Determinants of Enhanced Trained Human Resources in Flood Disaster Risk Reduction (A Case Study in Sidomulyo Village, Lamongan)

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Abstract. In many developing regions, top-down infrastructural solutions fail to mitigate recurrent disasters, such as the annual Bengawan Jero flood in East Java, Indonesia, which causes estimated losses of IDR 29 billion (approximately USD 1.8 million). This failure underscores the critical need for community-level capacity, yet Sidomulyo Village remains a "cold spot" with a severe deficit in trained human resources. This research aims to identify the key determinants for enhancing these resources. Employing Partial Least Squares-Structural Equation Modelling (PLS-SEM), the roles of local institutions, social capital and human capital were assessed. The analysis shows that human capital has a strong, direct positive effect on trained human resources ($\beta = 0.644$, p value 0.000), while local institutions and social capital have no significant direct effect. However, the study uncovers a critical indirect path wherein social capital significantly impacts trained human resources by mediating the development of human capital ($\beta = 0.343$, p value 0.013). The clear conclusion is that effective strategies for enhancing trained human resources must focus on building human capital while using social capital as the fundamental supporting mechanism.

1 Introduction

The integration of disaster risk management into spatial development is a critical necessity, particularly in regions where hazard exposure and systemic vulnerabilities intersect [1]. In East Java, the persistent inundation of the Bengawan Jero area exemplifies a high-risk profile characterized by complex hydrological imbalances and expanding spatial impacts [2]. Despite ongoing governmental interventions, the region's overall resilience remains constrained, with "low human resources" identified as a pivotal vulnerability [2]. The flooding impacts are substantial and protracted. A clear example occurred in early 2023, when a six-month flood event inundated 6,672 homes and 5,970 hectares of farmland, leading to significant economic losses [2]. Evidence suggests an escalating crisis, with the spatial extent of the flooding expanding from 42 to 59 villages in a single year [3]. The Bengawan Jero floods are attributed to complex hydrological deficits, including river

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geometry imbalances, low flow velocity [2], and overflow from the primary Bengawan Solo watershed [3].

Current assessments categorize the overall resilience of the Bengawan Jero area as "medium" (67.7%), yet explicitly identify "low human resources" as a significant vulnerability [2]. Specifically, Desa Sidomulyo has emerged as a "cold spot," suffering from a concentrated deficit in trained personnel, a demographic essential for ensuring adaptive and effective community-level response [3]. Addressing this gap requires a comprehensive understanding of community resilience through a capital-based approach, where the interplay between social and human capital serves as a foundation for preparedness [4]. While social capital facilitates community mobilization and mutual aid, human capital acts as a turnkey resource for the technical competence required in high-risk environments [5]. Therefore, this study aims to identify the determinants of enhanced trained human resources for flood disaster risk reduction in Sidomulyo Village, establishing the necessary empirical foundation using Partial Least Squares-Structural Equation Modelling (PLS-SEM) prior to the formulation of a concrete DRR framework.

2 Literature review

2.1 Trained human resources

Trained human resources, defined by specialized competencies in disaster mitigation and emergency response, serve as a fundamental determinant of community preparedness [3]. While disaster management necessitates multi-stakeholder engagement, volunteers both from national bodies and local organizations within the Bengawan Jero area remain central to operationalizing response and sustainable prevention efforts. Despite the active presence of these groups, systemic capacity in the region remains deficient, with Desa Sidomulyo critically identified as a "cold spot" [3]. Rectifying this deficit requires a capital-based approach to resilience, emphasizing the interplay between foundational social structures and individual capabilities [4,6].

Local institutions play a vital role in this framework, acting as pillars for governance, preparedness education, and the development of resilient livelihoods [7]. Furthermore, contemporary literature posits a formative theoretical link wherein social capital facilitated through norms, trust, and networks, drives the development of human capital [5]. Consequently, this study evaluates three interconnected indicators hypothesized to enhance trained human resources: local institutions; social capital, for its capacity to mobilize mutual aid and collective action; and human capital, which encompasses the specialized education, skills, and health baseline inherent to effective disaster personnel.

2.2 Floods

Flooding remains a dominant global hazard, defined by the United Nations Office for Disaster Risk Reduction (UNDRR) as the submergence of land by water that exceeds the drainage capacity of either natural or artificial systems [8]. These events result in significant multi-dimensional losses, encompassing casualties, property damage, and long-term environmental degradation [8]. A primary exemplification of this risk profile is found in East Java, where recurrent inundations are formally classified as high-priority threats within regional disaster management frameworks [2]. In the specific context of the Bengawan Jero area in Lamongan Regency, flooding is characterized as an annual, episodic,

and predictable phenomenon [3]. These inundations are driven by the overflow of the Bengawan Solo River and further exacerbated by the region's distinctive low-lying topography [2,3]. The impact is notably protracted, often lasting between four to six months with substantial water depths, consistently affecting a wide spatial extent of villages across the regency [2,3]. Such protracted events underscore the necessity of moving beyond structural solutions toward adaptive, community-based frameworks that address localized vulnerabilities and capacity deficits.

2.3 Disaster Risk Management

Disaster Risk Management (DRM) is conceptualized as a systematic process aimed at minimizing hazard probabilities and mitigating unavoidable damages through a continuum of identification and governance [8,9]. This management paradigm is operationalized via risk assessments that analyze the critical interplay between Hazards, Vulnerability, and Capacity. According to the United Nations Office for Disaster Risk Reduction (UNDRR), these components represent the potential for harm, the conditions heightening susceptibility, and the internal strengths available to enhance resilience, respectively [8]. Strategically, interventions are categorized as prospective, corrective, or compensatory, the latter focusing on strengthening resilience against residual risks [8]. In the Bengawan Jero area, where the flood risk index is driven by land use and soil characteristics [2], implementing an effective DRM framework is imperative. While the region maintains a medium overall capacity, the specific deficit in "trained human resources" has emerged as a critical vulnerability, particularly in "cold spot" areas like Desa Sidomulyo [3]. This critical gap in trained human resources constitutes a residual risk, necessitating the identification of its most influential determinants. Identifying these determinants will provide a foundation for compensatory DRM, which can then be integrated into future strategic and development plans.

2.4 Local institution

Local institutions (LIs), comprising community associations, village-level entities, and civil society organizations, are recognized as fundamental drivers for enhancing disaster risk management and localized resilience. In the context of the Bengawan Jero area, where LIs such as TAGANA and RBJ are active, their responsibilities span the full disaster cycle, from pre-disaster training and awareness to during-disaster rescue and post-disaster recovery [2,3]. Despite the implementation of national resilience programs, critical institutional gaps persist in specific locations such as Sidomulyo Village. These deficiencies require targeted capacity enhancement through both formal technical training and informal self-study to bridge the "cold spot" resource deficit [3]. The capability of these institutions is contingent upon a multifaceted interplay of governance, influence, and tangible existence [10]. Drawing from adaptive governance frameworks, this study focuses on several critical institutional variables essential for operational capability: the existence of the institution as a facilitator for resilience; adequacy of personnel to prevent capacity shortages; development initiatives that foster community-level education; and the establishment of regulations, specifically Standard Operating Procedures (SOP) and external rules, which are vital for effective collaboration during crisis scenarios.

2.5 Social Capital

Social capital (SC) is conceptually defined as the access to and participation in formal and informal networks that incorporate trust, norms, and collective institutions [4,7]. Theoretically, it is bifurcated into structural dimensions, such as participation and rules, and cognitive dimensions, including shared values and reciprocity [11]. This research operationalizes social capital through four key variables to determine its influence on trained human resources [7,11]. These variables are: Norms, the behavioral standards for community coordination [7,11]; Participation is examined through three sub-variables number of participants, frequency of participation, and level of participation as engagement in development programs directly enhances community capabilities [4,11]; Networks are assessed across reliable person, their bonding social (intra-community), bridging social (inter-group), and linking social (community-to-group) [4,7]; Finally, trust, comprising interpersonal trust and shared collective values, is evaluated for its role in fostering beneficial relationships and ensuring adherence to risk management protocols, thereby contributing to the enhancement of trained human resources [7,11].

2.6 Human Capital

Human capital (HC), defined as the acquired expertise, knowledge, and physical health of individuals, serves as a "turnkey" resource in enhancing community resilience to hydrometeorological hazards [12]. Within the context of disaster management, HC is operationalized through several critical variables that collectively determine the effectiveness of local resources. First, formal education is assessed via two sub-variables: education level [12] and disaster education material [4,7]. Second, skills are evaluated across the pre-disaster skills, during-disaster skills, and post-disaster skills [7,12]. Third, health is analyzed via two sub-variables: disability population and prevalence of severe disease, which identify underlying population vulnerabilities [12]. Finally, disaster knowledge, often acquired informally [7,12], is examined to establish the existing baseline capability of local human resources.

3 Study area and data sources

3.1 Study area

This research selects Desa Sidomulyo, a village within the Bengawan Jero Region, as the study area. The village, comprising four dusun (hamlets), covers 222 Ha and supports a population of 2,442 (density: 1,100/km²). The rationale for its selection is its significant and recurrent vulnerability to flooding, primarily caused by overflow from the Bengawan Solo watershed and supplemental runoff from Lamongan Kota. These flood events generate profound socio-economic consequences, as evidenced by a 2023 disaster that submerged hundreds of homes and resulted in substantial agricultural losses valued at hundreds of billions of rupiah. Inundation depths are significant, reaching 20-50 cm in residential zones and 2 m in agricultural areas during the 2023 event, while 2024-2025 levels remained high (1-2 m) in agricultural zones despite being lower (10-20 cm) in settlements.

The persistent flood risk in the region is attributed to two key factors: land use and soil texture [13]. The village’s land use is dominated by food crops (186 Ha, 78%) and rural settlements (12%), with residential zones situated near water bodies, thereby increasing exposure. This vulnerability is compounded by the area's soil composition, which

predominantly features fine and medium textures [13]. This fine texture inhibits soil permeability, consequently elevating the probability of surface inundation [13]. As illustrated in **Figure 1**, illustrates the flood disaster evacuation network in Sidomulyo Village, detailing the strategic distribution of assembly points and designated evacuation routes across its four hamlets to facilitate organized community displacement.

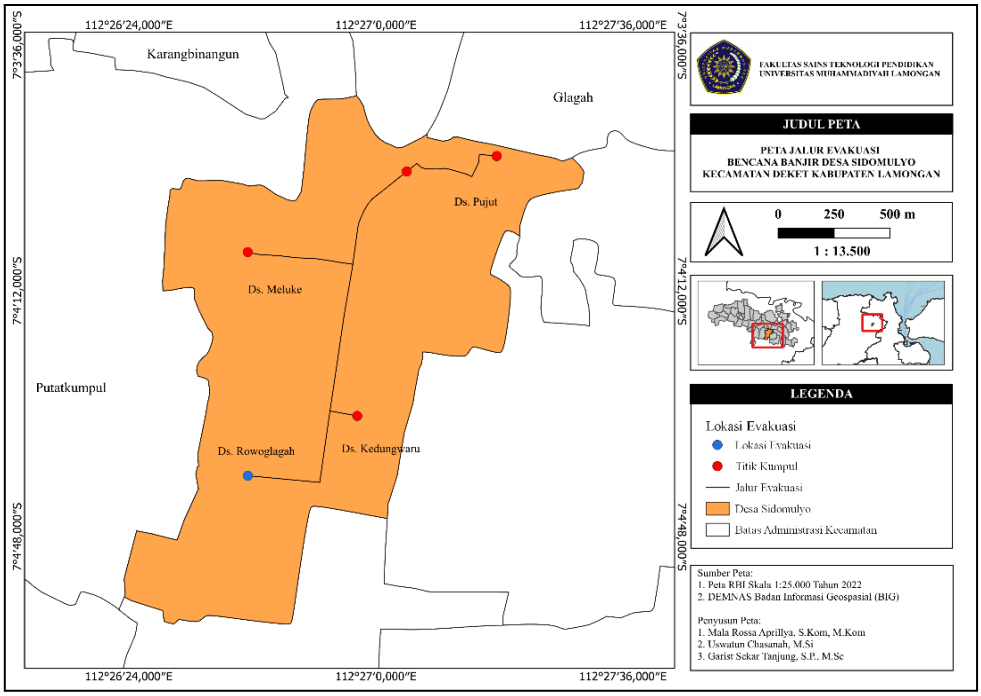

Fig. 1. Map of flood disaster evacuation routes in Sidomulyo Village

3.2 Data sources

This research is based on a systematic data collection methodology, utilizing both primary and secondary sources. The primary data acquisition strategy is centered on assessing the condition of trained resources within Desa Sidomulyo. To achieve this objective, empirical data were gathered directly from the public of the study area through the administration of structured questionnaires and in-depth interviews. To complement and contextualize the primary findings, secondary data collection was concurrently conducted. This process involved a multi-pronged approach; wherein relevant data was systematically sourced through institutional surveys and media surveys.

4 Methodology

This study employs a multi-stage quantitative framework, initiating with a Literature Review to identify hypothesized indicators, variables, and subvariables for the enhancement of trained human resources. Subsequently, Questionnaire and In-depth Interview data are utilized to establish respondent-derived weights and profiles for these selected factors. The analytical phase bifurcates: Descriptive and Inferential Statistics (Correlation) are applied to analyze the existing condition of trained human resources in

Desa Sidomulyo, while Partial Least Squares-Structural Equation Modeling (PLS-SEM) is implemented to identify the statistically significant determinants influencing their enhancement. The entire research methodology is illustrated in **Figure 2**.

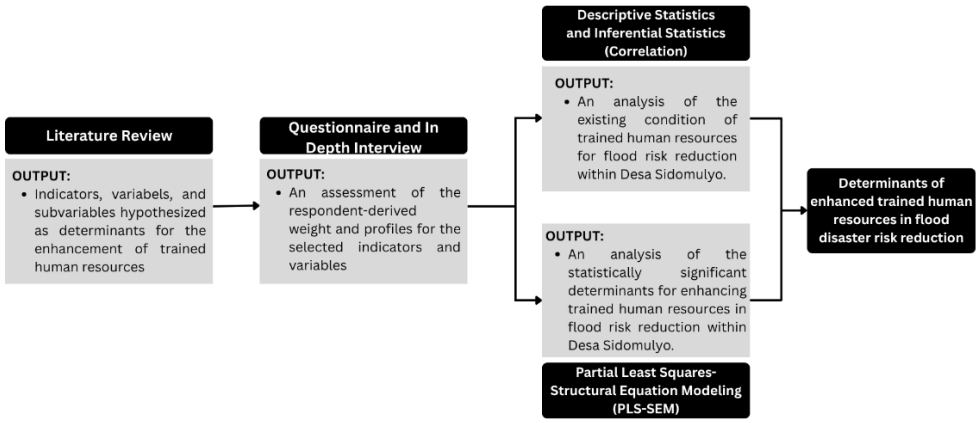

Fig. 2. Research methodology

4.1 Questionnaire and in-depth interview

Primary data for this research were acquired through the administration of a structured questionnaire and supplementary in-depth interviews. The sample comprised 42 community respondents from Desa Sidomulyo, selected via a proportional stratified sampling technique to ensure representation across the four hamlets (dusun). This sample size (N=42) satisfies the minimum requirements for Partial Least Squares-Structural Equation Modeling (PLS-SEM) analysis. The data collection instruments were designed to capture respondent-derived assessments and weighting for the selected indicators and variables. A 1-to-5 Likert scale was utilized to provide quantitative inputs for the subsequent statistical modeling.

4.2 Descriptive statistics and inferential statistics (correlation)

This study employs a dual analytical approach for its initial objective. Descriptive statistics are utilized to systematically gather, summarize, and outline the data, providing a clear overview of its primary characteristics and establishing a baseline profile of the existing condition of trained human resources for flood risk reduction in Desa Sidomulyo [14]. Following this, inferential statistics are applied to draw broader conclusions about the population from the sample data [14]. Specifically, correlation analysis (Pearson) is implemented to measure the strength and direction of the relationship between the variables under investigation.

4.3 Partial least squares-structural equation modeling (pls-sem)

To identify the statistically significant determinants of trained human resources, this research employs Partial Least Squares-Structural Equation Modeling (PLS-SEM). This analytical method is utilized to test and estimate the causal relationships between latent constructs [15]. It is particularly well-suited for this study as it effectively handles complex models without convergence issues, non-normally distributed data, and smaller

sample sizes. The analysis follows a two-stage process [15]: first, the specification of the outer model (measurement model) and the inner model (structural model); and second, the systematic evaluation of these models. The outer model is assessed for construct reliability and validity using criteria such as outer loadings, Average Variance Extracted (AVE), and the Heterotrait-Monotrait Ratio (HTMT), while the inner model is assessed by examining path coefficients, T-statistics (via bootstrapping), and *p*-values (<0.05) to determine the significance of the hypothesized relationships [15].

5 Result and discussion

5.1 Characteristics of each indicator

5.1.1 Characteristics of local institution

The Local Institution (X02) indicator was assessed to determine the perceived effectiveness of formal local institutions (e.g., Village Government, PKK, Karang Taruna) in developing trained human resources. The analysis reveals a significant disconnect between the community's high regard for institutional governance and its dissatisfaction with practical program implementation. A summary of the dominant respondent perceptions for each variable is presented in **Table 1.**

Table 1. Summary of dominant respondent perception for local institution

Variable/ Sub-variable	Code	Dominant Respondent Perception	% (n)
Local Institution	X02	**Score 2**: Efforts are minimal; limited to occasional verbal information/warnings (e.g., at mosque, via WhatsApp).	42.9% (18)
Existence	X03	**Score 3**: Gained basic practical skills (e.g., turning off power, basic first aid) from institutional programs.	42.9% (18)
Adequacy of Personnel	X04	**Split Perception:** **Score 3:** Sufficient (most involved residents were served well).	35.7% (15)
		Score 2: Lacking (service was limited and uneven).	35.7% (15)
Development Initiatives	X05	**Score 2:** Training was provided but offered only “fleeting insight” and did not build lasting, practical skills.	50.0% (21)
Regulations	X06	**Score 4:** Regulations are "very clear and accessible" and actively encourage compliance.	42.9% (18)
Standard Operating Procedures	X07	**Score 4:** Information is "very clear and consistent" and disseminated through accessible channels.	40.5% (17)
External Rules	X08	**Score 4:** Respondents "obey and actively encourage others" to comply with regulations.	61.9% (26)

The local institution (X02) is defined by a critical contradiction. On one hand, the Regulations (X06) variable was perceived positively, with 42.9% (n=18) finding rules “very clear and accessible”. This was strongly supported by its sub-variables; 61.9% (n=26) reported high compliance with External Rules (X08), and 40.5% (n=17) found the Standard Operating Procedures (X07) “very clear and consistent”. Conversely, this high regard for

governance did not translate to practical execution. Development Initiatives (X05) were viewed as superficial, with 50.0% (n=21) stating that training offered only "fleeting insight" rather than building lasting skills. This implementation gap was further reflected in Adequacy of Personnel (X04), which was perfectly split between sufficient (35.7%, n=15) and lacking (35.7%, n=15), indicating uneven service delivery. Despite these criticisms, the Existence (X03) variable indicated some tangible benefits, as 42.9% (n=18) of respondents acknowledged gaining basic practical skills from past programs.

5.1.2 Characteristics of social capital

The Social Capital (X09) indicator, measuring the capacity derived from community interaction, was perceived positively. A significant majority (85.7%, n=36) rated social interaction as either having a "positive influence" (Score 3) or being a "strong driver" (Score 4) in motivating residents to participate in training. The construct's performance was analyzed across four key variables—norms, participation, networks, and trust—with a summary of dominant respondent perceptions presented in **Table 2**.

Table 2. Summary of dominant respondent perception for social capital

Variable/ Sub-variable	**Code**	**Dominant Respondent Perception**	**% (n)**
Social Capital	X09	**Score 3:** Social interaction has a positive influence, motivating residents to learn.	47.6% (20)
Norms	X10	**Score 3:** A "sufficiently strong" habit exists to participate in training; residents respond well.	40.5% (17)
Participation	X11	**Score 2:** Participation is limited to giving input or practicing basic skills (e.g., First Aid).	31.0% (13)
Number of Participants	X12	**Score 2:** Involvement is mostly passive (e.g., listening to socialization).	47.6% (20)
Frequency of Participation	X13	**Score 2:** Attended once; gained knowledge but not practical skills.	45.2% (19)
Level of Participation	X14	**Score 2:** Involvement was limited to providing opinions in a forum.	35.7% (15)
Network	X15	**Score 1:** Cooperation is limited and functions only when there is an official order.	33.3% (14)
Reliable Person	X16	**Score 2:** Only a "handful" of the same few individuals can be relied upon.	45.2% (19)
Bonding Social	X17	**Score 4:** Many residents take the initiative to help each other in training programs.	35.7% (15)
Bridging Social	X18	**Score 4:** Groups (e.g., IKSPI Kera Sakti) actively and voluntarily seek collaboration.	35.7% (15)
Linking Social	X19	**Score 3:** Communication is "good enough" and provides space for discussion.	40.5% (17)
Trust	X20	**Score 3:** Trust is "good enough" for residents to discuss and conduct activities together.	64.3% (27)
Interpersonal Trust	X21	**Score 3:** Residents trust each other sufficiently for active discussion and small agreements.	52.4% (22)

Shared Collective Values	X22	**Score 3:** Residents voluntarily take real action (e.g., clearing evacuation routes) based on shared values.	52.4% (22)

The analysis of Norms (X10) indicated a positive foundation, with 40.5% (n=17) perceiving a "sufficiently strong" habit among residents to participate in training when invited. However, the Participation (X11) variable revealed this involvement is largely passive, with the dominant perception (31.0%, n=13) being limited to giving input rather than taking an active role. This is supported by the sub-variables, where Number of Participants (X12) was characterized by listening to socialization (47.6%, n=20), and Frequency of Participation (X13) was limited to a single attendance, which provided knowledge but not practical skill (45.2%, n=19). Reinforcing this, the Level of Participation (X14) was also predominantly consultative, with 35.7% (n=15) reporting their highest involvement as providing opinions in a forum, rather than taking an active role in implementation.

The Network (X15) variable highlighted a significant structural weakness, as 33.3% (n=14) reported that cooperation is limited and functions only when there is an official order. This is largely due to Reliable People (X16) being limited to a "handful" of the same individuals (45.2%, n=19). Despite this, Bonding Social (X17) and Bridging Social (X18) were strong, with 35.7% of respondents for both variables reporting high levels of initiative and voluntary collaboration. Linking Social (X19) was deemed "good enough" for discussion (40.5%, n=17). Finally, the Trust (X20) indicator was strong, with 64.3% (n=27) describing it as "good enough" for joint discussion and action. Interpersonal Trust (X21) was sufficient for active discussion and small-scale agreements (52.4%, n=22). This trust manifested as strong Shared Collective Values (X22), where 52.4% (n=22) confirmed that residents voluntarily take real action, such as clearing evacuation routes, based on shared values.

5.1.3 Characteristics of human capital

The Human Capital (X23) indicator, which assesses the knowledge, skills, and health capacity of the community, was perceived as being in a developmental stage. The dominant perception (50.0%, n=21) was that residents capacity was limited to passive knowledge gained from socialization (Score 2) , while 40.5% (n=17) reported active skill development through formal training or simulations (Scores 3 and 4). A detailed breakdown of the dominant perceptions for each variable within this construct is presented in **Table 3.**

Table 3. Summary of dominant respondent perception for human capital

Variable/ Sub-variable	**Code**	**Dominant Respondent Perception (Score & Description)**	**% (n)**
Human Capital	X23	**Score 2:** Attended socialization, gaining knowledge but not skills.	50.0% (21)
Formal Education	X24	**Score 3:** "Sufficiently equipped" to follow planned steps.	42.9% (18)
Education Level	X25	**Score 4:** Will assess the situation and prioritize actions.	38.1% (16)

Variable/ Sub-variable	**Code**	**Dominant Respondent Perception (Score & Description)**	**% (n)**
Disaster Education Material	X26	**Score 3:** Taught "basic steps" (e.g., go to assembly point).	38.1% (16)
Skills	X27	**Score 4:** Actively seek info, help neighbors, join community work.	45.2% (19)
Pre-disaster Skills	X28	**Score 2:** Clean drains and move items to higher ground.	35.7% (15)
During-disaster Skills	X29	**Score 4:** Check on neighbors and share critical information.	59.5% (25)
Post-Disaster Skills	X30	**Score 4:** Join community work (*kerja bakti*) to help neighbors.	54.8% (23)
Health	X31	**Score 2:** Participated in data collection of vulnerable residents.	42.9% (18)
Disability Population	X32	**Score 2:** Participated in data collection of residents w/ disabilities.	42.9% (18)
Prevalence of Severe Disease	X33	**Score 2:** Participated in data collection of residents w/ severe illness.	42.9% (18)
Disaster Knowledge	X34	**Score 4:** Check warnings, coordinate w/ neighbors, join post-flood work.	50.0% (21)

The analysis of Formal Education (X24) indicated it "sufficiently equipped" residents to follow planned steps (42.9%, n=18). This is supported by the high Education Level (X25) (47.2% High School, 36.1% College), which correlates with respondents confidence in assessing situations rather than acting spontaneously (38.1%, n=16). However, Disaster Education Material (X26) in schools was perceived as basic or purely theoretical (35.7%, n=15), focusing on procedures like moving to assembly points (38.1%, n=16). The Skills (X27) variable was rated highly, with 45.2% (n=19) actively helping neighbors and joining community recovery efforts. While Pre-Disaster Skills (X28) were largely limited to household preparations like clearing drains (35.7%, n=15), During-Disaster Skills (X29) and Post-Disaster Skills (X30) were exceptionally strong and community-oriented, with majorities (59.5% and 54.8%, respectively) focused on checking on neighbors and collective recovery. A significant weakness was found in the Health (X31) variable, which assesses planning for vulnerable populations. Actions for both Disability (X32) and Severe Illness (X33) populations were predominantly passive, limited to "data collection" (42.9% for all three variables). Conversely, Disaster Knowledge (X34) was very high, with 50.0% (n=21) demonstrating a comprehensive understanding of the full disaster cycle, from checking warnings to post-flood coordination.

5.2 Validity and reliability test

To ensure the quality of the research instrument, the validity of the data was rigorously assessed. Validity, which confirms the instrument measures its intended constructs, was evaluated using the Pearson correlation test at a 5% significance level. For the sample size of 42 respondents, the critical r value was 0.304. The analysis demonstrated

that all 3 indicators, 12 variables, and 18 sub-variables achieved a calculated r value greater than this critical r threshold. Consequently, all items were deemed valid, confirming that the instrument effectively and accurately measures the concepts under investigation. The detailed results of this validity test are presented in **Table 4.**

Table 4. Result of validity test

Indicators	**Variable/**Sub-variable	**Item**	**Validity Test**						
			Calculated r value		**Critical r values**	**Sig.**		**α**	**Description**
Trained Human Resources		Y01	0,334	>	0,304	0,031	<	0,05	**Valid**
Local Institution		X02	0,627	>	0,304	0,000	<	0,05	**Valid**
	Existence	X03	0,611	>	0,304	0,000	<	0,05	**Valid**
	Adequacy of Personnel	X04	0,441	>	0,304	0,003	<	0,05	**Valid**
	Development Initiatives	X05	0,546	>	0,304	0,000	<	0,05	**Valid**
	Regulations	X06	0,539	>	0,304	0,000	<	0,05	**Valid**
	Standard Operating Procedures	X07	0,626	>	0,304	0,000	<	0,05	**Valid**
	External Rules	X08	0,397	>	0,304	0,009	<	0,05	**Valid**
Social Capital		X09	0,539	>	0,304	0,000	<	0,05	**Valid**
	Norms	X10	0,710	>	0,304	0,000	<	0,05	**Valid**
	Participation	X11	0,684	>	0,304	0,000	<	0,05	**Valid**
	Number of Participants	X12	0,367	>	0,304	0,017	<	0,05	**Valid**
	Frequency of Participation	X13	0,563	>	0,304	0,000	<	0,05	**Valid**
	Level of Participation	X14	0,538	>	0,304	0,000	<	0,05	**Valid**
	Network	X15	0,575	>	0,304	0,000	<	0,05	**Valid**
	Reliable Person	X16	0,661	>	0,304	0,000	<	0,05	**Valid**
	Bonding Social	X17	0,597	>	0,304	0,000	<	0,05	**Valid**
	Bridging Social	X18	0,594	>	0,304	0,000	<	0,05	**Valid**
	Linking Social	X19	0,720	>	0,304	0,000	<	0,05	**Valid**
	Trust	X20	0,640	>	0,304	0,000	<	0,05	**Valid**
	Interpersonal Trust	X21	0,642	>	0,304	0,000	<	0,05	**Valid**
	Shared Collective Values	X22	0,608	>	0,304	0,000	<	0,05	**Valid**
Human Capital		X23	0,504	>	0,304	0,001	<	0,05	**Valid**

Indicators	Variable/Sub-variable	Item	Validity Test						
			Calculated r value		Critical r values	Sig.		α	Description
	Formal Education	X24	0,532	>	0,304	0,000	<	0,05	**Valid**
	Education Level	X25	0,561	>	0,304	0,000	<	0,05	**Valid**
	Disaster Education Material	X26	0,567	>	0,304	0,000	<	0,05	**Valid**
	Skills	X27	0,393	>	0,304	0,010	<	0,05	**Valid**
	Pre-disaster Skills	X28	0,445	>	0,304	0,003	<	0,05	**Valid**
	During-disaster Skills	X29	0,430	>	0,304	0,004	<	0,05	**Valid**
	Post-disaster Skills	X30	0,506	>	0,304	0,001	<	0,05	**Valid**
	Health	X31	0,818	>	0,304	0,000	<	0,05	**Valid**
	Disability Population	X32	0,818	>	0,304	0,000	<	0,05	**Valid**
	Prevalence of Severe Disease	X33	0,818	>	0,304	0,000	<	0,05	**Valid**
	Disaster Knowledge	X34	0,475	>	0,304	0,001	<	0,05	**Valid**

Subsequently, the data was subjected to a reliability analysis, which yielded a Cronbach's Alpha of 0.936. As this value exceeds the accepted threshold of 0.60, it indicates high reliability. This signifies that the consistency of the answers provided by the 42 respondents is classified as high. The complete results of this reliability analysis are available in **Table 5.**

Table 5. Result of reliability test

Case Processing Summary			
		N	**%**
Cases	Valid	42	100.0
	Excluded	0	.0
	Total	42	100.0
Cronbach's Alpha		**N of Items**	
.936		34	

5.3 Correlation test

A Pearson correlation analysis was conducted as an initial verification of the relationships between the independent variables (constructs) and their respective indicators. This step was essential for preliminary data screening and to identify the strength and direction of the relationships, utilizing a significance threshold of $p < 0.05$. A summary of the significant correlations and their respective strengths is presented in **Table 6.**

Table 6. Summary of pearson correlation strength

Indicator	Variable / Sub-Variable	Code	Correlation Strength
Local Institution	**Existence**	X03	High
	Adequacy of Personnel	X04	Low
	Development Initiatives	X05	High
	Regulations	X06	Low
	Standard Operating Procedures	X07	Low
	External Rules	X08	Low
Social Capital	**Norms**	X10	Medium
	Participation	X11	Low
	Number of Participants	X12	Low
	Frequency of Participation	X13	Low
	Level of Participation	X14	Low
	Network	X15	Low
	Reliable Person	X16	Low
	Bonding Social	X17	Medium
	Bridging Social	X18	Medium
	Linking Social	X19	Medium
	Trust	X20	Medium
	Interpersonal Trust	X21	Medium
	Shared Collective Values	X22	Medium
Human Capital	**Formal Education**	X24	Low
	Education Level	X25	Low
	Disaster Education Material	X26	Low
	Skills	X27	Low
	Pre-disaster Skills	X28	Low
	Health	X31	Medium
	Disability Population	X32	Medium
	Prevalence of Severe Disease	X33	Medium
	Disaster Knowledge	X34	Low

For the Local Institution (X02) construct, Existence (X03) and Development Initiatives (X05) showed a high correlation, indicating that tangible program impact is strongly linked to development initiatives. Conversely, Regulations (X06) and External Rules (X08) were found to be non-significant ($p > 0.05$), suggesting that formal rules alone do not currently drive the perception of institutional capacity. Analysis of Social Capital (X09) revealed that Norms (X10), Network (X15), and Trust (X20) including all sub-variables for Bonding Social (X17), Bridging Social (X18), and Linking Social (X19) demonstrated significant, medium-strength correlations. Critically, the entire Participation

(X11) construct (including sub-variables X12, X13, X14) and the Reliable Person (X16) variable were non-significant, implying that general participation levels are not strongly associated with the overall indicator. In the Human Capital (X23) indicator, Health (X31) (and its sub-variables X32, X33) showed a medium correlation, while Pre-disaster Skills (X28) and Disaster Knowledge (X34) were also significant. Notably, Formal Education (X24) and the general Skills (X27) construct (specifically 'during' and 'post-disaster' skills) were non-significant, suggesting preparedness is influenced more by specific health-related awareness and pre-disaster knowledge than by formal education levels.

5.4 Determinants of enhanced trained human resources

To answer the primary research objective, the hypothesized framework was tested using Partial Least Squares-Structural Equation Modeling (PLS-SEM) with SmartPLS 4 software. This method was selected for its suitability in handling smaller sample sizes (N=42) and complex models with non-normally distributed data.

5.4.1 Hypothesis Development

Based on the theoretical framework synthesized from the literature review, five primary hypotheses were developed. The framework posits that Local Institutions (X02), Social Capital (X09), and Human Capital (X23) are direct determinants of trained human resources (Y01). Furthermore, based on established theory that social structures influence human skill development, the model also hypothesizes that Local Institutions (H4) and Social Capital (H5) have a significant positive influence on Human Capital, positioning Human Capital as a potential mediator. The complete set of hypotheses is detailed in **Table 7** and the specified structural model, illustrating the hypothesized paths between the constructs, is presented in **Figure 3**.

Table 7. Hypothesized relationships in the model

Hypothesis	Path	Description
H1	X02 -> Y01	Local Institution (X02) has a significant positive effect on Trained Human Resources (Y01).
H2	X09 -> Y01	Social Capital (X09) has a significant positive effect on Trained Human Resources (Y01).
H3	X23 -> Y01	Human Capital (X23) has a significant positive effect on Trained Human Resources (Y01).
H4	X02 -> X23	Local Institution (X02) has a significant positive effect on Human Capital (X23).
H5	X09 -> X23	Social Capital (X09) has a significant positive effect on Human Capital (X23).

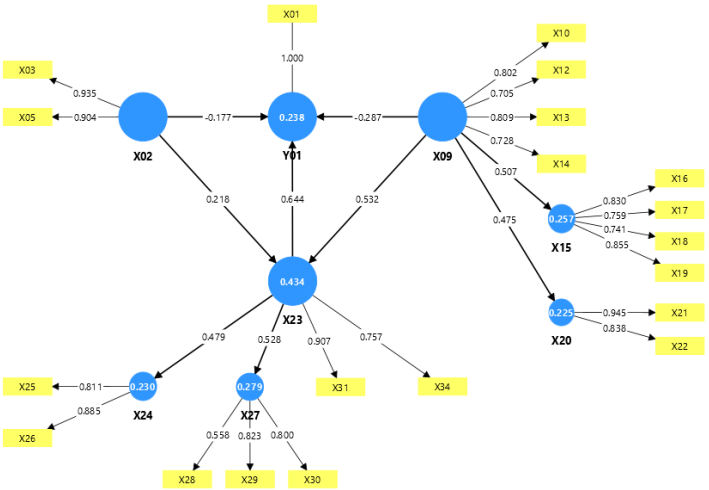

Fig. 3. Model Specification

5.4.2 Measurement Model Assessment

The analysis began with a rigorous assessment of the measurement model's reliability and validity. The initial model was refined based on these statistical criteria; Adequacy of Personnel (X04) and Regulations (X06) were removed from the Local Institution construct for failing to meet outer loading and AVE thresholds. Similarly, the Participation (X11) construct was reformulated, elevating its indicators (X12, X13, X14) to first-order variables to achieve model validity. The refined model demonstrated strong psychometric properties.

Reliability was assessed using Composite Reliability (ρA), which is considered a more robust measure than Cronbach's Alpha in PLS-SEM. All constructs met the required thresholds. Local Institution (X02), Social Capital (X09), Network (X15), and Trust (X20) all demonstrated high reliability (ρA > 0.80). Human Capital (X23), Formal Education (X24), and Skills (X27) were within the 0.60–0.70 range, which is acceptable for exploratory research. Validity was established by confirming both convergent and discriminant validity.

1. Convergent Validity was confirmed using two metrics. First, Outer Loadings for most indicators exceeded the 0.70 threshold. An exception was made for Pre-Disaster Skills (X28) (Loading = 0.558), which was retained due to its theoretical importance in the local context, where recurrent flooding has normalized the hazard. Second, the Average Variance Extracted (AVE) for all constructs surpassed the 0.50 minimum, confirming each construct explained over 50% of its indicators variance.
2. Discriminant Validity was established using two modern standards. First, the Heterotrait-Monotrait Ratio (HTMT) values for all constructs were below the 0.90 threshold, confirming empirical distinctiveness. Second, the Fornell-Larcker criterion was met, as the square root of the AVE for each construct was greater than its correlation with all other constructs.
3. Finally, a collinearity analysis found that all indicator Variance Inflation Factor (VIF) values were ≤ 2.140, well below the threshold of 5, confirming no

multicollinearity issues. Based on these tests, the measurement model was deemed robust, reliable, and valid.

5.4.3 Structural Model Assessment

Following validation of the measurement model, the structural model was assessed by running a bootstrapping procedure (5,000 samples) to test the hypothesized paths ($p < 0.05$). The results, summarized in **Table 8**, revealed that Human Capital (X23) was the only construct with a significant, strong positive direct effect on Trained Human Resources (Y01) ($\beta = 0.644$, $p < 0.001$). Contrary to H1 and H2, both Local Institution (X02) and Social Capital (X09) had no significant direct influence on Trained Human Resources. Further analysis showed that Social Capital (X09) had a significant, strong positive influence on Human Capital (X23) ($\beta = 0.532$, $p < 0.001$).

Table 8. Summary of structural model hypothesis testing

Hypothesis	Path	Original Sample (β)	T-Statistics	P-Values	Result
H1	X02 -> Y01	-0.177	1.203	0.229	Not Supported
H2	X09 -> Y01	-0.287	1.241	0.215	Not Supported
H3	**X23 -> Y01**	**0.644**	**3.830**	**0.000**	**Supported**
H4	X02 -> X23	0.218	1.437	0.151	Not Supported
H5	**X09 -> X23**	**0.532**	**4.439**	**0.000**	**Supported**

The non-significance of Local Institutions (X02) and Social Capital (X09) in directly enhancing Trained Human Resources (Y01) reveals a critical "implementation gap" within the specific context of Sidomulyo Village. While institutional governance is highly regarded with 42.9% of respondents finding Regulations (X06) "very clear" and 40.5% perceiving Standard Operating Procedures (X07) as "consistent", this does not translate into effective resource development. Empirical evidence shows that 50.0% of residents view Development Initiatives (X05) as superficial, providing only "fleeting insights" rather than sustainable technical skills. Furthermore, the adequacy of personnel (X04) is perfectly split, with 35.7% citing a lack of service that leads to uneven delivery. Similarly, the direct influence of Social Capital remains non-significant because Participation (X11) is predominantly passive and consultative (31.0%), with 45.2% of participants attending only once and gaining no practical expertise. Although the village maintains strong Interpersonal Trust (X21) and Shared Collective Values (X22) both at 52.4% these social bonds do not translate into immediate technical action for flood mitigation without a targeted mechanism for skill acquisition.

Conversely, the indirect effect of Social Capital (X09) on Trained Human Resources (Y01) through Human Capital (X23) was statistically significant ($\beta = 0.343$, $p = 0.013$). This central finding of the model illustrates that social dimensions such as norms, participation, networks, and trust function as foundational supporting mechanisms that first foster the development of Human Capital, which subsequently leads to the emergence of trained human resources. This mediated framework proves that enhancing Trained Human Resources in high-risk "cold spot" areas is dependent on a specific conversion process, where social connectivity is leveraged to build the tangible human capabilities necessary for effective and resilient disaster risk reduction. These significant determinants are summarized in **Table 9** for further strategic consideration.

Table 9. Recapitulation of variables influencing trained human resources

Indicator	Variable	Sub-variable
Human Capital (X23)	Formal Education (X24)	• Education Level (X25) • Disaster Education Material (X26)
	Skills (X27)	• Pre-disaster Skills (X28) • During-disaster Skills (X29) • Post-disaster Skills (X30)
	Health (X31)	
	Disaster Knowledge (X34)	
Social Capital (X09)	Norms (X10)	
	Number of Participants (X12)	
	Frequency of Participation (X13)	
	Level of Participation (X14)	
	Network (X15)	• Reliable Person (X16) • Bonding Social (X17) • Bridging Social (X18) • Linking Social (X19)
	Trust (X20)	• Interpersonal Trust (X21) • Shared Collective Values (X22)

6 Conclusion

This study concludes that enhancing trained human resources in high-risk, low-capacity areas like Desa Sidomulyo is a nuanced process, not of direct institutional action, but of multi-level capital conversion. The Partial Least Squares-Structural Equation Modeling (PLS-SEM) analysis confirmed that Human Capital (X23) is the only construct with a direct, strong, and statistically significant positive influence on the development of Trained Human Resources (Y01). Contrary to initial hypotheses, Local Institutions (X02) and Social Capital (X09) were found to have no significant direct effect on Trained Human Resources. However, the mediation analysis uncovered a critical pathway: Social Capital (X09) acts as a powerful predictor of Human Capital (X23), fully mediating the relationship between community bonds and trained resources.

Consequently, a fundamental paradigm shift is required: we must transform the current model of top-down instruction into one of bottom-up, sustained skill development. Strategic frameworks must stop treating social capital as the solution itself; instead, community bonds should be leveraged strictly as a driving tool to encourage residents to participate in training. This necessitates a hard pivot from abstract general socialization to concrete, applied training such as drills and mapping which is operationalized through four actionable strategies. First, regarding Variable of Formal Education, we must bridge the gap between theory and reality by integrating Bengawan Jero case studies into local curriculum to contextualize flood science. Second, Variable of Disaster Knowledge must evolve into operational competence by teaching residents to translate generic warning levels into specific checklists. Third, Variable of Practical Skills must embrace the shift towards simulation, incorporating route mapping workshops and boat operation drills. Finally, addressing Variable of Health Vulnerability requires a data-driven “Health Guardian”

system that assigns neighbors to assist specific individuals with disabilities during evacuations, effectively using social ties to protect the most vulnerable.

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