

## **Sustainable Management by Forest Farmer Group in Serayu Watershed**

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### **Abstract**

The conservation and development management of watersheds require comprehensive studies, planning, and implementation from the upstream water sources to the downstream areas. The active involvement of stakeholders, including government entities responsible for policies, regulations, and budgets, as well as civil society groups such as forest farmer communities, fishermen, business groups, environmental activists, and empowerment advocates, is essential. This research focuses on watershed management among forest farmer groups in the Serayu River area, the longest river in Central Java, specifically in Cilacap and Banyumas Regencies of Indonesia. A qualitative explanatory case study method was employed, utilizing direct observation, in-depth interviews, document analysis, and discussions. Data were analyzed through reduction, classification, clarification, and triangulation. The findings reveal that the management of the Serayu River watershed still requires socialization, coordination, and collaboration among stakeholders in planning, conservation, maintenance, development, monitoring, and evaluation. These stakeholders include local and village governments, socio-economic community groups, private entities, and academics. Relevant watershed management approaches include conceptual, deterministic, stochastic, parametric, and probabilistic methods.

**Keywords:** Forest farmer groups, Government, Socio-cultural empowerment, Sustainable management, Watershed

### **Introduction**

The economic development of communities in watershed areas in Indonesia, particularly in the Serayu River region of Banyumas and Cilacap Regencies in Central Java Province of Indonesia, is influenced by the complex interplay of environmental issues and resource utilization. According to the author's 2024 research and reviews of other scientific studies, several key factors affect the watershed: (1) Resource Utilization: Communities residing along the watershed rely on the river and natural resources for various economic activities, such as agriculture, fisheries, and tourism. The river serves as a critical economic lifeline for

downstream populations. (2) Economic Empowerment: Programs such as training and outreach are vital for effective watershed management, which can contribute to sustainable production of food and raw materials. (3) Environmental Awareness: Increasing public awareness to avoid disposing of both organic and inorganic waste into the river has fostered more responsible behaviour, which is crucial for maintaining environmental quality and supporting local economies. (4) Impact of Climate Change: The rising demand for clean water due to population growth and climate change underscores the importance of sustainable watershed management to support community economies. (5) Complex Issues: Challenges such as deforestation, pollution, and population growth significantly impact the watershed's condition, ultimately affecting the livelihoods of communities dependent on its resources.

The Serayu River, one of the largest rivers on Java Island, traverses Central Java Province and passes through several regencies, including Wonosobo, Banjarnegara, Purbalingga, Banyumas, and Cilacap. Originating from the Dieng Highlands in Wonosobo, the Serayu River flows to the southern coast of Java. It plays a vital role in supporting the economic and environmental potential of surrounding communities. The Serayu watershed is indispensable for various needs, such as drinking water, electricity generation, industrial processes, irrigation, sanitation, and sand mining.

The upstream conditions of the watershed are particularly influenced by the biophysical state of the catchment and water recharge areas, which are often vulnerable to human disturbances. This demonstrates that the sustainability of the watershed is closely linked to behavioral patterns, socio-economic conditions, and management practices, all of which are strongly tied to institutional frameworks. Watershed degradation is primarily caused by human activities, leading to natural disasters such as floods and landslides. Additionally, the characteristics of the watershed's morphology significantly affect flood risks[1-4]

The Serayu watershed is one of 15 priority watersheds in Indonesia, covering an area of 3,654.74 km<sup>2</sup> across five regencies in Central Java: Wonosobo, Banjarnegara, Purbalingga, Banyumas, and Cilacap. The Serayu River itself spans 165 km, with eight tributaries, including the Begaluh, Merawu, Klawing, Kalisapi, Piasa, Tajum, and Logawa rivers.

The upper Serayu watershed is located in Wonosobo and Banjarnegara Regencies, and environmental degradation in this area has become a critical concern. The biophysical condition of the catchment and recharge areas plays a pivotal role in influencing the overall health of the watershed.

Several factors affect economic growth in the Serayu watershed region in Banyumas and Cilacap, including the management of natural resources, agricultural, fisheries, and tourism activities, as well as the impact of local government policies. Agriculture: The river provides irrigation, boosting agricultural productivity and serving as a significant source of income for nearby communities.

Fisheries: The Serayu River supports local livelihoods through fishing, offering both a source of protein and income. Tourism: The natural beauty of the river attracts visitors, stimulating

local businesses. **Development Policies:** Local governments often implement infrastructure and quality-of-life improvement programs, benefiting communities within the watershed area.

The process of identifying vulnerabilities within watersheds, particularly socio-economic and biophysical vulnerabilities, remains incomplete. Natural resources and socio-economic vulnerabilities are closely interconnected. In regions where the primary source of income is agriculture, land degradation exacerbates socio-economic vulnerabilities. Flood vulnerability, particularly in the upstream regions of watersheds, has not been comprehensively studied. Consequently, this study aims to identify the relationship between vulnerabilities within the Serayu watershed and socio-economic factors.[5-8]

The Serayu watershed is a crucial hydrological area that plays a significant role in supporting livelihoods. The Serayu River is a primary economic resource for surrounding communities. Farmers rely on the river for irrigation, fishermen use it as a key fishing ground, and the tourism potential of the river attracts visitors from outside the region. The Serayu watershed also contributes to the cultural identity and social fabric of local communities, inspiring local traditions, arts, and music.

**Environmental Impact:** Pollution and unsustainable utilization of the river hinder the economic growth of local communities. Overall, the Serayu River presents significant opportunities; however, effective management is essential to ensure sustainable livelihoods for the communities of Banyumas and Cilacap.

### **Research Methods**

This study employed a qualitative case study approach, focusing on a system-level analysis rather than on individuals or institutions. The unit of analysis serves as a critical component in differentiating various case studies, whether between individuals or institutions. The case study method enables researchers to gain an in-depth and comprehensive understanding of individuals or small groups. Thus, it is classified as qualitative research that generates descriptive and narrative findings.[9-10]

Case studies are particularly compelling as they emphasise the exploration and explanation of phenomena under investigation, rather than concentrating on causation or seeking universally generalisable truths. This research adopts an explanatory case study approach, which is employed when researchers can no longer directly control or predict the phenomena being studied. Consequently, the inquiry focuses on addressing "why" or "how" certain phenomena occur and remain beyond control.

This type of case study typically examines real-world phenomena and groups that have not been fully explained. Such cases are often characterised by the presence of one or more variables that elude explanation. The primary objective of the explanatory case study method is to present previously unexplained data and conduct a causal investigative description.

The study was conducted in the Serayu Watershed located in Cilacap and Banyumas Regencies, Central Java Province of Indonesia. A purposive sampling method was used to select

informants, including local watershed communities organised into forest farmer groups, small business groups, village government representatives, environmental activists, and practitioners.

Data collection techniques involved direct observation, in-depth interviews conducted through dialogues, and the collection of relevant documentation. The research findings were subsequently discussed by the research team in collaboration with experts and practitioners.

The analysis process for the case study research followed these steps:[11]. (1) Understanding the Context: Reviewing the case history, relevant theories, and indicators affecting the situation. (2) Identifying Problems: Pinpointing the primary research questions requiring solutions or answers. (3) Data Collection: Gathering all relevant data, both primary and secondary. (4) Data Analysis: Applying descriptive, comparative, or thematic analysis methods as appropriate. (5) Drawing Conclusions: Synthesising findings to develop conclusions and, where necessary, providing recommendations for addressing the identified issues or improving conditions.

## **Results and Discussion**

### ***Socio-Economic Development in the Serayu Watershed***

The Serayu Watershed is categorized as socio-economically vulnerable, primarily due to high population density and an economy predominantly centred on agriculture. These factors are among the most significant contributors to vulnerability. For instance, the Dieng Plateau (Upper Serayu Sub-Watershed) remains predominantly agricultural. However, the soil layer has become increasingly thin, exposing the underlying rock. This condition compels farmers to rely heavily on fertilizers to cultivate the land.

The Serayu Watershed, a critical hydrological area in Central Java, spans several regencies, including Wonosobo, Banjarnegara, Purbalingga, Banyumas, and Cilacap. Non-compliance with agricultural conservation regulations has led to a high river discharge ratio between maximum and minimum levels, as well as sedimentation exceeding erosion threshold limits. The upstream conditions, particularly the biophysical state of catchment and recharge areas, significantly influence the watershed's sustainability. Many upstream areas remain vulnerable to human disturbances, demonstrating that behavioural patterns, socio-economic conditions, and management practices are key determinants of watershed sustainability, closely linked to institutional structures.

In the upstream Serayu region (Wonosobo and Banjarnegara Regencies), the per capita income of residents remains dependent on agriculture, with vegetable production being the primary commodity. The upstream area also experiences high rainfall. Conversely, the downstream Serayu region (Cilacap Regency) is dominated by processing industries and is prone to flooding. Similarities exist between the Serayu, Citandui, and Asahan watersheds, where high rainfall and agriculture dominate upstream livelihoods, while downstream areas are prone to flooding and dominated by service industries.

The Serayu Watershed is vital for the livelihoods of communities in Banyumas and Cilacap, Central Java. In addition to being a source of clean water, the river supports agriculture, fisheries, and the Mrica Reservoir hydroelectric power plant. Tree planting and fish stocking activities, such as those conducted in Tambaknegara Village, Rawalo Sub-District, Banyumas Regency, are part of environmental empowerment efforts led by the Environmental Control Division of Banyumas' Environmental Office. These initiatives aim to support environmental conservation, particularly in alignment with government programmes for climate change adaptation and mitigation in the region [12-13]

Each case must be addressed individually, considering the distinct socio-economic and biophysical aspects of the upstream and downstream regions. Monitoring and evaluating watershed performance revealed significant differences, including high rainfall, severe land vulnerability, and a predominance of agricultural income in upstream areas. To mitigate land degradation, a transition from agriculture to other sectors is necessary. High rainfall contributes to flooding, necessitating marine land rehabilitation. Although some solutions require long-term implementation, the outcomes are not immediate. Regular monitoring and evaluation (M&E) are therefore essential for assessing watershed health. Collaboration among stakeholders—government, communities, academics, and private entities—is critical for developing sustainable solutions and actionable plans to preserve the Serayu Watershed, ensuring ecosystem continuity and saving the watershed [14-17]

Many rivers in Java, including the Serayu, are in poor condition and unfit for direct consumption without treatment. Thus, collective action is needed to protect these rivers and restore their natural state. Forest conservation, land restoration, and effective water management are essential to reducing the risk of natural disasters such as floods and landslides. These efforts aim to enhance community well-being, create a healthy environment, and support ecosystem sustainability.

The current condition of the Mrica Reservoir is concerning due to sedimentation from upstream areas. Sediment now covers 83% of the reservoir's area, with predictions that the reservoir will only remain viable until 2028 without intervention. Conservation efforts are therefore essential in both upstream and downstream areas, including around the Serayu Weir. During recent conservation activities, 35,000 tree seedlings, including mangroves, were planted, and 120,000 fish and 100,000 shrimp fry were distributed.

### ***Alternative Methods for the Study of the Serayu Watershed***

The Serayu Watershed is defined by its topographical boundaries, where all water flows within the system drain through a single outlet. One of the prominent rivers in Central Java Province is the Serayu River, which traverses five districts: Wonosobo, Banjarnegara, Purbalingga, Banyumas, and Cilacap. The river originates in the Dieng Plateau and flows downstream to the Indian Ocean, spanning a length of 181 km. The Serayu River forms the main channel of the Serayu Watershed, covering an area of 3,660 km<sup>2</sup> under the supervision of the Serayu Opak Progo Watershed Management Agency.

Over the past five years, Geographic Information Systems (GIS) have experienced significant advancements. GIS is a computer-based information system designed to store, manage, and analyze geographically referenced data. This system integrates data such as maps, satellite images, and other geographical datasets, facilitating the mapping and land-use planning processes with greater efficiency.

A recurring problem in Indonesia during the rainy season is flooding. According to the Regional Disaster Management Agency of East Java, flooding occurs when water overflows onto typically dry land due to heavy rainfall, snowmelt, or other factors that prevent the soil from absorbing or existing channels from draining the water adequately.

Hydrological models are often employed to provide a simplified representation of watersheds and predict potential hydrological events. These models can calculate surface runoff, groundwater flow, river discharge hydrographs, and surface erosion. The watershed hydrological model, as the primary tool, is used to estimate river discharge resulting from rainfall.

The alternative methods for watershed studies [18-27] as illustrated in Figure 1 , include:

(1) Conceptual Methods: The simplification of processes within a watershed exemplifies a more straightforward representation of real-world scenarios. This approach encompasses several models: the first is the rational model, the second involves linear and non-linear reservoir approaches, and the third is a combination of the rational model and reservoir approaches.

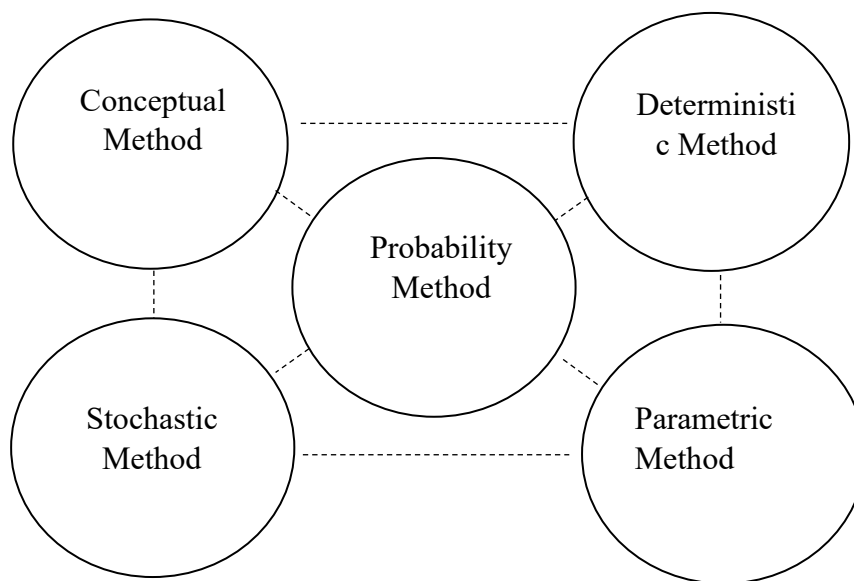
(2) Deterministic Methods: These methods can be classified into two categories based on the input or output variables and parameters: lumped and distributed. Variables or parameters are classified as lumped if they represent quantities without temporal or spatial variation, such as the average rainfall over a watershed. Conversely, they are classified as distributed if they exhibit temporal and spatial variations. Parameters are measurable quantities that define the hydrological system and remain constant over time, whereas variables are measurable quantities that may change over time.

(3) Stochastic Methods: These methods are commonly used to evaluate the statistical characteristics of physical outputs from a system influenced by sequences of events that fluctuate over time. Such methods generate long-term data series with similar characteristics, which can be analyzed to understand potential future event sequences, such as estimating the frequency of water discharge.

(4) Parametric Methods: These methods typically involve developing mathematical expressions that represent the functions of a watershed, which are subsequently transformed into input-output models, also referred to as black-box models. As key watershed parameters are incorporated, the model becomes more complex, resulting in variations in responses across different watersheds with identical inputs. Parametric models enhance our understanding of system behavior.

Based on the original system structure and the governing physical principles, deterministic models are mathematical representations that only accommodate variables free from random variations.

(5) Probabilistic Methods: Concepts of frequency and probability are integral to probabilistic models, similar to stochastic models. However, the sequence of events is not considered in probabilistic models. For instance, events are assumed to be independent of time, and extreme event predictions are based on population data.



**Figure 1. Alternative Methods for Watershed Study**  
*Socio-Economic Management of Forest Farmer Communities in the Serayu Watershed*

The management of watersheds remains unaffected by socio-economic and biophysical disparities between upstream and downstream areas. In the upstream region of the Serayu Watershed, which primarily comprises vegetable farmland in Wonosobo and Banjarnegara districts, land degradation and elevated levels of erosion and sedimentation—particularly at the Mrica hydropower plant—are prevalent. This situation raises concerns about potential energy crises in surrounding areas. Furthermore, the high population density exacerbates economic vulnerability.

Although the Serayu Watershed serves as a water source for local communities, unsustainable farming practices in the Dieng highlands adversely affect its sustainability. The phenomenon of "Rivers as Front Yards" has spurred collaboration among various stakeholders to restore and preserve the Serayu Watershed.

Illegal sand mining activities render the Serayu Watershed prone to cliff erosion, particularly in its middle and downstream regions. Additionally, with slopes predominantly less than 2% in these areas, flooding is a significant risk. This vulnerability is further compounded by their proximity to larger rivers and susceptibility to tidal effects from seawater [28-31]

Cultural factors also influence the condition of the Serayu Watershed, as local communities tend to cultivate horticultural crops rather than timber. According to the Director of Environmental Partnerships, that restoration of the Serayu Watershed can be pursued through the Social Forestry Programme. She explained, "This can be achieved using an agroforestry system, where farmers can continue producing potatoes while maintaining vegetation and tree crops."

Thus, a collaborative management approach is essential for watershed management. Collaborative management, or co-management, entails conflict resolution through cooperative and assertive strategies to achieve shared goals. Such an approach necessitates the active "participation" of all "stakeholders" involved in watershed management. Given that the Serayu Watershed spans multiple districts, the provincial governor's role is crucial in coordinating stakeholders. While each stakeholder may have differing interests and perspectives, it is the governor's responsibility to harmonize these interests.

Several challenges related to watershed management must be addressed promptly. Among the proposed solutions are land rehabilitation initiatives, such as civil and technical soil conservation, reforestation, and greening programs, alongside efforts to enhance agricultural yields, such as rice production. Planting timber species in vulnerable areas along the watershed—such as mahogany and teak—is an effective conservation strategy.

Key actors in the socio-economic management of the watershed include the government, which formulates policies, regulations, and budgetary allocations. According to Article 1, Clause 1 of the Regulation of the Minister of Environment and Forestry (MEF) No. P.10/Menlhk/Setjen/OTL/0/1/2016, the Watershed and Protected Forest Management Agency MEF functions as a technical implementation unit for watershed and protected forest management. MEF operates under the supervision of the Directorate General of Watershed and Protected Forest Management.

Pursuant to Article 15 of Presidential Regulation No. 16 of 2015 concerning the Ministry of Environment and Forestry, MEF is tasked with optimizing service delivery in the development of watershed and protected forest management. This includes formulating and implementing policies to enhance the carrying capacity of watersheds and protected forests.

The implemented watershed management strategies [32-38] in Figure 2 that encompass the following activities: (1) Developing technical plans for forest and land rehabilitation as well as soil and water conservation. (2) Designing models for watershed and protected forest management. (3) Conducting forest and land rehabilitation alongside soil and water conservation. (4) Monitoring and evaluating the reclamation of forest areas, degradation of inland waters, and management of protected forests. (5) Monitoring and evaluating watershed and protected forest management. (6) Establishing institutional frameworks. (7) Creating and disseminating data on protected forest and watershed management. (8) Implementing participatory, productive, and innovative socio-economic empowerment initiatives for communities within the watershed.

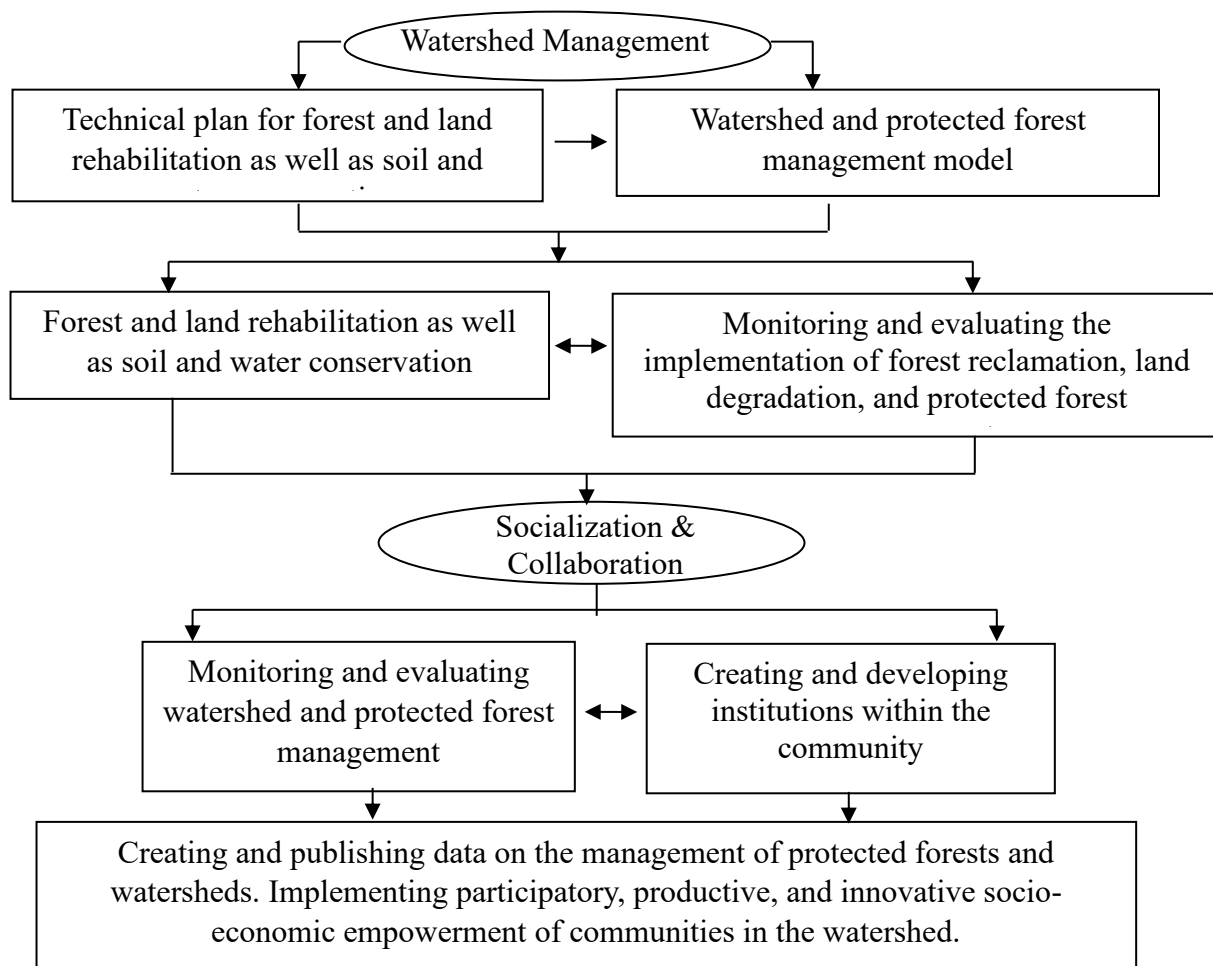


Figure 2: Watershed Management Based on Community Empowerment

In the fisheries sector, activities include cultivating fish such as catfish, tilapia, and carp. In the livestock sector, the focus is on rearing goats, buffaloes, and cattle. These efforts aim to increase community income and can be implemented in the upstream areas of the Serayu Watershed, such as Wonosobo and Banjarnegara. Meanwhile, the processing of raw materials into industrial products is carried out in the downstream regions, including Cilacap and Banyumas.

Industrial innovation encompasses products such as breadfruit-based goods, beef and goat corned meat, potato and banana chips, buffalo skin crackers, and fish crackers. Achieving these outcomes independently is not feasible; the involvement of relevant agencies, non-governmental organizations (NGOs), and academics as facilitators is essential [39-43].

The successful collaboration in watershed management will undoubtedly have a significant impact on society. The year-round availability of water ensures the biophysical resources

needed to support food industries. Consequently, the food business sector flourishes, improving community welfare. Furthermore, reduced risks of flooding and landslides allow economic activities to proceed uninterrupted. Success in collaborative watershed management will encourage policymakers to adopt a collaborative management model for future watershed initiatives.

## **Conclusion**

Several challenges remain in managing forest community groups within the Serayu Watershed. The high population density and critical urban land areas complicate forest and land rehabilitation efforts, as urban development tends to prioritize commercial activities.

Institutional challenges persist, such as sectoral egos among government agencies responsible for watershed management. This lack of coordination often leads to conflicting policies among the involved institutions.

Many communities still perceive watershed management as the sole responsibility of the government, resulting in limited public participation. This perception stems from factors such as low education levels and economic constraints, which drive communities to exploit natural resources excessively.

A shortage of human resources for water resource management further exacerbates the issue. The Regional River Basin Organization has identified insufficient coordination in water resource management, evidenced by overlapping programs implemented by various managing institutions.

Economic and biophysical vulnerabilities within the Serayu Watershed stem from poor management practices. To improve the effectiveness and efficiency of watershed management, collaboration among districts, provincial governments, NGOs, academics, and other stakeholders is imperative.

To achieve optimal watershed management outcomes—reducing social, economic, and biophysical vulnerabilities—collaborative management tools must be synergized and enhanced. Properly managed watersheds will yield significant benefits for society by improving watershed conditions.

Districts within the Serayu Watershed (Wonosobo, Banjarnegara, Purbalingga, Banyumas, and Cilacap) should involve religious leaders, community figures, and government officials to encourage productive-age communities to adopt a "two-child policy." Productive couples adhering to this policy could receive economic incentives from local governments, such as educational support from elementary to tertiary levels. Couples committed to this policy may also qualify for free medical treatment and surgical procedures at regional hospitals.

Moreover, it is crucial for district and provincial offices, NGOs, academics, and communities to ensure watershed management incorporates conservation, economic, social, and ecological

perspectives. Such an approach integrates watershed sustainability into economic ventures, conservation, and ecotourism.

To manage agricultural land wisely without harming the environment, strict regulations must prohibit farming on steep slopes. Robust oversight is needed for land use within protected areas, alongside the establishment of clear policies and regulations promoting environmentally friendly farming practices.

Addressing biophysical vulnerabilities requires adequate vegetative and civil water conservation measures, improved drainage systems, and the construction of embankments along both sides of rivers.

Effective management of cross-district watersheds requires consistent oversight. This research adopts a quantitative approach, utilizing both primary and secondary data. Socio-economic data were collected through direct interviews and questionnaires, while biophysical data were obtained from map interpretations and field observations. Secondary data were sourced from relevant institutions.

The findings indicate that biophysical and socio-economic vulnerabilities are interrelated. Thus, it is impossible to determine whether biophysical or socio-economic aspects should take precedence in watershed management, as each case requires a specific approach. Effective watershed management demands case-by-case analysis to meet the requisite standards.

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