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GENDER ROLE TRANSFORMATION IN VILLAGE FOREST MANAGEMENT THROUGH DIGITAL APPLICATIONS: A CASE STUDY OF VILLAGE FOREST MANAGEMENT INSTITUTION

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ABSTRACT

This study departs from the observation of the use of digital applications in village forest management, where women are more active in data collection and communication, reflecting the beginning of gender role transformation in village forest management in Kuala Indragiri Sub-district, Indragiri Hilir District. It investigates how digitalization affects women's participation in village forest management institutions (VFMI) and how sociocultural norms shape the gender digital divide. Using a mixed-methods case study in two mangrove coastal villages - Sapat and Sungai Piyai Village - the research combines surveys, in-depth interviews, participant observation, meaning that the higher the gender digital divide, the lower the role of women in institutions. Men dominating technical applications such as Avenza Maps (mapping), while women limited to administrative or communication tools WhatsApp and KoboToolbox (online surveys). Although limited, women's involvement in training and the use of digital applications is beginning to open space for recognition of their strategic role in village forest governance, reflecting the potential for gender transformation. Affirmative and intersectional strategies are needed, to minimize the reproduction of existing gender gaps. This study contributes to the discourse on inclusive digital transformation by highlighting the importance of overcoming structural and cultural barriers in social forestry programs. The findings also have the potential to be replicated in other coastal communities that face similar challenges in digitalization and gender inequality.

INTRODUCTION

The digitization of natural resource management at the community level promises efficiency, transparency and participation. In reality, this process often reproduces existing inequalities, particularly along gender dimensions. In many rural communities, including Kuala Indragiri sub-district (Kuindra), women face barriers in accessing technology, attending training, and being involved in decision-making related to forest management. This inequality undermines the contribution of women who have played an important role in the utilization of non-timber forest products, such as processed nipah leaves and river catches.

Digitalization is the process of transformation from analog to digital forms (Asaniyah, 2017; Isabella et al., 2023), which now includes the way knowledge is produced and disseminated through digital media (Lindgren, 2017). The availability of devices and the internet has expanded access to information, including in rural areas (Yunaningsih et al., 2021; Heeks, 2022), gaps in infrastructure inequality and digital literacy have persisted, leaving significant disparities (Wijoyo et al., 2020; D'Ignazio & Klein, 2020; Ortner, 2005). In the context of village forests, digitalization is starting to be integrated into community institutions. The use of technologies such as Kobo ToolBox (for harvest data collection), Avenza Maps (for spatial mapping) and WhatsApp (for communication) contributed to improved efficiency (Aristoteles et al., 2022). The government also encourages this approach through policies such as Minister of Environment and Forestry Regulation No. 9 of 2021.

In Sapat Village and Sungai Piyai Village, the establishment of Village Forest Management Institution (VFMI) as the implementer of Social Forestry scheme opened new opportunities for participatory forest management. However, administrative and technical demands, including the use of digital applications such as the KoboToolbox App and Avenza Maps App precisely show the inequality of participation. The digital training was only attended by men representing village forest management institutions with access to digital devices and literacy. In contrast, women and older adults, despite their involvement in the management and utilization of village forest resources, were excluded. This phenomenon reflected what Van Dijk (2006) conceptualized as the digital divide along four dimensions: motivation, access to devices, digital skills, and actual usage (Van Dijk, 2006)

Although not explicitly mandated in national policy, digitalization had become a practical necessity in the institutional reporting system of the VFMI. Activities such as forest patrol documentation, fisherfolk catch data collection, and daily reporting were increasingly conducted through digital means most notably through photo submissions and online forms via WhatsApp and KoboToolbox. The field data collected by VFMI members were later processed by NGO facilitators to generate formal reports submitted to the relevant authorities. The process revealed that digital transformation functioned not only as a technical instrument but had also been incorporated into the routine institutional practices of community forest governance. Nonetheless, unequal access to devices and digital skills particularly among women and the elderly rendered this process vulnerable to structural forms of social exclusion. These findings were based on field observations and in-depth interviews with VFMI staff and facilitators in both study sites during the 2024–2025 research period.

Patriarchal norms had limited women's access to decision-making and technology, including Information and Communication Technology (ICT). This inequality was reflected in the concept of the digital divide unequal access to technology in terms of motivation, devices, capacity, and actual use (Antonio & Tuffley, 2014). Hafkin & Huyer (2008) extend this concept into the gender digital divide, which highlights the disparities in access, use, and impact of ICTs based on gender. However, ICT also opens opportunities for women to challenge patriarchal domination through the use of digital media as an arena for gender struggle (Wahyudi & Kurniasih, 2022; Fajar, 2021). In this context, technology is not just a tool, but a field of contestation and reimagination of women's social roles.

Climate change and environmental degradation had generated new forms of vulnerability for coastal communities dependent on mangrove ecosystems, as highlighted by Widiono et al. (2024). In the context of mangrove management digitalization, international studies had demonstrated the significant potential of technology for environmental conservation and improving community well-being (Xiang et al., 2023; Xiong et al., 2024). However, this potential could only be realized inclusively if all social groups had equal access to and capacity for using technology. Otherwise, risked reinforcing social exclusion, particularly for women who were often excluded from decision-making processes (Genz & Schnabel, 2023; Linao et al., 2024). To understand these inequalities, this study adopted the framework proposed by Hafkin & Huyer (2008) formulated four main components: decision-making and policy, content, skills, and connectivity, consisting of 18 structural indicators. Factors inhibiting equal access include limited technology education, domestic workload, social norms, economic constraints, and gender-biased institutions (Antonio & Tuffley, 2014; Wajcman, 2004; Bokonda et al., 2020).

This research contributes to filling a gap in the existing literature, which has largely concentrated on the efficiency of digitalization in the environmental sector, with limited exploration of how these processes reshape power dynamics and gender roles within village-level institutions. Few studies had explicitly linked the distribution of digital application use to gender inequality within the context of social forestry institutions in Indonesia. Moreover, there was a lack of critical evaluation of how forestry digitalization policies such as Ministry of Environment and Forestry Regulation No. 9/2021 promoted the integration of administrative and data-based technical approaches into social forestry schemes. These policies potentially had different impacts on men and women in coastal communities with high structural vulnerabilities. Therefore, this study offered a new contribution to both academic literature and policy practice by investigating, in a contextualized manner, how digitalization served either as a field for gender transformation or as a mechanism for reinforcing existing inequalities at the grassroots level.

Accordingly, the research aimed to answer the following main questions: how did transformation of gender roles occurs within the digitalization of village forest management processes?, how did local dynamics influence opportunities, barriers and forms of participation in this context?. The findings of this research were expected to inform the development of more inclusive and gender-responsive policies regarding the digital divide at the institutional level in rural communities. These issues were explored through case studies in two coastal mangrove villages located in Kuala Indragiri District.

RESEARCH METHOD

This study was grounded in an interpretive paradigm, which views social reality as an intersubjective construction formed through experience, meaning and social interaction (Turyahikayo, 2021). A constructivist approach was employed to explore the dynamics of meaning-making within local digitalization processes, particularly in relation to gender in community forest governance.

The research design adopted a mixed-methods case study approach (Creswell & Clark, 2018), with a primary emphasis on qualitative data to interpret the social meanings of digitalization practices at the local level. The constructivist paradigm was operationalized through in-depth interviews and participatory observation to explore experiences, perceptions, and the symbolic construction of gender roles in the use of technology. The analytical attention was directed toward exploring how women and men perceived and reacted to the presence of digital applications in relation to social norms, institutional legitimacy, and power relations within the VFMI structure.

Quantitative data were then employed to identify relational patterns among variables, including the correlation between the digital gender gap and women's levels of participation. The integration of methods was carried out during the analysis stage: quantitative data were used to map participation trends and the distribution of digital technology use (e.g., Avenza Maps and KoboToolbox), while qualitative data offered insights into the social context, gender symbolism, and narratives underlying the numerical results.

This approach is informed by the Articulation Between Quantitative and Qualitative Anticipatory Methods (AQQAM) framework (Jahel et al., 2023), which highlights the importance of reflective integration between quantitative and qualitative findings when addressing complex socio-ecological issues. In this study, the AQQAM framework was applied by connecting quantitative indicators, including policy and decision making, content, capabilities, connectivity, access to digital applications, gender participation, and socio cultural norms, with qualitative data that examined actors' interpretations and experiences related to unequal access to and use of technology. Through this approach, the research examined not only the extent of the digital gap but also the reasons behind its existence, the ways it is negotiated, and the implications for women's roles in forest governance institutions. In this context, AQQAM is particularly relevant because it links objective data with subjective meanings, enabling a more contextual and policy relevant understanding. This approach facilitated the formulation of evidence-based recommendations that were not only technocratic, but also sensitive to social structures and gender norms at the grassroots level aligned with the study's objective to strengthen more just, digital, and inclusive village institutional systems.

The research was conducted in Sapat Village and Sungai Piya Village, Kuala Indragiri Sub-district, each of which has an active Village Forest Management Institution (VFMI). The study population included all VFMI administrators based on the Decree of the Ministry of Environment and Forestry (KLHK), totaling 34 people, with an organizational structure that included all VFMI board members except the VFMI Chairperson. The sampling strategy followed a non-probability sampling approach (Neuman, 2014), applying total sampling for VFMI members and

purposive sampling for key informants from government elements, VFMI leaders, and NGOs involved as facilitators.
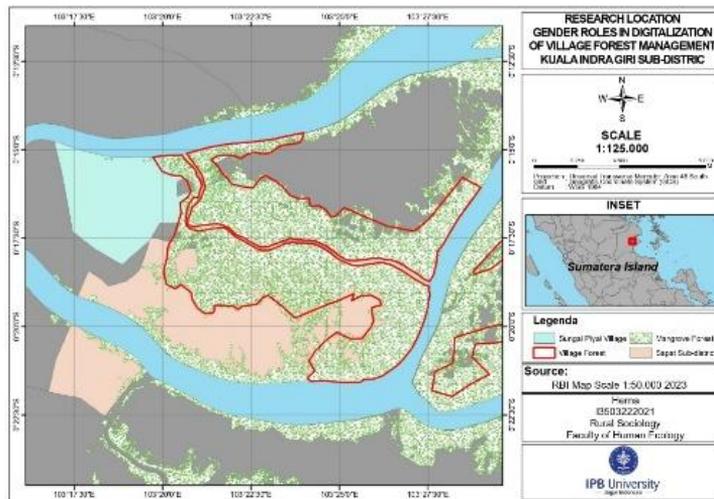

Figure 1.
Map of Research Location

Indicators measuring the gender-based digital divide are explained through four points, namely: (1) decision and policy making, namely women's involvement in ICT policy training and research; (2) content, related to access to gender-responsive digital; (3) skills, including digital literacy and mastery of technology; and (4) connectivity, namely access to digital devices and networks. The dependent variable in this study is the role of gender in VFMI, which refers to two main dimensions accord ance with the Minister of Environment and Forestry Regulation No. 9 of 2021 Article 7, namely institutional aspects and activity programs (Zahra et al., 2024). Institutional participation included involvement in planning, evaluation, and communication, while program-based participation referred to field activities such as patrolling, coordination, and utilization of forest products. Quantitative data was collected through a survey with a 1-4 Likert scale questionnaire (1 = Strongly Disagree, 4 = Strongly Agree), which measured gender participation and the digital divide.

Quantitative data analysis was conducted using several statistical tests. Construct validity was assessed through Pearson correlation between each indicator and the total score. In the variable of Gender Digital Divide, all sub-variables showed very strong and significant correlations ($r > 0.87$, $p < 0.01$), while the variable of Gender Roles in Institutions also demonstrated significant correlations ($r > 0.43$, $p < 0.05$). Reliability was tested using Cronbach's Alpha, yielding 0.906 (GDD; N = 4) and 0.714 (Gender Roles; N = 2). Data distribution was examined through descriptive statistics, showing that most variables were normally distributed (skewness and kurtosis within ±1). Hypothesis testing employed Spearman correlation (Bonett & Wright, 2000; Zahriyah et al., 2021). In addition, a Chi-Square test was used to examine the relationship between gender and the use of digital applications, and an Independent Samples t-Test was applied to compare attitudes toward sociocultural

norms between two groups. Statistical formulas such as Spearman, Chi-Square, and t-Test were included to clarify the analytical approach used.

Qualitative data were obtained through in-depth interviews and participant observation to explore the social roots of the digital divide and its implications for gender roles in forest management. A total of 16 informants were interviewed, including former and current VFMI leaders (4 informants), female VFMI members from both the former and current administrations (4 informants), NGO field facilitators (3 informants), village government officials (2 informants), and one sub-district official. Informants were selected using purposive sampling based on their roles in digital application usage and institutional decision-making, in order to explore their experiences, narratives, and perceptions of digitalization and women's participation. Observations were carried out during various institutional activities such as forest patrols and hands-on training sessions involving the use of digital applications.

Qualitative data analysis was conducted using the interactive model of Miles and Huberman (Suwarti et al., 2015), which involved data reduction, data display, and conclusion drawing. The validity and credibility of the data were maintained through source triangulation strategiesValidation was conducted by cross checking information from multiple data sources and institutional documents, such as leadership decrees, attendance records, and WhatsApp communication archives, and by confirming the findings through direct field observation. The unit of analysis in this study was the individual, with the aim of examining the roles of men and women in the use of information and communication technology within VFMI. The distribution of gender roles was analyzed using the distribution formula proposed by Hafkin and Huyer (2008), combined with narrative data presentation and interpretive conclusions. Interpretations were developed by integrating personal narratives, socio cultural contexts, and the gendered positions of informants, enabling the meanings of roles and barriers in digitalization to be understood within their broader context.

This study also recognized several limitations. The use of total sampling for VFMI members and purposive sampling for key informants was considered appropriate for an exploratory study, yet it did not allow the findings to be statistically generalized to a broader population. In addition, the use of Likert scales to measure gender participation and the digital divide, both of which represent complex social constructs, may have simplified the nuanced realities that exist in practice. Despite these limitations, the mixed methods approach provided an interpretive complement to the qualitative data, allowing the contextual richness of social dynamics to be maintained. Several statistical tests, including correlation, chi square, and t tests, were applied to support the analysis. However, more advanced assumption testing such as variance homogeneity and sample adequacy was not conducted, which was acknowledged as a technical limitation within the scope of this case study.

Cross verification was also carried out between interview data and institutional documents, including leadership decrees, training attendance records, and communication archives from the VFMI WhatsApp group. This triangulation ensured that the qualitative analysis was not solely based on individual perceptions, but also reflected the actual dynamics occurring in the field (Creswell & Clark, 2018;

Jahel et al., 2023). The unit of analysis in this study was the individual, in order to examinegender roles in the use of Information and Communication Technology (ICT) by VFMIs (Ruiz et al., 2021). Hafkin & Huyer's (2008) formula for measuring gender distribution was used to identify the role of men and women in the use of village forest management applications.

Table 1. Calculating the Percentage of the Role of Women and Men in the Use of Village Forest Management Applications in VFMIs

No	Criteria	Description
1	Percentage of Female/Male Application Users	(Number of female / male users) ÷ (Total app usage) x 100%
2	Percentage of Female/Male Application Users in Institutions	(Number of female / male users) ÷ (Number of VFMI user members) x 100%

Source: adaptation of Hafkin & Huyer (2008)

RESULT AND DISCUSSION

Gender and Role Digital Divide Relationship in VFMI

In the digital era, technology also encourages changes in people's attitudes towards movement (Anam et al., 2020). One problem that is less recognized is the gender-based digital divide in communities or institutions. This gap stems from cultural factors, lack of access, and structural barriers in utilizing technology (Begum et al., 2022; Elias et al., 2017; Hidrobo et al., 2024). Hafkin & Huyer (2008) note that gender-based ICT statistics are difficult to access and rarely used in policy. Orton and Prior (2013) emphasize the importance of critical reflection on gender issues in digital spaces, which offer opportunities while reinforcing old inequalities. They question: "how do we explain the persistence of entrenched inequality in the digital age?" This study contributes to explaining how the gendered digital divide affects gender roles in Village Forest management, as shown in Table 2.

Table 2. Spearman's rho Correlation Test on the Variables of Digital Gender Divide – Gender Role   in Village Forest Management

Correlations			Gender Digital Divide	Gender Role in Village Forest Management Institution
Spearman's rho	Gender Digital Divide	Correlation Coefficient	1.000	-.372[*]
		Sig. (2-tailed)	.	.030
		N	34	34
	Gender Role in Village Forest Management Institution	Correlation Coefficient	-.372[*]	1.000
		Sig. (2-tailed)	.030	.
		N	34	34

*. Correlation is significant at the 0.05 level (2-tailed).

The correlation test results showed a significant negative relationship between the gender digital divide and gender roles in Village Forest Management Institutions ($r = -0.372$, $p < 0.05$) with the correlation strength categorized as weak to moderate. Nevertheless, there is a clear indication that the greater the digital divide, the lower the participation of women in forest management. Significant correlations were also found between digital skills ($r = -0.457$; $p = 0.007$) and access to digital content ($r = -0.369$; $p = 0.032$) with levels of participation. This condition indicates that women's exclusion from digital spaces is not only the result of individual limitations, but is also shaped by training structures, social norms, and unequal legitimacy of roles.

Therefore, These correlations serve as an important initial indication that will be elaborated further in the subsequent discussion section. The inequality is not merely an issue of individual capability, but more so about the unequal distribution of institutional opportunities. These findings reinforce Hafkin & Huyer (2008) argument that the digital gender divide encompasses dimensions of skills, motivation, and social legitimacy not merely limited access to devices. Antonio and Tuffley (2014) also observed that the digital divide is rooted in class, nation, and gender inequalities, which reinforce the exclusion of certain groups from the digital realm (Antonio & Tuffley, 2014). Without adequate digital capacity, women are more vulnerable to being excluded (Nelson et al., 2023).

Qualitative data findings in the field clarify this picture. Women's involvement in using KoboToolbox applications is generally triggered by NGO programs not the result of equitable processes within the institutions themselves (Henriksen et al., 2023; Wajcman, 2004). As stated by a female informant:

"Kami belum pernah diajarkan untuk menggunakan aplikasi Avenza Maps seperti bapak-bapak. Pernah disuruh download, tapi belum ada pelatihan cara pakainya. Padahal, kalau diajarkan, kami juga mau belajar."

"We've never been taught how to use the Avenza Maps app like the men. We were once told to download it, but there was no training on how to use it. If we were taught, we would also be willing to learn." (female VFMI, personal communication, January 31, 2025)

This statement illustrates that the lack of skills is not due to a lack of willingness, but rather limited access to training. This gap is reinforced by social norms and patriarchal structures within VFMI. Another informant shared:

"Suami saya pernah ajari saya pakai Avenza Maps, dan saya pakai itu untuk cari arah ke rumah saudara di desa sebelah, karena di daerah kami banyak sekat-sekat sungai kecil. Aplikasinya bisa dipakai meski walaupun tak ada sinyal."

"My husband once taught me to use Avenza Maps, and I used it to find the way to my relative's house in the neighboring village, because our area has many small river branches. The app works even without a signal." (female Avenza User, personal communication, January 29, 2025)

This story proves that women are capable of operating technical applications when given informal access. However, as long as formal training is still dominated by men, women remain left behind. Wajcman (2004) emphasizes that patriarchal structures institutionalized through norms and institutions are one of the main barriers to women's participation in technology (Wajcman, 2004).

Meanwhile, the use of WhatsApp by all VFMI management members has not ensured equal engagement. Most women primarily receive information and prefer to respond privately to the VFMI leader rather than in group chats. In specific social contexts such as in VFMI Sungai Piyai women continue to be confined to domestic roles, such as preparing meals during meetings or patrols, rather than being involved in digital tools or decision-making processes.

This underlines the fact that the digital divide cannot be separated from local social and cultural contexts. As Henriksen et al. (2023) assert, the success of digitalization programs is largely determined by the available opportunity structures not merely by the provision of technology (Henriksen et al., 2023). An informant from the supporting NGO noted:

"Jadi pada intinya karena itu adalah kebijakan lokal juga kami hanya bisa memfasilitasi memberikan arahan-arahan. Tetap hasil sebuah keputusan itu — hasil dari kawan-kawan musyawarah."

"At the end of the day, it's a matter of local policy. We can only facilitate and provide guidance. The decision is always the result of the internal deliberations of the group." (HB, personal communication, February 28, 2025)

This reinforces the point that NGOs act merely as facilitators, while strategic decisions rest in the hands of the internal VFMI leadership. Therefore, even though applications like KoboToolbox were actively used at one point, their continuity depends not on the technological capacity itself but on whether the institution and village government perceive the data collection as an institutional need. Without reinforcement through local policy, the transformation of women's digital roles remains vulnerable to being temporary and elitist limited to certain actors who are closely connected to local power structures. To clarify the relationship between the use of village forest management applications based on gender, a Chi-Square test was conducted with the results in Table 3 below.

Table 3. Chi-Square Test Results of Cross Tabulation of Digital Application Usage in Village Forest Management by Gender

Chi-Square Tests			
	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	20.922[a]	3	.000
Likelihood Ratio	24.878	3	.000
Linear-by-Linear Association	5.634	1	.018
N of Valid Cases	34		

a. 5 cells (62.5%) have expected count less than 5. The minimum expected count is .53.

The Chi-Square test results in Table 3 show a significant relationship between gender and the use of digital applications in village forest management (Pearson Chi-Square value = 20.922, p = 0.000). The data shows that men and women tend to use different types of applications. The findings are reinforced by the significant Likelihood Ratio results (p = 0.000), as well as the Linear-by-Linear Association results which show a significant linear relationship between gender and the type of application used (p = 0.018). The difference can be explained by the gender-based division of roles in village forest management activities (Denwood et al., 2023). Men use the Avenza Maps App more because they are more often involved in field patrol activities that require live location tracking (Gabrys, 2022; Gabrys et al., 2022), often

in areas that are difficult to access and high risk. In contrast, women use the KoboToolbox App for fishermen's catch data collection activities such as crabbing and shrimping, which are conducted in safer locations and do not require direct interaction with challenging field conditions (Kadel et al., 2022; Nelson et al., 2023).

However, this segmentation does not merely stem from differences in preference or technical capacity. It is shaped by a combination of social norms, field-related risk structures, and gender-unresponsive training designs. VFMI actors often consider safety concerns during patrols such as extreme weather, water conditions, and long distances accessible only by speedboat. These considerations reinforce the tendency to exclude women, particularly those who are married, due to concerns over social perceptions and domestic dynamics.

In some cases, the women involved are those who are unmarried or have strong social support networks. In addition, the role of data collection is often considered more "suitable" for women, as it is perceived to require greater attention to detail, especially when filling in 18 data points in KoboToolbox, compared to only 5 points in Avenza Maps. This assignment reflects how perceptions of risk, gender roles, and digital competence interact to determine access to technology.

This segmentation has significant implications for technological equity and decision making. When applications that provide access to spatial information, such as Avenza Maps, are used primarily by men, control over strategic information and leadership positions tends to become exclusionary. As such, digitalisation efforts without affirmative strategies risk reinforcing existing structural inequalities. Through the lens of the sociotechnical systems framework (Wajcman, 2004), it becomes evident that technology does not operate in a neutral space, but is embedded within social structures that reproduce patriarchal norms and limit women's access to and control over strategic technologies.

Distribution and Types of Applications in VFMI

Applications as a medium or tool of interaction digitization (Asaniyah, 2017), are digital applications that do not recognize gender. Gender is a socially and culturally shaped behavior, in other words, stereotypes or subordination in society (Togubu et al., 2022). The following figure will explain how the distribution of application use based on gender in village forest management among VFMI board members.

According to the data in Table 3 and Figure 2, there is a gender-segmented pattern of digital application use in Village Forest management. Men dominate the use of Avenza Maps and WhatsApp, while women only use WhatsApp or a combination of KoboToolbox and WhatsApp. No women used Avenza Maps, and no men were found to be KoboToolbox users. This segmentation reflects differences in training allocation and task sharing, determined by program needs, training quotas and available resources.

The example for forest patrols using Avenza Maps is conducted in difficult-to-access and high-risk areas requiring high mobility and physical endurance. Due to safety considerations, this activity is mostly participated in by men. In contrast, data collection on non-timber forest products such as crabs and shrimps using KoboToolbox is conducted in safer locations, and is mostly done by women. This

shows that training and access to technology are gendered, according to the social and spatial context.
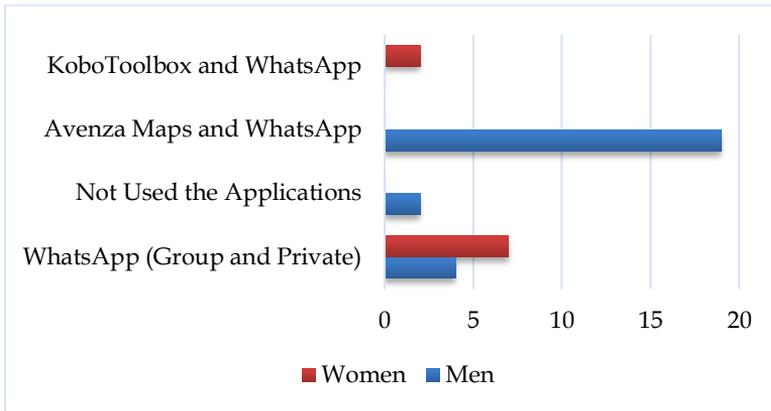

Figure 2.
Digital Applications in Village Forest Management Based on Gender

While WhatsApp is used by all members, this access does not automatically guarantee equal digital empowerment. Women are indeed "connected", but their active engagement more often occurs when there is external support, such as from NGOs. Gabrys et al. (2022) and Nelson et al. (2023) confirmed that access to technology is influenced by role sharing and training structures. The study in Cameroon (Maukonen et al., 2020) also shows a similar pattern. When women's digital engagement only occurs through projects, their participation becomes unsustainable and dependent on external interventions. In line with this statement, one of the interviewees explained as follows:

"untuk sejauh ini tidak ada program yang secara khusus dibuat untuk Perempuan dari pemerintah daerah"

"so far there is no program specifically made for women from the local government" (lS & KD, personal communication, January 29, 2025).

This statement implies the low bargaining power of women in the structure of the management institution, which is a strategic space for data and technology-based decision-making. But it has not received serious attention through local government programs. Strengthening the results of the intersectional analysis of the research results, the following table will explain the data on age, education and role or position in the institution.

Table 4. Digital Access Patterns by Gender, Age, Education, and VFMI Role

Gender	Dominant Age	Dominant Education	VFMI Role	Applications Used
Woman	Gen Y, Boomer	High School, Elementary School, Associate Degree	Secretary, Staff	WhatsApp, KoboToolbox
Man	Gen X, Gen Y	Junior High School, High School, Associate Degree	Head of devition, Staff	Avenza Maps, WhatsApp

Based on table 4, women-particularly from the Boomer and Gen Y age groups with lower secondary education are generally assigned to administrative or field staff roles, with limited access to applications such as WhatsApp and KoboToolbox (Beneito-Montagut et al., 2022). These limitations restrict their opportunities to access information, lead, and express their opinions in digital spaces. In contrast, men from Gen X and Gen Y with higher levels of education more often hold strategic positions, such as field coordinators, and are proficient in technical applications like Avenza Maps. The institutional structure thus reflects a reproduction of gender inequality in spatial data access and decision-making processes (Maukonen et al., 2020; Nelson et al., 2023).

Using an intersectional approach (Crenshaw, 1991; Pandya, 2023), these disparities should be understood through the overlapping dimensions of age, education, and structural position (Elliott et al., 2023) Digitalisation that is not accompanied by affirmative strategies risks deepening gender inequalities. Therefore, interventions within VFMI should target structural transformation—not merely expanding access to devices but also broadening leadership opportunities for women across diverse social backgrounds.

Influences of Social and Cultural Norms

In addition to the technical dimension of application use, the gender-based digital divide is also influenced by socio-cultural norms prevailing in society. These norms are identified through the perceptions and social attitudes of institutional board members, which are shown in the Table 5.

Statistical tests revealed that socio-cultural norms such as the belief that "women should not work too much outside the home" had a significant influence on women's participation in digital-based decision-making (p = 0.021). Similarly, the stereotype that women are "less suited for technological work" significantly affected the dimension of digital connectivity (p = 0.049). These findings align with Juwita et al. (2024), who argue that technological norms and stereotypes hinder women's engagement in strategic digital spaces(Arwida et al., 2017).

Table 5. The Influence of Social and Cultural Norms on The Gender Digital Divide

Indicator of Gender Digital Divide	Socio-cultural Norm Statement	Significance (p < 0,05)	Description
Decision and Policy Making	Women are not good at working too much outside the home	(p = 0,021)	Norms that limit women's mobility and strategic role in training and decision-making in VFMI.
Connectivity	Women are less suited for jobs with technology	(p = 0,049)	Norms that reinforce stereotypical technology tips against women, so they do not engage in the use of technical applications such as Avenza Maps.

As a result of such norms, women are more likely to be involved in digital functions perceived as non-technical, while men tend to dominate strategic roles involving technical applications. Although not all dimensions showed statistical significance, qualitative data highlighted that social perceptions still position technology as a domain for men or younger generations (Anugrah et al., 2022; Yuliani, 2014).

Access to technology, in this context, is not merely about technical skills but also concerns symbolic status and social legitimacy. This is illustrated by the case of a woman in Sapat with only a primary school education who was trained as an enumerator and provided with a digital device by an NGO. Although she carried out her tasks effectively, some community members questioned the legitimacy of her role, citing her lack of formal education. One community member remarked:

"kok dia yang dipilih untuk data-data, padahalkan cuma lulusan SD. Harusnya yang lebih sekolah yang lebih tinggi yang pegang,"

"Why was she chosen for data tasks? She only graduated from elementary school. It should be someone with a higher education." (EL, personal communication, January 29, 2025)

This statement illustrates that digital technology is not merely perceived as a work tool but also as a symbol of status and legitimacy. Digital access, therefore, extends beyond technical competencies and is deeply embedded in social interpretations of gender, education, and class. Resistance to women's participation in digital spaces is reinforced by norms that associate women primarily with domestic roles rather than as users of technology or decision-makers. This creates a form of ambivalence: on one hand, there is recognition of women's capacity; on the other, symbolic boundaries continue to hinder their legitimacy. This ambivalence was reflected in interviews with local leaders who acknowledged the need for women with technological skills to strengthen institutional administration and data systems:

"Sebenarnya lembaga ini butuh perempuan yang bisa komputer, bisa input data. Itu bisa buat LPHD lebih baik. Tapi ya memang belum ada sekarang."

"This institution actually needs women who can use computers, who can input data. That would make the VFMI stronger. But we don't have that yet." (AM, personal communication, January 29, 2025)

"Akan lebih baik kalau perempuan bisa pakai teknologi. Tapi biasanya perempuan itu bantu masak, buat air, jadi nggak terlalu pegang komputer."

"It would be great if women could use technology. But usually, they help with cooking, fetching water, so they don't really handle computers." (KD personal communication, January 31, 2025)

These two statements highlight the persistent social ambivalence within the community. While the importance of women's involvement in digitalization is acknowledged, social norms that confine women to domestic spaces remain symbolic barriers to their legitimacy as technological actors. These findings reaffirm that the gender digital divide is not solely a matter of access to devices and training but is also deeply influenced by social norms and power structures. Without affirmative

strategies and intersectional approaches, digitalization may in fact exacerbate existing inequalities (Bitzer et al., 2024; Dewi et al., 2020; Long et al., 2023).

Within the sociotechnical systems framework proposed by Wajcman (2004), the relationship between technology and social structures is never neutral. The use of digital technology at the community level often reflects and reproduces entrenched social norms. In this context, women's legitimacy as technology users is not solely determined by technical capacity, but by social interpretations that associate technology with status, education, and gender. Therefore, digital transformation in the context of VFMI governance requires institutional approaches capable of intervening in the normative and power structures that hinder equitable participation.

Gender Transformation in Village Forest Management

Village Forest Management by Village Forest Management Institutions (VFMI) was initiated in 2015 through the assistance of Yayasan Mitra Insani (YMI), followed by an administrative process for almost three years until the issuance of the KLHK decree in 2017 for Sungai Piyai Village and Sapat Village. Until 2020/2021, activities were still carried out manually with paper-based records. Digital transformation began in 2021 through training on the use of the KoboToolbox application, aimed at catch distribution actors such as collectors and intermediary traders. The training involved nine participants (four men and five women), marking the initial involvement of women in the digitization of forest management. The following year, YMI conducted a training on the use of Avenza Maps for reporting the location of findings during patrols, which was attended by male participants. This development reflects the integration of digital technology in the VFMI work system.

Community participation in technology promotes social welfare and sustainability of forest management (Wahyudi & Kurniasih, 2022), and increases administrative efficiency. The government responded through to this through the Minister of Environment and Forestry Regulation No. 9 of 2021, which provides a technology-based participatory framework (Rohmy & Nihayaty, 2023). The establishes demonstrated adaptive capacity in this process.

Table 6. Digital Transformation and Gender Roles in Village Forest Management

Year	Digitalization Activity	Village	Application Used	Dominant Gender	Indication of Gender Transformation
2021	KoboToolbox Training	Sapat	KoboToolbox	Women and men	Women involved, active in data collection
2022	Avenza Maps Training	Both	Avenza Maps	Men	Men dominant in patrol activities
2024	Social Media Training	Both	WhatsApp/ Instagram	Mixed	Participation becoming more inclusive

These findings indicate that disparities in digital skills and content access are not merely the result of individual limitations, but are deeply rooted in selective and gender-biased training structures. In the KoboToolbox training facilitated by the NGO, both women and men were trained together. In Sapat Village, women even actively contributed by entering data and serving as enumerators demonstrating that, when given the opportunity, they are fully capable of making strategic contributions. In contrast, training for more technical applications such as Avenza Maps involved only male participants, thereby restricting women's access to spatial literacy and their ability to use data in decision-making processes.

This situation highlights that the dimensions of digital skills and content, as proposed in the Hafkin & Huyer (2008) framework, cannot be separated from the social context of training and power relations. When training structures are exclusive, women are denied equal opportunities to build digital capacity.

Nevertheless, field observations reveal early indications of a shifting gender dynamic. Women's involvement in forest product data collection particularly in Sapat reflects an emerging shift from their previously limited, domestic-support roles within the institution. However, this transformation is not yet widespread. In Sungai Piyai, some female members still perceive their role as limited to preparing meals for meetings or patrols, rather than serving as key actors in data documentation or decision-making. This indicates that the transformation of women's roles within VFMI remains in progress and is heavily influenced by the structure of training programs, institutional support, and the slow evolution of social norms.

Women's involvement in marine resource data collection using KoboToolBox serves as an example of strategic participation. In Sapat Village, one woman not only served as a data enumerator for mangrove crab monitoring but also represented the VFMI in a regional forum. The Sub-district Head of Kuala Indragiri described this involvement as a form of meaningful contribution by women in environmental information governance:

"...Anggota LPHD perempuan menjadi delegasi kita untuk menjelaskan data-data di Bali..."

"...A female VFMI member was our delegate to present the data in Bali..." (Sub-district Head of Kuala Indragiri, personal communication, January 29, 2025)

"...karena yang hadir kebanyakan laki-laki, keikutsertaan perempuan menjadi hal yang dihargai..."

"...Since most of the attendees were men, the presence of a woman was highly appreciated..." (Head of Sapat Village, personal communication, January 29, 2025)

These findings mark a shift from administrative to strategic roles. However, this transformation remains partial and segmented. Women tend to be more involved in data-based applications such as KoboToolBox, while Avenza Maps used for forest patrols continues to be male-dominated. The main barrier is not capability, but rather limited access to training and entrenched social norms surrounding technology.

Interestingly, even though Sapat Villageis led by a female village head, local cultural norms continue to constrain women's strategic roles in institutional decision-making. This highlights how leadership structures, gendered technical perceptions, and local culture shape the trajectory of digital transformation. The following section compares the digital transformation dynamics of VFMIs in Sapat and Sungai Piyai Village.

These findings reinforce the Hafkin & Huyer (2008) framework that gender digital divides are not only about physical access, but also about skills, motivation, and social legitimacy. In rural community contexts such as VFMIs, access must be understood contextually: short training sessions do not equate to the more comprehensive training typically received by men, and social recognition remains a prerequisite for women's participation. Digitalization will only serve as a tool for gender transformation if it is consciously designed to challenge normative and structural barriers rather than merely providing symbolic access to technology or training. To analyze gendered proportions of technology use, this study applies Hafkin & Huyer's (2008) formula, with results presented in Table 1 and visualized to illustrate patterns of digital inequality within VFMI institutions. Based on the formula used, the resulting percentages are presented in the bar chart in Figure 3.

Figure 3 illustrates the low level of women's involvement in the use of VFMI digital applications, with only 28.13% compared to 71.88% male users. In terms of total membership, only 26.47% of female members actively use the applications, while the figure for male members reaches 67.65%. This disparity reflects not only a numerical difference in users but also a divergence in digital functions and responsibilities, particularly in access to spatial data and strategic institutional roles. This analysis adopts the framework of Hafkin & Huyer (2008), which takes into account the types of applications used (Avenza Maps, WhatsApp, and KoboToolbox), as well as the proportion of users by gender and their position within the institution. WhatsApp is measured based on total membership, as it serves a collective function, while Avenza Maps and KoboToolbox are calculated based on active users by gender, as they are utilized in program implementation. These findings indicate that inequality is evident not only in the number of users but also in the differentiated functions of applications, digital responsibilities, and legitimacy of access. The visual findings presented in Figure 3 show that the gender digital divide in VFMI is not only quantitative but also reflects a gendered division of roles embedded within the social structure. This access disparity occurs not only between men and women but also within gender groups themselves.
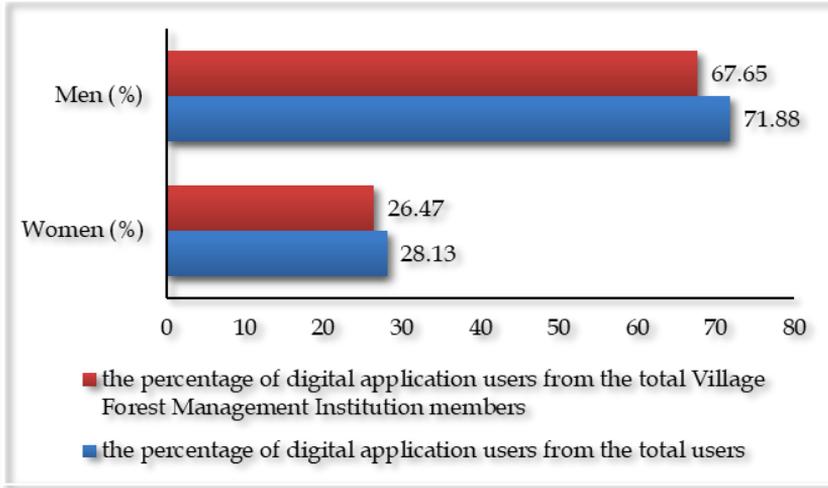
Figure 3.
Comparison of Percentage of Digital App Usage by Gender
Source: Adapted from Hafkin & Huyer (2008), based on field data (2025)

This visualization should not be read as a neutral reflection. Visual data, in fact, represent power relations, social norms, and unequal structures of opportunity. Access to digital applications is not evenly distributed even within gender groups themselves. Among women, those who actively use KoboToolbox are typically individuals selected by NGOs, involved in seafood distribution, or wives of VFMI administrators. These women are generally younger (Generation Y) and already familiar with digital technology. In contrast, male users of Avenza Maps are usually those who have spare time and participate in patrols not necessarily those with technical capacity. This gap is also confirmed qualitatively. One female member stated:

"kalau ada pelatihan kayak gitu, ibu kasih ke yang muda-muda aja soalnya bukan masa ibu lagi"

"If there's training like that, I let the younger ones join, because it's no longer my time." (MH, personal communication, January 29, 2025)

Meanwhile, there are also women who are able to use Avenza Maps because they were taught by their husbands, and even use it for navigation when visiting relatives in coastal areas with no internet signal. This indicates that technical ability is not the main barrier; rather, it is the unequal distribution of opportunities and training.

WhatsApp, as the most widely accessed application, is often used in a one-way communication pattern. Many members especially women prefer to share their opinions privately rather than participating in open group discussions. VFMI leaders also tend to directly contact members they perceive as responsive, such as unmarried women, for field-related needs. In contrast, older women who are not involved in digital activities more often contribute to logistical support during events.

Thus, the visual narrative in Figure 3 must be read critically as part of a social structure that produces gendered digital inequality. This inequality does not stem from women's lack of capacity, but from unequal access to training, institutional roles, and social recognition none of which have yet been made gender-sensitive.
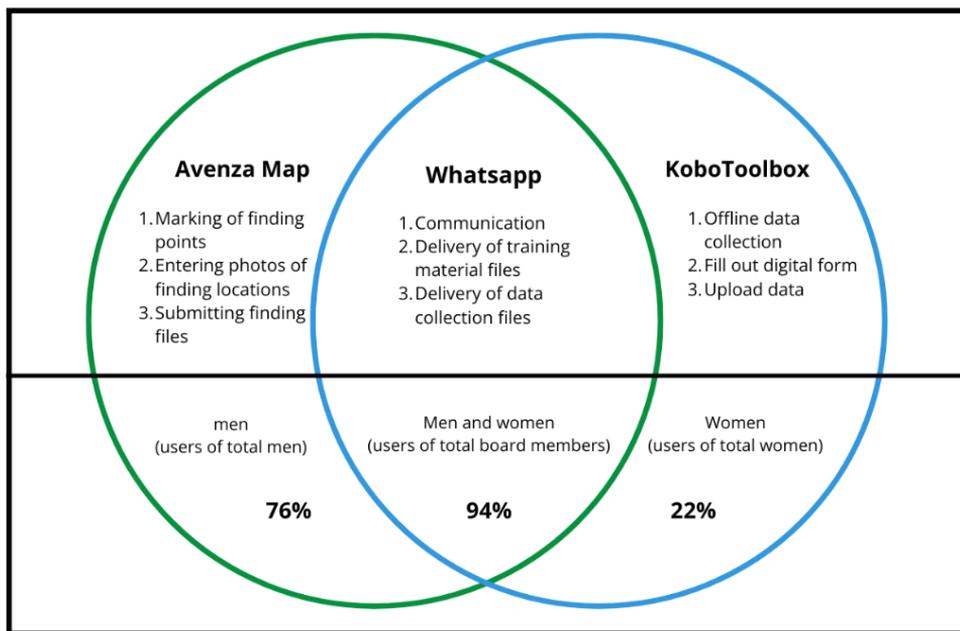

Figure 4.
Applications and usage distribution by gender
Source: Adapted from Hafkin & Huyer (2008), based on field data, 2025

Figure 4 presents a visualization of the use of three digital applications-Avenza Maps, WhatsApp, and KoboToolbox-in Village Forest management by VFMI. This visualization was developed to enrich the gender digital divide indicators based on Hafkin & Huyer's (2008) approach, particularly on the dimensions of usage access and institutional access. This diagram shows not only who is using the technology, but also the function of each application and its distribution by gender.

Avenza Maps was used most by men (76% of the total male respondents), especially in forest patrolling: marking finding points, taking photos, and sending files of patrol results. Meanwhile, KoboToolbox was used more frequently by women (22% of total women), especially for recording non-timber forest products, products, filling in digital forms, and uploading data. WhatsApp was used equally by 94% of of VFMI members for communication, sharing training materials, and sending data.

Thus, although women's involvement in the use of digital technology remains quantitatively limited, this pattern indicates a gradual and contextual transformation of gender roles aligning with the constructivist approach of this study. This transformation is shaped not only by existing gender structures, but also by the support of local actors such as village heads, VFMI administrators, and facilitating organizations such as NGOs.

In an interview, the Head of the VFMI in Sapat Village stated that the use of digital applications like KoboToolbox has demonstrated that women are capable of operating technology, particularly when provided with appropriate training. However, he also acknowledged that not all members possess adequate technical capacity, as the available training is limited and not conducted on a continuous basis. According to him, digital data collection has only been implemented as part of NGO programs, and would be difficult to sustain without additional incentives or institutional support. He stated:

"Kalau ada lagi program seperti itu dan ibu-ibu dibayar untuk nge-data, ya bisa saja mereka mau. Tapi sekarang kan pekerjaannya itu tak ada."

"If there's another program like that and the women are paid to collect data, then they might be willing to do it. But right now, there's no such work." (JH Sapat Village, personal communication, January 29, 2025).

The VFMI Head further noted that, ideally, such data collection efforts should be adopted and continued by the village or sub-district government. However, its sustainability depends heavily on the decisions of local government or technical agencies particularly on whether they consider the data relevant for policy-making.

A similar perspective was expressed by the program coordinator of the supporting organization. He explained that the data collection initiative was originally launched by the Ministry of Marine Affairs and Fisheries to document fishers' catches in coastal areas. In its implementation, the data collection targeted community members considered strategic in the distribution of marine products including women who work as seafood collectors. However, to date, there has been no indication that local governments have taken over or further developed this program.

These findings are consistent with the theoretical framework of Hafkin & Huyer (2008), which provides a robust analytical lens for understanding the structural dimensions of the gender digital divide. Women's limited access to technical training and applications reflects problems not only in individual access and skills, but also in program design and power structures. The types of applications used also reflect gender-oriented content: men tend to access technical spatial data, while women are assigned to collect administrative data on marine catches. Women's motivation to participate is often limited by a lack of incentives and social recognition, not a lack of interest. Most critically, control over technology remains concentrated in the hands of men who occupy strategic positions and determine the direction of institutional programs. Therefore, without gender-sensitive interventions that address these five dimensions, digitalization risks reinforcing existing inequalities rather than overcoming them.

Although this study reveals a significant relationship both quantitatively and supported by qualitative data between the gender digital divide and women's roles in village forest governance, as well as the potential for gender transformation through the use of digital technology, several limitations must be acknowledged: (1) The number of respondents was limited to 34 institutional members, which, although representative of the VFMI unit, constrains the generalizability of the findings to broader social contexts; (2) The use of purposive sampling in selecting key informants may introduce bias toward individuals who are active or institutionally connected, thereby potentially excluding more passive or marginalized women's

groups, this should be recognized as an analytical gap; (3) The lack of structured institutional documentation, particularly regarding gender-disaggregated data and digital participation records, hinders longitudinal analysis of decision-making indicators; (4) As a case study employing a non-probability approach, the findings are not intended for statistical generalization. Rather, they aim to provide contextual understanding and theoretical contributions to the study of digitalization and gender transformation at the village institutional level.

To address these limitations, future research is recommended to adopt a participatory approach that involves women from diverse social backgrounds, including those who are underrepresented within institutional structures. Subsequent studies should also expand the research sites to villages with varying social and geographical characteristics such as mountainous regions, border areas, or customary territories in order to examine the contexts of digitalization and gender disparities more comprehensively. Furthermore, the use of longitudinal or quasi-experimental designs would be highly beneficial for evaluating the long-term impacts of digital training and gender-based affirmative interventions on women's participation in natural resource governance. Another recommendation includes the integration of spatial data with gender-disaggregated records of digital participation, to strengthen evidence-based policymaking at the village and district levels.

Finally, as this research was conducted in two coastal villages with specific social and geographical characteristics, generalizing the findings to the national context requires caution and broader follow-up studies. Nevertheless, the findings of this study remain relevant as an initial reference for designing inclusive digitalization policies in social forestry that are responsive to gender dynamics and the diversity of local contexts.

CONCLUSION

This research found that the gender digital divide in village forest management is not only related to access to technology, but also influenced by social norms, training structures and institutional positioning. Findings show that women, particularly from older age groups and low education, have limited engagement in the use of strategic digital applications, although they demonstrate capacity when given participatory space. Using an intersectionality approach, this study emphasizes the importance of understanding inequality not in isolation, but through the interaction between gender, age, education and local power structures. However, the study also found that without change in institutional structures and organizational culture, digitization has the potential to reinforce existing exclusion rather than reduce it. Therefore, community-based digitalization needs to be designed with affirmative strategies that consider social context and equal distribution of opportunities. This study makes an initial contribution to formulating a more digitally and gender-inclusive social forestry policy direction. Further research with regional coverage and longitudinal approach is needed to assess the sustainability of gender role transformation in digital village institutions.

AUTHOR CONTRIBUTION STATEMENT

[Author 1]: conducted field research, data analysis, and prepared the initial manuscript draft; [Author 2]: provided academic supervision, conceptual guidance, and manuscript review; [Author 3]: supervised the research process, contributed to manuscript editing, and strengthened the theoretical framework. All authors reviewed and approved the final version of the article.

DECLARATION OF COMPETING INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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ETHIC STATEMENT

Prior to data collection, official research permission was obtained from the Kuala Indragiri Subdistrict Government, the Sapat and Sungai Piyai Village Forest Management Institutions, and the respective Village Governments. All participants were informed about the purpose of the research and the voluntary nature of their participation. Written or verbal consent was obtained from all respondents before interviews, surveys, or observations were conducted. All personal data collected during the research was anonymized, treated confidentially, and used solely for academic purposes.

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