaptation to Climate Change

Due to the increasing impacts of climate change on water resources, Pani Panchayats need to incorporate climate change adaptation strategies for conserving water. Promotion of integrated water resource management practices such as watershed management, rainwater harvesting, and groundwater recharge to increase

resilience to changing climate conditions. Solar photovoltaic (SPV) systems can be installed for pumping water extra power generated can be sold through mini grids which can be utilized for O&M works. Production of climate-resilient crops like millets should be encouraged to reduce dependency on paddy and wheat which consume the maximum amount of irrigated water. The UN has declared 2023 as the International Year of Millets to harness the untapped potential of millets as a super food and promote sustainable agriculture. Odisha Millets Mission, a flagship program of the Dept. of Agriculture & Farmers Empowerment, was launched in 2018 to promote millet cultivation in tribal pockets of Odisha and has been very successful.

6. Conclusions

This research examines the Pani Panchayat initiative, a community-based water governance model, in the Angul and Dhenkanal districts of Odisha. The study focuses on stakeholder perspectives to evaluate the effectiveness of this local water management approach. The findings suggest that active community involvement plays a vital role in fostering inclusive development, enhancing agricultural productivity, and ensuring equitable access to water resources for all stakeholders. However, the research also highlights persistent challenges, particularly in Dhenkanal district, where industrial water consumption has had a significant impact on the availability of water for agricultural use. Despite these challenges, the Pani Panchayat model holds immense potential to strengthen local water governance and build resilient communities that can collectively manage their shared water resources in a sustainable manner.

The key recommendations for strengthening the Pani Panchayat approach involve bolstering institutional structures, increasing the engagement of marginalized communities, and incorporating advanced technologies to enhance water resource management. Future scholarly inquiries could concentrate on the long-term assessment of the initiative's impacts and the influence of climate change adaptation measures on local water governance. Implementing these strategies will ensure the continued alignment of Pani Panchayats with the Sustainable Development Goals and promote sustainable water management within the region.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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