International Journal of Multidisciplinary Advent Research and Review (IJMARR)
Vol. 1, No. 2, February 2025
E-ISSN: 3049-1932
Available online at https://www.ijmarr.org/

Integrated Multipurpose Water Resource Management: The Wardha-Penganga Project

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Abstract-Integrated multifunctional water resource management: In the Vidarbha area of Maharashtra, India, the Wardha-Penganga project initiative is a major endeavor with the dual goals of improving agricultural water management and producing energy. Connecting nearby rivers is the main goal to provide a steady supply of water for farming and generate electricity to meet the region's growing power needs. Through the integration of irrigation and hydropower generation, the project aims to maximize water use, encourage sustainable farming methods, and provide reliable energy resources to support regional growth. This study assesses the project's planning, implementation, and ability to improve agricultural output, ease water scarcity, and promote socioeconomic development in the area. It also discusses the social and environmental issues the project faced, especially those connected to the fair allocation of water and climate change. Numerous case studies have been thoroughly examined to inform this review.

Index Terms- Vidarbha Jal Setu, Interconnect River, Irrigation, Hydropower, Generate electricity, Socio-Economic Development, Environmental challenges, Case studies.

1. Introduction:

The Wardha-Penganga Multipurpose Project in Maharashtra, which focuses on water resource management, intends to address the vital role that rays play in flood reduction, energy production, and agricultural growth. The regional water shortage, enhanced irrigation infrastructure, and the production of renewable energy were the inspirations for the Polavaram Multipurpose Project in Andhra Pradesh. Large-scale irrigation and hydropower projects could be supported by the Wardha and Penganga rivers, which are important tributaries of the Godavari. To effectively distribute water throughout Vidarbha's drought-prone areas, this project calls for the construction of a sizable dam and connecting canals. It also incorporates hydropower generation, guaranteeing a sustainable energy source to satisfy local needs.

Fig1: Proposed view of the multipurpose project

The project has several difficulties, such as site acquisition, environmental impact studies, and community rehabilitation, despite its apparent advantages. The Wardha-Penganga Multipurpose Project's viability, technical features, socioeconomic impact, and future scope are examined in this article. Best practices and possible enhancements are highlighted through comparisons with the Polavaram project.

2. Objectives:

- To guarantee a consistent supply of water for Vidarbha's agricultural sector.
- To use hydropower to generate renewable energy.
- To control water flow to avoid flooding during periods of high precipitation.
- To effectively manage water for future needs.
- To supply cities and villages with clean water.

3. Overview of Polavaram Multi-purpose Irrigation Project:

One of the biggest and most ambitious water infrastructure projects in India is the Polavaram Multi-Purpose Irrigation Project, which is situated in Andhra Pradesh on the Godavari River. Irrigation, drinking water supply, hydropower production, flood management, and river interconnection are just a few of its many uses. The project was first planned in the 1940s, and the Andhra Pradesh Bifurcation Act, of 2014, officially recognized it as a national project, guaranteeing that the Government of India would pay the majority of its expenses. To serve several industries, especially agricultural and power production, the project intends to capture and manage the Godavari River's enormous water potential. The earth-cum-rockfill dam is a crucial part of the Polavaram Project, helping to store and control water for different applications. A 960 MW hydropower facility is also part of the project, which should lessen the area's need for fossil fuels by supplying green energy. To provide farmers with water security and boost agricultural output, a vast canal system is also being created to irrigate more than 7.2 lakh hectares of farmland in the districts of East Godavari, West Godavari, Krishna, and Visakhapatnam. To alleviate water scarcity in Telangana and Rayalaseema, which are prone to drought, the project also intends to move excess water from the Godavari River to the Krishna River basin.

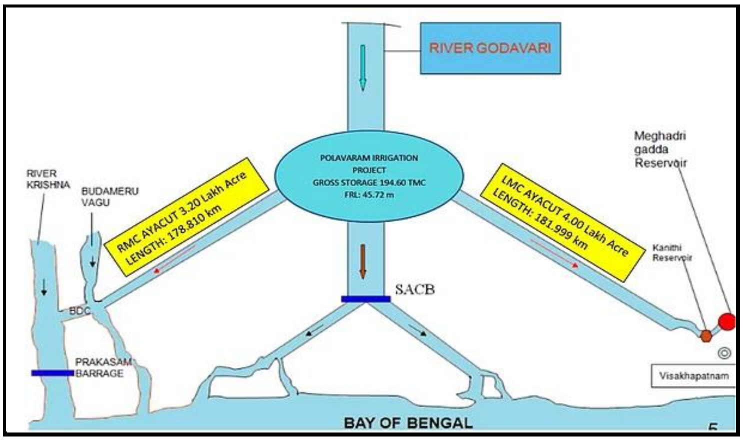

Fig2: Polavaram project water utilization [1]

In addition to its benefits for the economy and development, the Polavaram project is essential for flood control since it will help manage water flow during the monsoon season and stop flooding in farmlands and coastal settlements. Nearly 28 lakh people in the area would also be able to get drinking water from it. Additionally, it is anticipated that the project will aid in groundwater recharge, which will help to sustain and restore subsurface water levels in the surrounding areas. The initiative does, however, confront several difficulties. Due to the reservoir, about 98,000 families, or nearly 2 lakh people, are impacted by land submergence, making rehabilitation and resettlement (R&R) one of the main challenges. One of the authorities' principal responsibilities is still to provide alternative housing, chances for livelihood, and fair pay. Concerns about the environment have also elevated, since biodiversity may be impacted by the submersion of woodland areas and wildlife habitats. The project's cost has also increased dramatically, from an anticipated Rs. 129 crores in 1946 to over Rs. 55,000 crores presently, resulting in delays in execution and financial pressures. Regarding water sharing and the effects of submersion on their boundaries, the project has also resulted in legal issues with neighboring Indian states Odisha, Chhattisgarh, and Telangana. Notwithstanding these obstacles, the project is moving forward in different stages, and efforts are being made to build important infrastructure elements such as spillways, powerhouse units, and canals. To guarantee that the area benefits from improved water management, economic expansion, and sustainable development, the Andhra Pradesh government plans to finish important project components by 2026. The Polavaram Project is one of India's most important water management projects, with the potential to change Andhra Pradesh's agricultural landscape, increase renewable energy production, and improve water security if it is carried out properly.

3.1. Dam details:

It is one of the biggest and longest dams in India, measuring 1,100 meters in length and 45 meters in height. It is a roller-compacted concrete (RCC) gravity dam. The dam was built to contain a reservoir that can retain about 9.6 billion cubic meters (BCM) of water in total. Over 80,000 square kilometers make up the project's catchment area, demonstrating the wide geographic reach that the dam affects. This sizable reservoir is essential to maintaining a steady supply of water for areas that experience periodic droughts, especially the agricultural districts of Andhra Pradesh and Telangana.

Fig3: Polavaram Dam [2]

One of the Polavaram project's most important contributions is its irrigation component. It is anticipated that the dam will irrigate approximately 2.91 million acres (1.18 million hectares) of agricultural land throughout these regions once it is finished. In addition to giving farmers water security, this would lessen the effects of droughts and unpredictable monsoons, which have long been a problem for the area's agricultural output. A key component of the project, the canal system will transport water from the dam to different districts, guaranteeing that water reaches even the driest and most drought-prone regions.

3.2. Cannels details:

An integral part of the Polavaram Multi-purpose Irrigation Project, the canal system is intended to effectively transfer water from the dam to the neighboring villages and agricultural fields, mostly in Andhra Pradesh and Telangana. With a length of 174 kilometers and a carrying capacity of up to 80,000 cusecs, the main canal is the main waterway from the Polavaram dam. It is divided into two main feeder canals, the Left Bank Canal (LBC) and the Right Bank Canal (RBC), which carry water to the Godavari River's banks. To guarantee that water reaches specific farms and agricultural regions in multiple districts, like as Khammam, East Godavari, and West Godavari, these feeder canals are further subdivided into smaller branch canals.

Fig4: Canal [3]

The canal system supplies irrigation to areas that are generally prone to drought, encompassing a vast command area of over 2.91 million acres (1.18 million hectares) of agricultural land. To ensure effective delivery and reduce water loss through seepage, the canals are walled with concrete. In addition to boosting agricultural output, this extensive irrigation system is intended to provide residents with potable water.

3.3. Hydropower generation:

The project's goal is to produce hydropower. One of the project's main components is a 960 MW installed hydroelectric power station made up of six 160 MW turbines. In addition to meeting the local areas' electrical demands, this energy generation will add to Andhra Pradesh's overall energy system, offering a cleaner and more sustainable energy source.

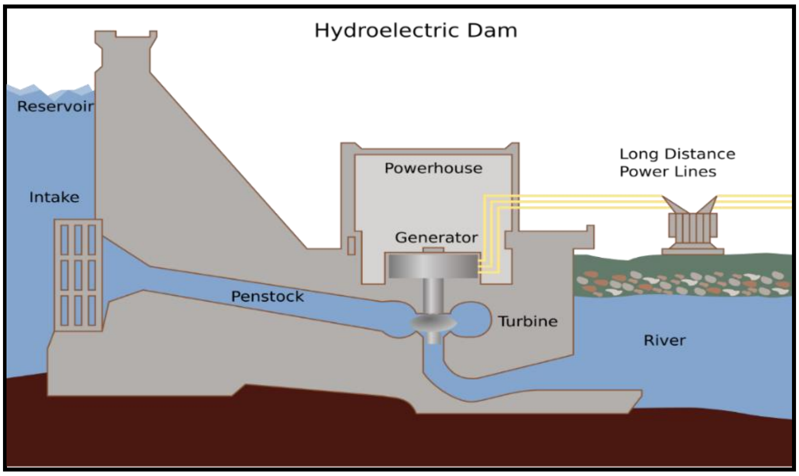

Fig5: Generation of Electricity [4]

Flood control is another critical aspect of the Polavaram project. The Godavari River is prone to heavy flooding during the monsoon season, often leading to the destruction of property, crops, and infrastructure. The construction of the dam is intended to manage and control the floodwaters, protecting the surrounding areas from flooding and minimizing the damage to crops and infrastructure. By regulating the flow of the river, the dam will help to balance the water levels during the monsoon season, preventing the devastation that has historically occurred due to uncontrollable floods. However, despite its many benefits, the Polavaram project has encountered several challenges throughout its development. One of the most significant challenges has been the rehabilitation and resettlement of the large number of families who have been displaced by the project. Thousands of people living in the areas that would be submerged by the reservoir have had to be relocated, and ensuring their proper resettlement has been an ongoing challenge. The state government has been working to address these issues, but the resettlement process has faced delays, leading to protests and legal challenges from affected communities. The project has caused displacement. It has been necessary to transfer thousands of residents to the areas where the reservoir would submerge, and it has been difficult to ensure their effective resettlement. Although the state administration has been making efforts to resolve these problems, the relocation process has been delayed, which has caused impacted communities to protest and file legal challenges.

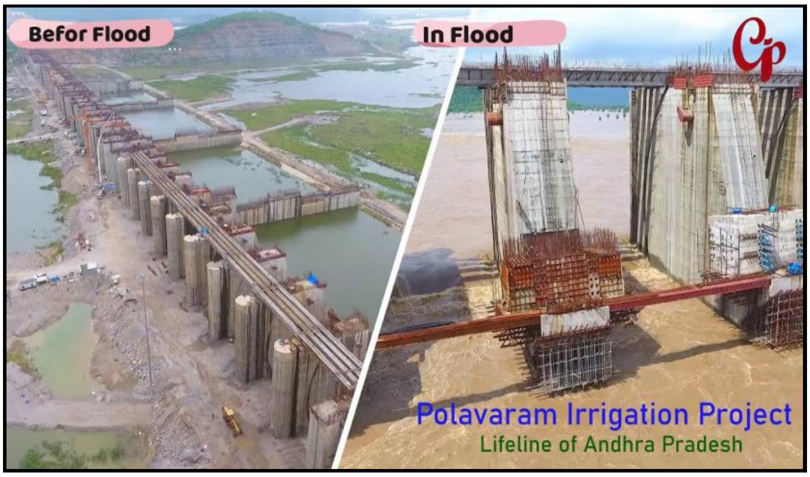

Fig6: Flood Control [5]

Environmental issues are still another crucial factor. The region's biodiversity has been impacted by the dam's construction, which has caused wildlife habitats and wooded areas to be submerged. Concerns have been voiced by conservationists regarding the project's long-term environmental effects as well as the loss of plants and animals. Although steps like afforestation and animal management have been proposed to lessen these effects, it is still challenging to guarantee sustainable environmental practices when undertaking major infrastructure projects. Over the years, there have been delays in the Polavaram project's progress, mostly because of problems with funding, acquiring land, and resettlement. Nonetheless, the building of the spillway, the canals, and the dam has advanced significantly. Phases of the project are being finished, and by the late 2020s, it is anticipated that the dam's full benefits—including flood control, irrigation, and electricity generation—will be realized. The project's completion is essential for the area since it will boost agricultural productivity, offer much-needed water security, and encourage sustainable energy production for many years to come.

3.4. Cost:

Since its commencement, the Polavaram Multi-Purpose Irrigation Project, located on the Godavari River in Andhra Pradesh, India, has seen substantial cost increases. The project's initial 1980 estimate of ₹8,261 crore has increased as a result of several reasons, including design modifications, inflation, and unanticipated difficulties. By 2004, ₹1,320 crore and ₹1,353 crore, respectively, had been approved administratively for the building of the right and left canals. The project's cost increased to ₹58,319 crore in 2017. The updated cost estimate, which now includes the 960 MW power plant, is ₹47,725.74 crore at 2017–18 pricing as of August 2023.

4. Literature Review:

4.1. Dr. Narisetti Sankara Rao and Dr. Narisetti Srinivasa Rao (2023) examine the Andhra Pradesh Polavaram Project's rehabilitation initiatives, paying particular attention to its goals of building dams, irrigating the land, producing hydropower, and resolving interstate conflicts. It brings to light issues including legal conflicts, environmental issues, and population displacement. Resettlement requires additional funding, even though the government has promised to provide it. The project, which aims to alleviate water scarcity, is a component of the National River Linking Project. Although Polavaram is essential to Andhra Pradesh's future, continuing rehabilitation and legal concerns are delaying its completion. [6]

4.2. Vankayalapati S. Ramarao and Yogendra Nath Srivastava (2022) spill channels draw attention to their function in securely rerouting floodwaters from spillways to rivers downstream. In addition to preventing embankment erosion and maintaining water levels within safe bounds, their design must provide steady flow. Hydraulic model studies are crucial for optimization in the limited research on big spill channels that handle over 1.41 lakh m^3/s. At CWPRS, Pune, the Polavaram Irrigation Project refined its spill channel design using a 1:140 scale model. All things considered; hydraulic modeling is crucial for maximizing spill pathways for efficient flood control.[7]
4.3. K. Anil Kumar and Nagaraju Chikkala (2022) according to the 2014 High-Level Tribal Committee Report, tribal people bear the brunt of the harm, frequently getting subpar restitution and rehabilitation. For displaced populations, poor resettlement policy execution has resulted in social and economic suffering. The efficacy of rehabilitation and resettlement strategies, specifically in the Andhra Pradesh Indira Sagar Project, is investigated in this paper through empirical research methods. According to the findings, relocated households endure serious socioeconomic difficulties. [8]
4.4. S K Verma et.al (2022) research on the Tehri and Polavaram dams brings to light issues including sedimentation, displacement, and socioeconomic effects. While minimizing negative effects, long-term sustainability requires effective planning, execution, and administration. Water resource initiatives that are sustainable should meet current demands without affecting the ability of future generations to meet theirs. [9]
4.5. **K. Harathi et. al (2021)** draw attention to the idea of river interlinking in India, which would improve water management by delivering excess floodwater to regions that are vulnerable to drought. Additionally, it provides advantages including flood control, hydropower generation, and year-round navigation. This idea was first introduced by Andhra Pradesh through initiatives like Patti Seema, which redirects water from the Godavari to the Krishna River. This project employs GIS software to help with planning and management, providing a long-term, sustainable solution to India's water crisis by focusing on infrastructure data (roadways, trains, and bridges) between Polavaram and Prakasam Barrage. [10]
4.6. Maniklal Adhikary and Sabana Parveen (2021) the impact of several factors on financial inclusion is examined in this study, which analyzes the financial inclusion status of Indian states and union territories in 2014 and 2018. A financial inclusion index was computed using twelve banking services-related characteristics that were examined. According to the study, changes in financial metrics between 2014 and 2018 did not differ significantly. Notably, financial inclusion was found to benefit from rural unemployment but not from urban unemployment.[11]
4.7. Dr. Devendra K. Bisen (2021) examining how land use, land cover, and topography interact with the socioeconomic circumstances of the area to influence the water system overall is the goal of this study, which attempts to investigate the physical and environmental dynamics of the Wainganga basin.[12]
4.8. Amarnath C R and Shashidhar Thatikonda's (2020) prior research has shown that dams have a major effect on flood hazards and upstream water levels. To forecast water surface heights in the event of severe flooding, hydraulic models such as HEC-RAS are frequently employed (Gupta et al., 2017; USACE, 2016). Inadequate gate operations have been found to worsen backwater effects, raising the danger of flooding for communities close (Kumar et al., 2019). This work expands on previous studies by employing 2D hydraulic modeling and flood frequency analysis to examine the backwater impact of the Polavaram Dam.[13]
4.9. Klara Feldes (2017) draws attention to the discrepancy between development promises and displaced communities' actual circumstances. Even though big dams are sometimes viewed as markers of a country's advancement, underprivileged groups are disproportionately impacted, suffering hardships and reaping few rewards. Although the media portrays the Polavaram Project, which is a component of NRLP, as a solution to water problems, ethnographic research conducted in impacted areas shows notable inequalities. The study makes the case that development narratives worsen social and economic inequality by continuing to obscure the detrimental effects on displaced communities.[14]
4.10. S. G. Munde et.al (2017) this study focuses on using canals and closed conduits to move water from Dhom Dam, which is located in an area with a lot of rainfall, to Ner Reservoir, which is located in a semi-arid area. Water can move by gravity because of the difference in altitude. To ensure an economical and successful water transfer system, electrical resistivity methods assist in determining the ideal canal alignment depending on geological conditions. In water-deficient areas, these projects raise living conditions and improve water balance.[15]
4.11. Sumit Das and Sudhakar D. Pardeshi (2017) this study examine the morphometry of the Vaitarna and Ulhas basins in Maharashtra using the Shuttle Radar Topographic Mission (SRTM) DEM. The basins have dendritic and sub-dendritic patterns and are categorized as drainage systems of the sixth and seventh orders. Greater structural control and steeper gradients are indicated by the Vaitarna Basin's higher bifurcation ratio. Low stream frequency and drainage density point to homogeneous lithology and permeable subsurface material. With both

basins moving into the mature stage, GIS-based analysis demonstrates that lithology has a major impact on drainage development**.**[16]

4.12. Bibhuti Mishra et.al (2015) present serious issues about environmental effects, human rights abuses, and tribe relocation. Incorporating tribal welfare into forestry strategies was a priority for the Working Group on Tribal Development (1978–83). The Forest Rights Act (FRA) and the National Tribal Policy, which prohibit projects that uproot more than 50,000 tribal people, will be broken by the project, which will uproot a record number of indigenous households. Villages in Andhra Pradesh, Chhattisgarh, and Odisha are affected by the underreported submergence estimates, according to reports. Because the Koya tribe's displacement jeopardizes their ethnic, linguistic, and cultural identity, inclusive development policies based on agreement are essential.[17]

4.13. D. Ramprasad Naik et.al (2015) in the Polavaram reservoir submergence area, the study uses IRS P6 LISS III satellite imagery to evaluate the loss of biological resources. Dense, open, scrub, and plantation forests are among the identified forest types; 245 species have been found in the impacted area. The study emphasizes how different approaches are required to lessen ecological harm and enhance the biotic environment. To minimize project consequences and guarantee sustainable resource management, environmental evaluations are essential. [18]

4.14. K. P. Kumaran (2013) demonstrates its detrimental socioeconomic and cultural effects, especially on underprivileged groups like tribal people. Due to strong emotional and cultural links to their ancestral area, many people oppose removal even in resettlement colonies with enhanced infrastructure. They would rather suffer losses than relocate, even in regions that are vulnerable to disasters. Displacement frequently results in social unrest, poverty, and loss of livelihood. All things considered, research highlights the necessity of resettlement laws that are not just compensatory but also socially and culturally viable.[19]

4.15. R. H. Jadhav et.al (2007) demonstrate that a significant problem is water scarcity, particularly in areas like Vidarbha, Maharashtra, where overuse of surface and groundwater has resulted in decreased crop yields and farmer suicides. To alleviate shortages in cities such as Akola, Amravati, and Yavatmal, the Upper Wardha Project was suggested. To plan water supply networks, optimize irrigation channels, and lessen the effects of drought, GIS-based technologies such as ERDAS are useful. In water-scarce locations, spatial analysis using ERDAS improves water allocation tactics, guaranteeing better resource management for agriculture and drinking water demands.[20]

5. Future Scope:

- Supply drinking water to water-scarce urban and rural communities.
- Produce clean energy to cut carbon emissions and reliance on fossil fuels.
- Support the local economy by generating jobs during development and operation.
- Encourage crop variety and enhance agricultural productivity.
- Develop tourism activities like boating, fishing, and sightseeing near the dam and reservoir.

6. Summary:

In summary, the creation of a multifunctional project such as the Polavaram project on the Wardha and Pen Ganga rivers would necessitate meticulous planning and evaluation of several variables, such as water availability, environmental impact, and socioeconomic aspects. Water supply, irrigation, and power generation could all be greatly enhanced by a well-designed project, even though the scale may vary depending on the features of the rivers. Such a large-scale project requires a thorough investigation that includes hydrological, environmental, and social impact studies to be successful and sustainable.

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