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Wastewater Management Strategies for Reducing Drought Vulnerability and Enhancing Women's Local Wisdom: A Case Study of Kebonharjo Village, Indonesia

Yuniarta Vuspita*, RR. Susilastuti Dwi Nugrahajati, Arif Rianto Budi Nugroho, Yohana Noradika Maharani, Johan Danu Prasetya, Ficky Adi Kurniawan

Universitas Pembangunan Nasional "Veteran" Yogyakarta, Indonesia

*Correspondence: yuniartavuspita@gmail.com

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ABSTRACT: Prolonged drought has become a recurrent hydrometeorological disaster that significantly affects rural communities in Indonesia, particularly in areas with limited water infrastructure. In 2023, the Special Region of Yogyakarta experienced widespread drought, with severe impacts in Kulon Progo Regency, especially in Samigaluh Subdistrict. Kebonharjo Village, located in the Menoreh Hills, has faced persistent clean water shortages due to climate variability, environmental degradation, and increasing water demand. These conditions have intensified social vulnerability, especially among women, who are primarily responsible for household water management and water-dependent livelihood activities. This study aims to examine women's multidimensional vulnerability to drought, analyze wastewater management as a form of local wisdom-based adaptation, and identify policy implications for gender-responsive disaster risk reduction. Using a qualitative case study approach, data were collected through in-depth interviews, focus group discussions, participatory observation, and document analysis from January to March 2025. Data were analyzed using the interactive model of Miles and Huberman. The findings reveal that women experience physical vulnerability due to long distances to water sources, economic vulnerability resulting from declining agricultural income and increasing household expenditures, and structural vulnerability linked to limited participation in village-level decision-making. At the same time, women demonstrate strong adaptive capacity through wastewater reuse, rotational water collection, and ecological knowledge of seasonal indicators. The novelty of this study lies in positioning wastewater management as a gendered adaptation strategy rooted in women's local wisdom rather than merely a domestic coping practice. The study concludes that integrating women's local knowledge into village-level drought governance and strengthening their participation in decision-making are essential for building community resilience and advancing gender-equitable disaster risk reduction.

KEYWORDS: Drought vulnerability; women's empowerment; wastewater reuse; local wisdom-based adaptation; disaster risk reduction; gender resilience

1. Introduction

A prolonged drought affected many areas of the Special Region of Yogyakarta throughout 2023, with significant impacts recorded in Gunungkidul, Kulon Progo, Bantul, and Sleman Regencies. According to the Regional Disaster Management Agency of the Special Region of Yogyakarta, the drought reduced clean water availability in dozens of villages and contributed to the declaration of drought emergency conditions in affected regencies, including Kulon Progo [1]. This event confirms that drought remains one of the most pressing hydrometeorological threats for rural communities whose livelihoods depend heavily on local water availability.

Drought in Yogyakarta is driven by both natural and anthropogenic factors. Climate variability, increasing temperature, delayed rainy seasons, and large-scale climate anomalies such as El Niño and the positive Indian Ocean Dipole have intensified the duration and severity of dry periods [2]. At the same time, rising household and agricultural water demand, land degradation, and declining environmental carrying capacity have accelerated groundwater depletion and water insecurity [3]. In such contexts, drought is not merely a biophysical phenomenon but also a social condition shaped by unequal access to resources, infrastructure, and adaptive capacity [4].

Samigaluh Subdistrict, located in the northern upland area of Kulon Progo Regency, is particularly vulnerable to drought because of its hilly topography, limited water infrastructure, and seasonal dependence on springs and rain-fed water sources. Kebonharjo Village, one of the villages in Samigaluh, lies in the Menoreh Hills and is characterized by uneven access to clean water, especially during the dry season [5]. Field observations and local disaster records indicate that springs in this area have dried more rapidly since 2023, worsening household-level water shortages and increasing pressure on local coping systems [1].

The social impacts of drought are not experienced equally. Women are among the most affected groups because their domestic and productive responsibilities are closely tied to water availability [6–10]. In rural settings, women are typically responsible for cooking, washing, caregiving, small-scale farming, livestock care, and other reproductive labor that depends directly on daily access to water [8,9]. When drought intensifies, women must spend more time and energy securing water while continuing to manage household needs. This condition produces a gendered form of vulnerability in which environmental stress interacts with unequal gender roles and limited institutional support [11–15].

Structural inequality further deepens this burden. Although women play a central role in managing household water needs, they often have limited influence over water governance, disaster planning, and local decision-making forums [11–16]. Their everyday knowledge is frequently treated as informal and therefore marginalized from formal planning processes, even though such knowledge is often critical to community survival under environmental stress [16]. As a result, local adaptation practices carried out by women tend to remain invisible in public policy and village development planning.

In drought-prone communities, women frequently respond through practical and collective adaptation measures rooted in local knowledge. These include water-saving habits, informal water sharing, reuse of household wastewater, ecological observation of seasonal changes, and mutual support networks [17-21]. Such practices reflect community resilience and locally grounded adaptation, yet they are rarely recognized as strategic resources for disaster risk reduction. In Kebonharjo, this gap is particularly important because women's

responses to drought appear to operate largely outside formal policy frameworks, despite the existence of broader regional commitments to gender mainstreaming in development [22].

This study offers three main contributions. First, it extends gender and disaster scholarship by examining drought vulnerability through the combined lenses of social vulnerability and Gender and Development perspectives, emphasizing how unequal gender relations shape women's exposure, burdens, and limited control over water governance [4, 23, 24]. Second, it highlights wastewater management not merely as a technical household practice, but as a form of gendered adaptation rooted in women's local wisdom and everyday ecological knowledge [25−27]. Third, it moves beyond a descriptive case account by proposing policy implications for scalable, gender-responsive, and community-based drought risk reduction, particularly for rural areas with limited water infrastructure [28−31].

To clarify the analytical relationship among drought hazard, women's multidimensional vulnerability, local wisdom-based wastewater management, and community resilience, this study develops a conceptual framework as presented in Figure 1. The framework illustrates that drought acts as the main environmental stressor that intensifies women's physical, social, economic, and structural vulnerability in rural areas with limited water infrastructure. At the same time, women respond through local wisdom-based adaptation, particularly household wastewater management and other everyday water-saving practices. These adaptive practices mediate the impacts of drought by reducing household water pressure, sustaining daily survival, and strengthening community resilience. In this way, the framework emphasizes that women should not be viewed solely as vulnerable subjects, but also as knowledge holders and active agents of drought adaptation. Accordingly, this study aims to: (1) examine the multidimensional vulnerability of women in facing drought; (2) analyze wastewater management as a form of local wisdom-based adaptation developed by women; and (3) formulate gender-responsive and locally grounded policy recommendations for disaster risk reduction.

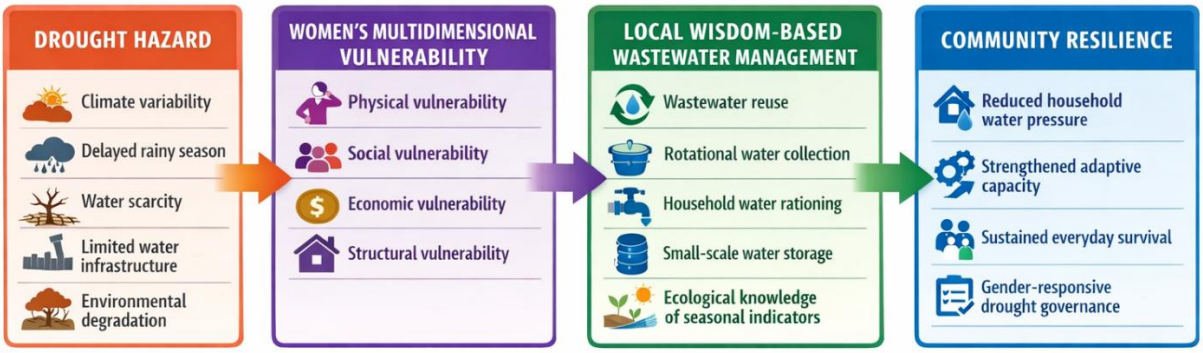

Figure 1. Conceptual Framework Of Drought Hazard, Women's Multidimensional Vulnerability, Local Wisdom-Based Wastewater Management, And Community Resilience.

2. Materials and Methods

2.1. Study area.

This research was conducted from January to March 2025 in Kebonharjo Village, Samigaluh Subdistrict, Kulon Progo Regency, Special Region of Yogyakarta, Indonesia. The study area was selected because it represents a drought-prone rural upland region characterized by uneven access to clean water, limited water infrastructure, and strong dependence on seasonal springs

and rain-fed water sources. Kebonharjo Village is located in the Menoreh Hills and consists of ten hamlets with diverse ecological and socioeconomic conditions, making it an appropriate site for examining the relationship between drought, women's vulnerability, and locally developed adaptation practices [5]. The variation in topography, water access, and livelihood conditions across hamlets also enabled the study to capture differences in women's experiences in managing household water scarcity during the dry season.

2.2. Research design.

This study employed a descriptive qualitative approach using a case study design. A qualitative case study was considered appropriate because it enables an in-depth exploration of women lived experiences, meanings, and adaptation strategies in responding to drought within a specific social, ecological, and cultural context [32]. This design was particularly relevant for understanding how gendered vulnerability is formed and how women develop local wisdom-based responses under conditions of recurring environmental stress. By focusing on a single case, this study sought to generate a contextually grounded understanding of the intersection between drought vulnerability, gender relations, and wastewater management practices in a rural community [4,23,25].

2.3. Sampling and informant selection.

The primary informants in this study were women who had direct experience in managing household water needs during the dry season. They included housewives, women farmers, livestock keepers, and community cadres. Informants were selected using purposive sampling based on several criteria: (1) direct involvement in household water management, (2) experience in wastewater reuse or other local drought adaptation practices, and (3) knowledge of community conditions related to water scarcity. This sampling strategy was applied to ensure that the selected informants possessed relevant experience and insights aligned with the objectives of the research [32]. In addition to women informants, several village stakeholders were involved to provide contextual and institutional perspectives on drought governance, local development planning, and village-level disaster risk reduction efforts. Their inclusion was important for understanding the extent to which women's experiences and knowledge were reflected in formal decision-making processes [23,26].

2.4. Data collection techniques.

Data were collected through four main techniques: in-depth interviews, focus group discussions, participatory observation, and document analysis [32]. First, in-depth interviews were conducted to explore women's personal experiences, perceptions, and adaptive strategies in facing drought. These interviews focused on daily water-related practices, gendered responsibilities, coping mechanisms, and the challenges women encountered during periods of water scarcity. Second, focus group discussions were conducted to identify collective understandings of drought, women's roles in household and community adaptation, and shared forms of local wisdom related to water management. The discussions also helped reveal common patterns and differences in women's experiences across the study area. Third, participatory observation was undertaken to examine women's daily routines in managing water, household needs, agricultural activities, and livestock care during the dry season.

This technique enabled the researcher to observe directly how adaptation practices were carried out in everyday life and to relate interview findings to actual field conditions [24]. Fourth, document analysis was conducted on village reports, local disaster records, and policy documents related to drought risk management and gender-responsive development. These documents were used to strengthen contextual understanding and to compare community-based experiences with formal institutional responses [1,22]. The use of multiple data collection techniques allowed the researcher to obtain rich, contextual, and triangulated qualitative data [32].

2.5. Data analysis procedure.

Data were analyzed using the interactive model of Miles and Huberman, which consists of three interconnected stages: data reduction, data display, and conclusion drawing or verification [33]. In the data reduction stage, field data from interviews, observations, focus group discussions, and documents were selected, organized, and categorized according to the main themes of the study, including women's physical, social, economic, and structural vulnerability; access to and control over water resources; local wisdom-based adaptation; and participation in drought governance [4,23,25].

In the data display stage, the categorized data were systematically arranged to facilitate interpretation and comparison across sources and informants. Patterns, recurring themes, and relationships among categories were then identified to build an analytical understanding of women's drought experiences and adaptation strategies. Finally, conclusions were drawn and continuously verified throughout the research process. Data analysis was conducted iteratively, meaning that interpretation was refined as new data emerged and as earlier findings were re-examined. This iterative procedure helped strengthen the consistency and depth of the analysis [33].

2.6. Data validity and triangulation.

To ensure the credibility and trustworthiness of the findings, this study applied source triangulation and technique triangulation. Source triangulation was conducted by comparing information obtained from different informants, including women participants and village stakeholders. Technique triangulation was applied by cross-checking findings derived from in-depth interviews, focus group discussions, participatory observation, and document analysis [32, 33]. The researcher served as the primary instrument in the study, supported by semi-structured interview and observation guidelines. These guidelines provided flexibility in responding to field dynamics while maintaining consistency with the research objectives [32]. Through triangulation and iterative verification, the study sought to ensure that the findings accurately reflected the social realities and lived experiences of women in Kebonharjo Village in facing drought.

3. Results and Discussion

3.1. Women's multidimensional vulnerability in facing drought.

The findings indicate that women in Kebonharjo Village experience drought-related vulnerability in multidimensional forms. These include physical, social, economic, and structural

vulnerability, each of which is interconnected and shapes women's capacity to respond to water scarcity. A summary of these forms of vulnerability is presented in Table 1.

Table 1. Summary of women's multidimensional vulnerability in facing drought in Kebonharjo Village.

Type of vulnerability	Indicators observed	Evidence from field observations/interviews	Implications for drought adaptation
Physical vulnerability	Long distances to water sources; repetitive manual water collection; increased domestic workload during the dry season	Women had to travel to lower areas to collect water and carry containers several times a day while continuing cooking, washing, childcare, and other domestic responsibilities.	Increases physical exhaustion and time burden, thereby reducing women's capacity to participate in broader adaptive and community-based activities.
Social vulnerability	Gendered division of labor; normalization of women's domestic burden; low social recognition; emotional stress during water scarcity	Women remained primarily responsible for household water management, while their burden was treated as an expected part of domestic duty. Water shortages also generated stress and tension when women had to prioritize limited water for competing household needs.	Reinforces unequal coping responsibilities and places adaptation pressure on unpaid and socially underrecognized labor.
Economic vulnerability	Declining agricultural productivity; reduced livestock support; rising household expenditures; disruption of women's small-scale productive activities	Drought reduced crop output and fodder availability, while women had to manage higher spending on water and food and experienced reduced flexibility in gardening, food processing, and livestock-related work.	Weakens household adaptive flexibility and deepens women's economic precarity under worsening livelihood conditions.
Structural vulnerability	Limited participation in village forums; weak control over water-related decisions; exclusion from drought planning and governance	Although women were central to household water management, their knowledge and experiences were rarely incorporated into village discussions on water access, aid distribution, and drought response.	Limits women's influence over long-term adaptation strategies and reduces the effectiveness of local drought governance by excluding practical experiential knowledge.

As shown in Table 1, women's vulnerability in Kebonharjo Village is not limited to direct exposure to drought or declining water availability. It is also shaped by gendered social relations, livelihood insecurity, and limited influence over decision-making processes. The findings show that women experience interconnected forms of physical, social, economic, and structural vulnerability, each of which affects their ability to cope with and adapt to water scarcity. These dimensions are mutually reinforcing and reflect the broader social and institutional context in which drought is experienced. They are discussed in greater detail in the following subsections.

3.1.1. Physical and social vulnerability.

The findings of this study show that drought in Kebonharjo Village creates a significant physical burden for women, particularly because they are the primary actors responsible for securing, allocating, and managing water for household survival. During the dry season, when local springs and nearby household water sources decline or dry up, women must travel considerable distances to access water points located in lower areas of the village landscape. Based on field observations and interview accounts, this activity is not occasional but repetitive and embedded in everyday routines. Women often carry jerrycans or other water containers manually, sometimes several times a day, while simultaneously maintaining domestic responsibilities such as cooking, washing, cleaning, caring for children, and supporting elderly family members. This condition illustrates that drought intensifies not only water scarcity but also the bodily demands of gendered labor.

The physical burden experienced by women cannot be separated from the social structure that assigns domestic water management almost exclusively to them. In Kebonharjo, water is not only a basic need but also a resource central to household reproduction. As a result, when drought occurs, women become the first social group to absorb the immediate consequences of scarcity. This finding is consistent with previous studies showing that drought deepens women's exposure to environmental stress because their daily responsibilities are closely tied to the availability of water for domestic and livelihood-related activities [6-10]. In this case, the shortage of water translates directly into longer working hours, reduced rest, and increased fatigue, showing how ecological stress is embodied through gendered divisions of labor.

The study also found that this physical vulnerability is closely intertwined with social vulnerability. Although women bear the heaviest responsibility for ensuring household water security, their labor is often normalized and treated as an expected extension of their domestic role. This normalization reduces the visibility of their burden and contributes to the absence of institutional responses that directly address their needs. Several informants explained that when water became insufficient, they were often blamed for not managing household supplies efficiently, even though the root cause lay in structural shortages and limited village water infrastructure. Such conditions reflect the gendered injustice of drought: women are held accountable for coping with water scarcity, but are not provided with sufficient support, recognition, or decision-making power.

From a social vulnerability perspective, this condition demonstrates that disaster risk is not determined solely by exposure to natural hazards, but also by unequal social relations and unequal access to coping resources [4,24]. In other words, women in Kebonharjo are vulnerable not only because the village experiences drought, but also because local gender norms place them in positions of responsibility without corresponding authority or support. Their vulnerability is therefore relational and structural. It is shaped by the interaction between environmental stress, gendered expectations, and the limited redistribution of domestic burdens within households and communities.

This pattern also reflects what disaster gender scholars describe as the "double burden" of women in crisis situations [23]. On the one hand, women experience physical strain due to the increasing demands of water collection and household maintenance. On the other hand, they remain socially constrained by expectations that domestic duties are naturally theirs, leaving little room for renegotiation of labor or for public acknowledgment of their contribution. In the context of Kebonharjo, drought does not simply create a temporary workload increase; it reproduces and intensifies pre-existing gender inequalities. Thus, the physical and social vulnerability of women should be understood as a cumulative process in which environmental pressure reinforces gendered labor hierarchies and reduces women's overall well-being.

Another important finding is that women's social vulnerability is also reflected in the emotional and relational dimensions of drought. Several accounts suggested that prolonged water scarcity creates tension within households, particularly when available water must be rationed among competing needs such as drinking, cooking, bathing, livestock care, and gardening. In such situations, women are often placed in the position of deciding which needs are prioritized, yet these decisions are made under pressure and without institutional backing. This can generate stress, guilt, and conflict, especially when family expectations remain high despite worsening scarcity. Therefore, the social effects of drought are not limited to labor

burdens, but also include psychological pressure and reduced social recognition, which further deepen women's vulnerability.

Taken together, these findings indicate that physical and social vulnerability in Kebonharjo are mutually reinforcing. Drought increases the material burden of water collection, while social norms ensure that this burden remains feminized and underrecognized. For this reason, disaster risk reduction policies in drought-prone rural areas must move beyond general assumptions about household vulnerability and explicitly address the gendered organization of daily survival work. Without such recognition, women's physical exhaustion and social marginalization will continue to be treated as private matters rather than as central issues in community resilience planning.

3.1.2. Economic vulnerability.

The study reveals that the economic vulnerability experienced by women in Kebonharjo Village is strongly linked to the broader livelihood structure of the community, which remains highly dependent on agriculture, livestock, and informal household-based production. In rural settings where income generation is closely tied to environmental conditions, drought does not only reduce water availability but also weakens the economic base of households. In Kebonharjo, this situation is particularly severe because the dry season affects both subsistence production and small-scale income-generating activities. As a result, women face a dual economic pressure: they lose or experience reductions in sources of household income while simultaneously managing increasing expenditures related to water and food.

Field findings indicate that prolonged drought disrupts farming cycles, reduces crop productivity, and limits fodder availability for livestock. For many households, these disruptions translate into unstable income and declining food security. Women are heavily affected because they are not only contributors to rural livelihoods, but also managers of household consumption and survival strategies. In many cases, women are responsible for allocating limited money to cover food, clean water purchases, children's needs, and other daily essentials. This places them at the center of economic adaptation, even though their access to productive assets and formal financial support remains limited.

The findings also show that drought undermines women's small-scale productive activities. Informants reported that activities such as home gardening, food processing, and livestock-related tasks became more difficult during periods of water scarcity. Water that might otherwise support these income-enhancing activities had to be reserved for drinking, cooking, and other essential domestic uses. This indicates that drought reduces women's economic flexibility by narrowing the range of livelihood options available to them. In this context, women's economic role becomes paradoxical: they are expected to maintain household welfare, yet the material basis for doing so is increasingly constrained.

This pattern aligns with the asset vulnerability framework, which explains that vulnerability is intensified when households have limited access to productive assets, weak savings, low diversification, and restricted control over decision-making [34]. In Kebonharjo, women's economic vulnerability is not simply caused by temporary crop failure, but by deeper structural conditions that limit their access to capital, information, assistance, and alternative income opportunities. The ability to cope with drought is therefore unevenly distributed, and women often occupy a more precarious position because their economic contributions are

embedded in unpaid labor and informal production rather than in secure or recognized forms of employment.

Another important aspect is that additional expenditures during drought disproportionately affect women's daily management responsibilities. The need to buy water, increase transportation costs, or adjust food consumption patterns requires constant financial negotiation within the household. Women are usually the first to reorganize consumption, reduce non-essential expenses, and absorb shortages through unpaid substitution labor. This may include using less water for personal needs, reducing dietary diversity, or increasing time spent preparing food under constrained conditions. These strategies may enable short-term survival, but they also reveal how women internalize economic shocks through intensified domestic management.

The findings further suggest that village-level aid distribution and support mechanisms do not always adequately recognize women as economic actors. Assistance programs, when available, are often mediated through male household heads or community structures in which women have limited influence. This reduces women's direct access to information and resources, and may weaken their bargaining position within households and communities. Such conditions are important because they show that economic vulnerability during drought is closely tied to institutional arrangements and power relations, not merely to environmental hardship [34]. Women's exclusion from formal channels of support can deepen their dependence and make recovery more difficult.

From a broader gender and disaster perspective, these results reinforce the argument that women's economic vulnerability is produced at the intersection of ecological stress and social inequality [11,12,28]. Drought reduces livelihood stability, but gendered norms determine who manages scarcity, who absorbs household shocks, and who remains invisible in official support systems. In Kebonharjo, women's economic vulnerability is therefore both material and relational: material because it affects income and expenditures, and relational because it is structured by unequal access to productive resources and institutional support.

These findings suggest that addressing drought-related economic vulnerability requires more than temporary relief. Policies need to strengthen women's access to livelihood diversification, local economic institutions, and village-level assistance mechanisms that recognize them directly as economic decision-makers. Without such interventions, drought will continue to magnify women's unpaid labor and precarious economic roles, undermining both household welfare and long-term community resilience.

3.1.3. Vulnerability of access and control.

One of the most significant findings of this study is that women's vulnerability in Kebonharjo is not limited to physical hardship or economic stress, but also includes restricted access to and control over decision-making processes related to water and drought governance. Although women are the primary managers of household water use and are among the first to confront the practical consequences of scarcity, they remain marginal in formal village discussions concerning water infrastructure, aid distribution, and local disaster risk management. This disconnect between responsibility and authority is a central feature of gendered vulnerability in the study area.

Most informants indicated that they had little or no substantive involvement in village meetings related to water access, drought response, or development planning. Even when

women attended village forums, their presence was often symbolic rather than influential. Their practical knowledge about water-saving strategies, seasonal patterns, and household priorities was rarely sought as part of collective planning. This indicates that women's participation is still framed in terms of formal inclusion rather than meaningful representation. As a result, decision-making remains dominated by actors who are more distant from the everyday management of water scarcity.

This finding is important because it demonstrates that drought vulnerability is deeply connected to power relations. From a Gender and Development perspective, women's subordination is maintained not only through labor divisions but also through exclusion from institutional arenas where priorities are defined and resources are allocated [23]. In Kebonharjo, women may be central to the survival of households during drought, but this centrality does not translate into policy influence. Their lived experiences remain outside formal governance systems, which limits the responsiveness and effectiveness of local interventions.

The study also confirms arguments from feminist political ecology and gendered knowledge frameworks that women's knowledge is often devalued because it emerges from domestic and everyday practices rather than from technical or bureaucratic institutions [16,25]. In the case of Kebonharjo, women possess detailed knowledge about which types of water can be reused, how far water must be carried, how household priorities shift during scarcity, and how social support can be mobilized in times of crisis. However, such knowledge is rarely considered legitimate in village governance. This creates an epistemic gap in which the most relevant experiential knowledge remains unrecognized.

The consequences of this exclusion are substantial. When village-level decisions are made without incorporating women's perspectives, policies may fail to address the practical realities of water access and household survival. For example, decisions about water storage, infrastructure placement, or aid mechanisms may not reflect actual usage patterns or the burdens involved in water collection. This can lead to interventions that are technically visible but socially incomplete. In this sense, the lack of women's control is not only an issue of fairness, but also one of policy effectiveness.

The findings further show that limited access and control contribute to the reproduction of women's dependency within drought governance. Because women have little institutional authority, they must rely on informal negotiation, household-level improvisation, and community solidarity to cope with water shortages. While these practices may be adaptive, they do not replace the need for formal recognition and participation. Instead, they reveal how women compensate for exclusion through unpaid and informal mechanisms. Over time, this can normalize the idea that women's role is to cope rather than to shape policy.

From a social vulnerability standpoint, restricted access and control should be seen as structural drivers of risk [4,24]. Vulnerability is heightened when those most affected by a hazard are excluded from decisions about preparedness, response, and adaptation. In Kebonharjo, women's limited influence over drought-related governance reduces their capacity to transform their own conditions, even when they possess the knowledge and motivation to do so. Thus, control over resources, voice in public forums, and recognition of local expertise are all essential components of resilience.

These findings suggest that strengthening community resilience requires a shift from tokenistic participation toward substantive inclusion. Village governance mechanisms need to

create spaces in which women can articulate priorities, contribute to planning, and influence implementation. This is particularly important in drought-prone contexts, where household-level knowledge is critical to designing realistic and sustainable adaptation strategies. Unless women's access and control are improved, local drought governance will remain partial and gender-biased, limiting its capacity to support equitable and effective adaptation.

3.2. Wastewater management as local wisdom-based adaptation.

The findings show that women in Kebonharjo Village have developed a range of local wisdom-based water management practices as part of their everyday adaptation to drought. These practices are not limited to technical water-saving measures, but also reflect accumulated ecological knowledge, household-level decision-making, and socially embedded strategies for sustaining water use under conditions of scarcity. A summary of these practices is presented in Table 2.

Table 2. Summary of women's local wisdom-based water management practices in Kebonharjo Village.

Type of practice	Description of the activity	Environmental benefit	Potential policy relevance
Wastewater reuse	Women selectively reuse household wastewater, such as water from washing rice, vegetables, kitchen utensils, and in some cases laundry, for watering plants, cleaning yards, and supporting small-scale household production.	Reduces freshwater consumption, extends the utility of available water, and minimizes household water waste during drought.	Can be integrated into village-level drought adaptation programs, household water conservation campaigns, and gender-responsive community training.
Rotational water collection	Women organize the timing and frequency of water collection according to household needs, source availability, and daily routines during the dry season.	Helps regulate pressure on limited water sources and improves household water allocation under scarcity conditions.	Relevant for community-based water management planning and for designing locally appropriate drought response mechanisms.
Household water rationing	Women prioritize water use for essential needs such as drinking, cooking, and caregiving, while reducing or postponing less urgent uses during periods of shortage.	Encourages efficient water use and supports short-term household water security during prolonged dry periods.	Can inform public education on water-saving behavior and strengthen household-level drought preparedness strategies.
Small-scale water storage	Women store water in containers for later use in domestic and productive activities, especially when access to water sources becomes uncertain.	Increases short-term water availability and helps households cope with interruptions in water access.	Can be supported through local programs promoting safe and low-cost household water storage infrastructure.
Ecological knowledge of seasonal indicators	Women observe environmental signs, seasonal patterns, and changes in local water conditions to anticipate drought and adjust water use practices.	Supports anticipatory adaptation and improves local responsiveness to changing environmental conditions.	Important for integrating local ecological knowledge into participatory drought risk reduction and village planning.

As shown in Table 2, women's local wisdom-based practices in water management are not merely routine domestic responses, but constitute adaptive strategies with environmental, social, and practical significance. These practices demonstrate how women translate everyday experience and ecological knowledge into concrete forms of drought adaptation. At the same time, the table shows that such practices have broader policy relevance, particularly for strengthening gender-responsive, community-based, and locally grounded approaches to drought risk reduction. These dimensions are discussed further in the following subsections.

3.2.1. Everyday adaptation and ecological knowledge.

Despite the considerable vulnerabilities they face, women in Kebonharjo also demonstrate strong adaptive capacity through a range of everyday strategies rooted in local wisdom and practical ecological knowledge. One of the most notable findings of this study is the role of household wastewater management as an adaptive response to drought. Rather than treating used water as waste, women selectively reuse water from washing rice, vegetables, kitchen utensils, and in some cases laundry, for purposes such as watering plants, cleaning yards, or supporting small-scale household production. This practice reflects a careful and context-sensitive approach to resource management under conditions of scarcity.

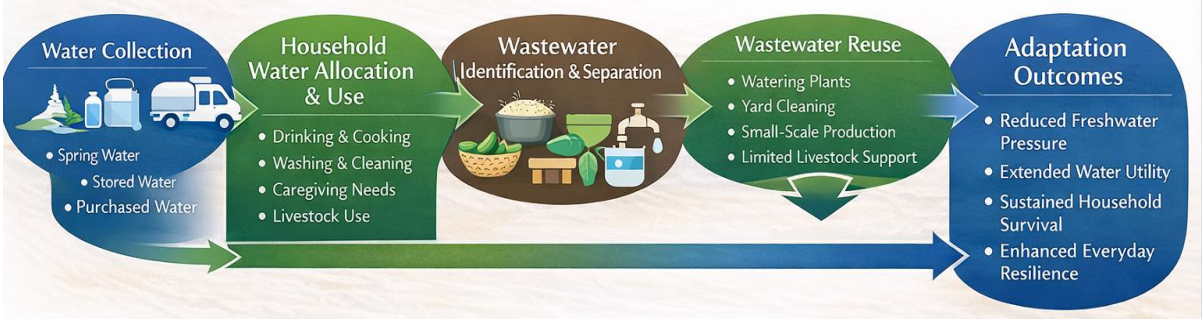

Figure 2. Household water management and reuse cycle practiced by women in Kebonharjo Village during drought.

As illustrated in Figure 2, household water management in Kebonharjo follows a cyclical process in which women play a central role in collecting, allocating, using, and selectively reusing water for secondary purposes. This cycle demonstrates how women extend the utility of limited water resources through practical ecological knowledge and everyday decision-making. Such practices reduce pressure on scarce freshwater sources while sustaining household needs during drought conditions.

The significance of this practice lies not only in its utility, but also in what it reveals about women's adaptive agency. Wastewater reuse is based on daily judgment, accumulated experience, and contextual knowledge of what types of water remain usable, for which purposes, and under what conditions. Women make continual decisions about prioritization, safety, household needs, and environmental constraints. These decisions are not random or merely habitual; they are forms of applied ecological reasoning grounded in the realities of water scarcity. Thus, wastewater management should be understood as a knowledge-based adaptation strategy rather than as a simple coping behavior.

The findings indicate that such practices are often learned informally and passed down across generations through observation, family interaction, and shared experience within the community. Women acquire knowledge about water conservation from mothers, older relatives, neighbors, and everyday experimentation. In this sense, adaptation is embedded in social reproduction. It is developed not through formal training programs, but through repeated engagement with drought conditions and through the transfer of practical wisdom in daily life. This intergenerational dimension is important because it shows that local adaptation is sustained through community-based knowledge systems rather than through external technical interventions alone.

In addition to wastewater reuse, women also employ other forms of local wisdom-based adaptation, including rotational water collection, household water rationing, small-scale storage practices, and ecological observation of seasonal indicators. These strategies are interconnected. Wastewater reuse is not practiced in isolation, but as part of a broader adaptive

logic aimed at maximizing the utility of every available water source. This reflects what recent literature describes as gendered adaptation: forms of resilience built through women's everyday labor, social coordination, and environmental knowledge [26,27,29].

The findings also suggest that local adaptation in Kebonharjo is shaped by the specific ecological and topographical conditions of the village. Because the community experiences uneven access to springs and a high dependency on seasonal water availability, women have developed highly contextual responses. These responses do not rely on expensive technologies or large-scale infrastructure, but on flexibility, discipline, and collective adjustment. Such practices are especially significant in rural drought-prone settings where formal systems are weak or insufficient. In this regard, wastewater management emerges as a low-cost but meaningful strategy for strengthening household resilience.

From a theoretical perspective, these findings resonate with feminist political ecology, which emphasizes that environmental management is deeply shaped by everyday gendered interactions with nature and resources [25]. Women's adaptation practices in Kebonharjo demonstrate that local ecological knowledge is not peripheral, but central to how communities cope with environmental stress. Their actions reveal an understanding of water not only as a natural resource, but as something that must be circulated, prioritized, and socially managed. This expands the interpretation of adaptation beyond technical measures to include routine practices that sustain life under difficult conditions.

The novelty of this finding lies in positioning wastewater management as a form of gendered adaptation rooted in local wisdom. In many discussions of drought resilience, wastewater reuse is treated as a technical water-efficiency strategy. However, in Kebonharjo it also has social and cultural meaning: it reflects women's role as guardians of household continuity, managers of scarcity, and carriers of environmental knowledge. Recognizing this broader meaning is important because it shifts policy attention from infrastructure alone toward the everyday practices that make resilience possible at the household level.

Recent scholarship further supports this interpretation. Studies on rural women's climate adaptation show that women often develop resilience through combinations of local environmental knowledge, domestic innovation, and social cooperation [26,39]. Broader reviews of adaptation in water-scarce settings also identify water reuse and decentralized management practices as important pathways toward resilience, especially where centralized infrastructure is limited [30]. In line with these insights, the Kebonharjo case demonstrates that adaptation does not always begin with formal projects; it often begins with women's practical efforts to reconfigure household water use under pressure.

Therefore, wastewater management in Kebonharjo should be understood as both an adaptive technique and a social process. It is adaptive because it extends the usability of scarce water resources. It is social because it depends on gendered labor, household negotiation, and shared local knowledge. This combination makes it a particularly important entry point for understanding how resilience is built in everyday life and how local wisdom can contribute to more inclusive drought governance.

3.2.2. Social and cultural barriers to recognition.

Although women's local wisdom-based adaptation is highly relevant to drought resilience, the study found that these practices remain weakly recognized in formal village institutions and policy processes. This lack of recognition is not simply an administrative oversight; it is shaped

by broader social and cultural barriers that determine whose knowledge is considered valuable, whose voice is heard in public forums, and which forms of adaptation are treated as legitimate. In Kebonharjo, women's everyday strategies are widely practiced and socially important, yet they continue to occupy a marginal position in formal drought governance.

One of the main barriers is the persistence of gender norms that position women primarily as implementers of domestic responsibilities rather than as contributors to public decision-making. Because wastewater reuse, water rationing, and seasonal observation are embedded in daily household labor, these practices are often perceived as ordinary domestic behavior rather than as forms of environmental expertise. As a result, they do not easily enter the language of policy or village development planning. This reflects a broader pattern in which knowledge associated with women's everyday work is undervalued because it is seen as practical, informal, and non-technical [16].

The findings suggest that this devaluation has both symbolic and institutional consequences. Symbolically, it reduces the public visibility of women's contribution to drought adaptation. Institutionally, it limits the possibility that their strategies will be supported, scaled, or integrated into formal programs. Several informants indicated that while they regularly practice water-saving and reuse strategies, these efforts are rarely discussed in village meetings and are not treated as part of official resilience measures. In this sense, women's adaptation remains socially necessary but politically invisible.

This invisibility can also be linked to what feminist scholars describe as the marginalization of gendered knowledge systems [16,25]. Knowledge produced through domestic labor and local experience is often excluded from formal decision-making because it does not conform to dominant ideas of technical expertise. In village governance, this may mean that infrastructure-oriented or externally framed solutions are prioritized, while everyday community-based adaptation receives less attention. Such a hierarchy of knowledge can weaken the overall quality of drought governance because it overlooks practices that are already functional, affordable, and socially embedded.

The study also found that cultural norms influence women's willingness and ability to articulate their knowledge in public spaces. In some cases, women hesitate to speak in meetings because they assume their perspectives will not be prioritized or because public discussion is still culturally associated with male authority. This does not mean women lack opinions or ideas; rather, it indicates that the structure of public participation is not yet conducive to the expression of their knowledge. Consequently, women's silence in formal settings should not be interpreted as a lack of competence, but as an outcome of unequal communicative and institutional conditions.

Another barrier concerns the absence of documentation and formalization. Because many local adaptation practices are transmitted orally and enacted through routine behavior, they remain difficult to identify within administrative systems that privilege written plans, measurable outputs, and formal programs. Yet the absence of documentation should not be mistaken for the absence of value. On the contrary, the findings show that these practices are central to household resilience precisely because they are embedded in everyday routines and collective memory. What is lacking is not substance, but recognition.

These barriers matter because they limit the possibility of transforming women's local wisdom into a broader resource for community resilience. Without formal acknowledgment, adaptation remains individualized and dependent on personal initiative. This can make it

fragile, especially when younger generations are less exposed to traditional practices or when changing socio-economic conditions disrupt informal learning processes. Therefore, policy support is needed not only to recognize existing practices, but also to sustain and strengthen them over time.

Recent literature increasingly emphasizes the importance of indigenous and local knowledge in climate adaptation, particularly when such knowledge is linked to gendered roles in food, water, and environmental management [27]. Similarly, adaptation policy reviews stress that resilience becomes more effective when it integrates community practices and decentralized forms of knowledge rather than relying exclusively on top-down technical solutions [30,31]. The Kebonharjo case supports this argument by showing that women's adaptation strategies already provide a foundation for resilience, but one that remains institutionally underutilized.

In summary, the barriers faced by women in gaining recognition for their adaptation practices are social, cultural, and epistemic. They involve unequal norms of participation, unequal valuation of knowledge, and weak institutional mechanisms for incorporating local wisdom into planning. Addressing these barriers is essential if village-level drought governance is to become more inclusive, context-responsive, and sustainable. Recognition of women's local wisdom is therefore not only a matter of gender justice, but also a practical requirement for improving the effectiveness of adaptation policy.

3.3. Implications for gender-responsive disaster risk reduction policy.

3.3.1. Women's participation and representation.

The findings of this study indicate that one of the central weaknesses in local drought governance in Kebonharjo lies in the limited substantive participation of women in decision-making forums. Although women are deeply involved in managing the direct impacts of drought at the household level, this centrality is not reflected in their representation within formal village structures. Their role in policy processes remains relatively weak, and their participation, when present, is often symbolic rather than transformative. This gap between lived experience and institutional authority has significant implications for the effectiveness and fairness of local disaster risk reduction.

The evidence gathered during the study suggests that village meetings related to water access, infrastructure, and disaster response do not yet function as inclusive spaces where women's knowledge can shape collective decisions. Women may attend meetings, but attendance alone does not guarantee influence. Many informants indicated that they were rarely invited to speak on technical or planning issues, despite being the primary household managers of water scarcity. This reflects a persistent governance pattern in which public decision-making remains associated with male authority, while women's expertise is confined to the domestic sphere.

Such a condition is problematic from both gender and policy perspectives. From a gender perspective, it reproduces structural inequality by keeping women responsible for survival but excluded from power [23]. From a policy perspective, it weakens the quality of local decision-making because it excludes those with the most direct and practical understanding of drought impacts. Women know how scarcity is negotiated in everyday life, how water is allocated among competing needs, which coping strategies are sustainable, and what forms of support

are actually useful at the household level. Excluding this knowledge reduces the capacity of village policy to respond to real conditions on the ground.

The findings support the argument that participation should not be measured merely by numerical presence, but by the extent to which women can influence agendas, priorities, and outcomes. Gender-responsive disaster risk reduction requires institutional mechanisms that move beyond token inclusion and create meaningful avenues for women's representation. This includes involving women in water planning committees, local disaster management teams, and village development deliberations in ways that recognize them as legitimate contributors rather than supporting actors. Without such mechanisms, village governance risks reproducing gender bias while claiming to be participatory.

Another important point is that women's participation is closely linked to the recognition of their knowledge. Representation is not only about who sits in meetings, but also about what kinds of experience are considered relevant in public deliberation. In Kebonharjo, women's everyday adaptation strategies such as wastewater reuse, water prioritization, and ecological observation—provide valuable information for planning drought responses. When these practices are ignored, local governance loses access to an important source of context-sensitive insight. Therefore, improving women's participation must also involve changing the epistemic boundaries of policy so that local and experiential knowledge are treated as valid inputs.

The study also suggests that strengthening women's participation could have wider social effects beyond drought management itself. Greater representation in village forums may enhance women's confidence, expand their public roles, and improve inter-household communication about adaptation strategies. In this sense, participation is not only an institutional right, but also a process of empowerment that can strengthen community resilience more broadly. When women are able to articulate priorities, negotiate needs, and shape local decisions, resilience becomes more inclusive and socially grounded.

Thus, the issue of participation in Kebonharjo should be seen as a strategic entry point for improving gender-responsive drought governance. Formal commitments to gender mainstreaming will remain limited in impact unless they are translated into village-level mechanisms that ensure women's voice, authority, and recognition. Participation must therefore be designed as substantive involvement in planning, implementation, and evaluation not merely as attendance in pre-existing forums.

3.3.2. Policy relevance beyond the case study.

Although this study is based on a specific case in Kebonharjo Village, its findings have broader implications for drought-prone rural areas facing similar socio-ecological conditions. The vulnerabilities and adaptive responses documented in this research are not unique to one locality; they reflect wider patterns found in communities where water scarcity intersects with gendered labor divisions, limited infrastructure, and underrecognized local knowledge. For this reason, the case provides useful insights for developing scalable models of gender-responsive drought governance beyond the immediate research site.

A major contribution of this study is its identification of wastewater management as a practical and socially embedded adaptation strategy that can be incorporated into broader resilience planning. In many rural areas, large-scale water infrastructure may be costly, unevenly distributed, or difficult to maintain. Under such conditions, low-cost household and community-based adaptation measures become especially important. The Kebonharjo findings

suggest that wastewater reuse, combined with water-sharing practices, simple storage systems, and local seasonal knowledge, can form part of a realistic adaptation framework for villages with constrained resources. These strategies are not substitutes for infrastructure investment, but they can complement formal responses by strengthening everyday adaptive capacity.

The policy relevance of this finding lies in its potential for replication. A scalable model inspired by the Kebonharjo case would include at least three interrelated dimensions. First, local governance should recognize women's knowledge and adaptation practices as legitimate components of drought management. Second, village institutions should ensure women's substantive participation in planning and implementation processes. Third, support should be provided for low-cost, locally appropriate adaptation measures that are already socially practiced, such as wastewater reuse, household water allocation strategies, and community-based mutual support mechanisms. Together, these dimensions offer a governance approach that is both gender-responsive and grounded in local realities.

Recent literature supports the need for such integrated approaches. Studies on gender and climate adaptation increasingly show that effective resilience depends not only on technical interventions, but also on social inclusion, knowledge recognition, and locally rooted practices [30–34]. Reviews of adaptation in low- and middle-income contexts likewise emphasize that decentralized and community-based measures can play an essential role in water security, especially where state capacity and infrastructure are limited [30]. The Kebonharjo case aligns with these findings by demonstrating that adaptation is strongest when formal and informal systems are connected rather than treated as separate domains.

Another important policy implication concerns the way village-level disaster risk reduction is conceptualized. In many settings, drought response is still dominated by short-term emergency delivery such as water aid or temporary logistical support. While such measures are necessary during acute shortages, they do not necessarily strengthen long-term resilience. The findings of this study suggest that resilience planning should also include institutional recognition of household-based adaptation, capacity-building for women's groups, and the integration of local practices into formal policy documents. This would allow drought governance to become more preventive, participatory, and context-specific.

The scalability of this model also lies in its flexibility. The precise form of women's local wisdom may differ from one village to another, depending on ecological conditions, cultural patterns, and livelihood systems. However, the broader principle remains applicable: adaptation policy becomes more effective when it recognizes the people who manage scarcity on a daily basis and the practices they have developed over time. In this regard, the Kebonharjo case provides not a rigid formula, but a transferable framework for designing inclusive drought policy in other rural settings.

From a theoretical standpoint, these findings reinforce the value of linking social vulnerability theory with Gender and Development perspectives. Social vulnerability theory helps explain why drought impacts are unevenly distributed across groups, while Gender and Development clarifies how those inequalities are organized through power relations, labor structures, and decision-making systems [4,23,24]. The addition of local wisdom-based adaptation to this framework enriches the analysis by showing that vulnerable groups are not only exposed to risk, but also produce valuable forms of resilience. This is especially important for policy design because it challenges deficit-based narratives that portray women only as victims rather than as knowledge holders and adaptive actors.

In practical terms, the study suggests that future village-level drought policies should include explicit indicators of women's participation, mechanisms for documenting and disseminating local adaptation practices, and support for community-based experimentation in water management. Such measures would not only improve gender equity, but also strengthen the sustainability of local adaptation. Therefore, the broader significance of the Kebonharjo case lies in demonstrating that effective drought governance requires attention to everyday practices, local knowledge, and gendered power relations at the same time.

Overall, the policy lesson from this study is clear: drought resilience in rural areas cannot be built solely through technical infrastructure or emergency response. It must also be constructed through inclusive institutions, recognition of local wisdom, and support for the gendered practices that sustain everyday life under conditions of scarcity. In this sense, the Kebonharjo case offers a meaningful contribution to the development of more grounded, equitable, and scalable disaster risk reduction policies.

4. Conclusions

This study shows that drought in Kebonharjo Village produces multidimensional vulnerability for women, encompassing physical, economic, social, and structural dimensions. Women bear a disproportionate burden because they are primarily responsible for household water management while also sustaining caregiving and productive roles under conditions of limited water access. At the same time, the findings demonstrate that women are not merely passive victims of drought but active agents of adaptation who develop context-based strategies through wastewater reuse, rotational water collection, and ecological knowledge of seasonal indicators. The key contribution of this study lies in highlighting wastewater management as a gendered adaptation strategy rooted in local wisdom, thereby extending social vulnerability and Gender and Development perspectives within the context of rural drought governance. Practically, the study suggests that women's informal knowledge should be recognized as a valuable resource for strengthening household and community resilience. From a policy perspective, village-level disaster risk reduction should move beyond infrastructure-oriented responses by creating inclusive participation mechanisms, integrating women's local practices into formal planning, and promoting gender-responsive drought governance that can be adapted in other drought-prone rural areas.

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Author Contribution

The authors contributed to this study in various roles. Yuniarta Vuspita and RR. Susilastuti Dwi Nugrahajati were responsible for conceptualization, methodology, and data analysis. Data collection was carried out by Yuniarta Vuspita, Arif Rianto Budi Nugroho, Yohana Noradika Maharani, Johan Danu Prasetya, and Ficky Adi Kurniawan. The original draft was prepared by Yuniarta Vuspita and Ficky Adi Kurniawan, while all authors participated in reviewing and editing the manuscript. Supervision was provided by RR. Susilastuti Dwi Nugrahajati, and funding acquisition was secured by Yuniarta Vuspita. Overall, Yuniarta Vuspita served as the main contributor, leading most aspects of the research, while the co-authors provided essential support in data collection, discussion, and manuscript refinement.

Competing Interest

The authors declare that there are no financial, personal, or professional relationships that could be construed as potential conflicts of interest in relation to this study. All authors confirm that the research was conducted independently and objectively. No external influence has affected the design, analysis, or reporting of this work.

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