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Original Article

From Households to Communities: Building Flood Resilience Through Catchment Systems and Community Partnerships in Carrascal, Surigao del Sur

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Abstract. Flooding in Carrascal, Surigao del Sur, poses persistent and evolving risks driven by overlapping factors—climate variability, land-use changes, and socioeconomic vulnerabilities. This thesis examines the effectiveness of catchment systems and community partnerships in building long-term flood resilience in Carrascal through a convergent descriptive mixed-methods approach. The research combines quantitative survey data from 100 households across the municipality's most flood-prone barangays with qualitative insights from 11 key informant interviews involving community leaders, MDRRMO, and barangay officials. Results show that technical solutions, such as rainwater catchment systems, are most effective when supported by robust social strategies, including participatory planning, cooperative maintenance, and inclusive governance. The findings indicate that catchment systems, when actively maintained and managed with widespread community participation, can significantly reduce flood volumes and improve local preparedness and recovery. Residents rate their readiness and ecological stewardship highly but point out gaps in neighbor-to-neighbor trust, communication, and long-term impact assessment. The study concludes that Carrascal's adaptive progress depends on the continuous integration of engineering solutions and social capital, backed by transparent management and ongoing capacity building. Policy recommendations focus on strengthening multi-level partnerships, enhancing social cohesion, and establishing adaptive monitoring to ensure that flood mitigation strategies remain effective and relevant. These findings offer valuable empirical evidence and practical guidance for disaster risk reduction in flood-prone communities across the Philippines, positioning Carrascal as a model for grassroots-driven climate adaptation and sustainable development.

Keywords: *Catchment systems; Community partnerships; Ecological stewardship; Flood mitigation strategies; Sustainable development.*

Flooding in Carrascal, Surigao del Sur, is not just a recurring problem but a complex risk shaped by interactions between climate, land use, and social practices. Recent decades have seen Carrascal experience increasing flood severity due to intensified rainfall from phenomena such as the Amihan northeast monsoon, land development that accelerates runoff, and ecological changes such as deforestation and mining, which weaken the land's natural absorption capacity. These events reflect and extend beyond global and national trends, in which urbanization, vegetation loss, and climate extremes together increase flood vulnerability (Swiss Re Institute, 2024; Pantaleon et al., 2024).

A catchment system refers to any infrastructure—such as rainwater tanks, drainage canals, and river dikes—constructed to intercept, divert, and contain surface water runoff. Moreover, there is a significant lack of empirical research on the effectiveness of catchment systems (CS) in flood mitigation, especially regarding how local cooperation and context-specific factors—such as household roof area, storage capacity, and rainfall patterns—affect their performance (Pantaleon, 2024). While CS has been promoted as an effective strategy to reduce flood volume and enhance community resilience, existing studies consistently emphasize the vital role of community collaboration and participatory planning in maximizing the benefits of these systems. Such a partnership enables timely maintenance and strategic emptying of storage tanks before heavy rainfall, thereby significantly reducing flood volumes and helping downstream communities better prepare for potential flooding (Pantaleon, 2024).

Additionally, adaptation in Carrascal shows that resilience is strongest when technical solutions, such as catchment systems, drainage canals, and river dikes, are integrated into social-ecological strategies that emphasize inclusive governance, participatory planning, and continuous public awareness (Quinn et al., 2018; Abdullah et al., 2024). The municipality's recent history—marked by rapid recovery after floods in areas such as Barangay Baybay following drainage upgrades, and by ongoing challenges in maintaining open waterways—demonstrates how community ownership and leadership amplify the effectiveness of engineering solutions. These patterns are further reinforced by Carrascal's collaborative efforts to maintain flood infrastructure, institutionalize risk education, and develop local evacuation protocols, which align with the best international practices for fostering community-driven resilience (Fitriani et al., 2022).

Consequently, Carrascal's catchment-based adaptation succeeds by combining rigorous, context-specific technical measures with a bottom-up governance approach. Residents, barangay leaders, and the MDRRMO collaboratively monitor, maintain, and improve interventions, connecting local knowledge to adaptive management. This participatory model not only maintains technical effectiveness but also builds social capital and trust—key assets highlighted by survey data and supported by broader disaster literature as the glue that holds resilient systems together (Lasco et al., 2022; Gaillard & Mercer, 2013).

Furthermore, persistent challenges remain, including the need for stricter management of upland areas, continued investment in ecological restoration, and strengthened neighbor-to-neighbor solidarity. However, Carrascal's trajectory provides strong evidence for a systems approach: the community's willingness to innovate, learn, and collaborate across institutional boundaries is proving crucial to its ongoing adaptation and well-being. Ultimately, Carrascal's flood risk management exemplifies how combining engineering, ecology, and governance—grounded in participatory practices and ongoing learning—can help a vulnerable municipality not only cope with flooding but also actively build its resilience to flooding (Folke et al., 2010; Ostrom, 2009).

Thus, Carrascal's catchment systems (CS) serve as a crucial local adaptation strategy to flooding. These systems collect rainwater from rooftops via gutters into storage tanks, reducing runoff and lowering flood risk while providing an alternative water supply (OAS, 1996; Water, 2019). The success of CS in Carrascal relies on community cooperation for maintenance and coordinated use, which together enhance flood volume reduction and benefit downstream communities. These systems are integrated into local governance and community participation frameworks, exemplifying a combination of technical and social adaptation measures designed for the municipality's flood-prone area.

Methodology

Research Design

This study used a convergent descriptive mixed-methods approach to provide a comprehensive assessment of catchment systems and the role of community partnerships in strengthening flood resilience in Carrascal, Surigao del Sur. By combining quantitative and qualitative methods, the research not only evaluated the technical performance of catchment system infrastructure but also explored the social and environmental conditions, perceptions, and collaborative practices of local stakeholders (Quinn et al., 2018). This approach was particularly suited to Carrascal's flood issues, in which environmental, technical, and social elements are closely interconnected. Quantitative data were collected through structured surveys conducted with households and key stakeholders in flood-prone barangays, assessing awareness, participation, knowledge, and socio-economic factors related to flood risk and catchment systems. These surveys, along with municipal records and hazard maps, enabled the evaluation of flood extent, depth, and duration before and after implementation of the

catchment systems, providing empirical evidence of their effectiveness (Galguera, 2018).

The qualitative component enriched this technical analysis by capturing the community's insights. Interviews with residents, barangay, and municipal officials explored collective perceptions, barriers, and enablers of rainwater catchment adoption and maintenance. In contrast, key informant interviews with MDRRMO staff and community leaders explained policy implementation, governance, and lessons learned from recent flood events. Thematic analysis of these qualitative data revealed recurring patterns related to community participation, institutional support, and adaptive governance (Lew, 2023). For instance, active community partnerships, characterized by regular consultations, shared maintenance responsibilities, and participatory planning, proved essential for the successful implementation and sustainability of catchment systems.

Research Respondents and Participants

In this study, purposive sampling was employed to ensure that the respondents and participants represented those most exposed to flood risks and most engaged with catchment systems in Carrascal, Surigao del Sur. The research specifically targeted settlers living adjacent to river dikes and in barangays where catchment systems were implemented. A total of 100 individuals, comprising 10 respondents from each of the 10 selected barangays, participated in the study. The purposive approach also extended to the qualitative phase, where 11 key informant interviews were conducted with barangay and municipal officials who played critical roles in flood adaptation and water management: the Municipal Disaster Risk Reduction and Management Office and the Barangay Captains, with direct involvement in the implementation of river dike and water catchment systems.

Data Gathering Methods and Instruments

This study adopted a convergent descriptive mixed-methods design to comprehensively assess the effectiveness of catchment systems and the role of community partnerships in flood resilience in Carrascal, Surigao del Sur. Quantitative data were collected through structured household surveys administered to 100 purposively selected respondents from 10 flood-prone barangays. These barangays include Taganito, Bacolod, Saca, Embarcadero, Doyos, Gamuton, Bay-bay, Panikian, Adlay, and Bon-ot. The surveys measured socio-economic status, awareness, participation, and experiences with flooding. Secondary data, such as municipal flood records, hazard maps, and technical documentation, were used to validate and contextualize survey findings.

The qualitative component included interviews with 10 barangay community leaders, one from each barangay, and the MDRRMO Coordinator, who were directly involved in flood management and catchment system implementation. These qualitative methods explored community perceptions, barriers, and institutional practices related to flood adaptation and system maintenance. Data integration followed a convergent parallel approach, with quantitative results on flood reduction and flood management interpreted alongside qualitative insights on safety, participation, and empowerment.

Data Analysis Technique

This study employed a convergent, descriptive, mixed-methods design to assess catchment systems and community partnerships for flood resilience in Carrascal, Surigao del Sur. Quantitative data from 100 purposively selected household surveys across 10 flood-prone barangays were analyzed using statistical software. Descriptive statistics summarized socio-economic profiles, awareness, participation, and perceptions of flooding. Qualitative data from key informant interviews with local leaders and officials were transcribed and subjected to thematic analysis following Braun and Clarke's (2006) framework. Coding identified themes related to flood risk perceptions, adoption barriers, participatory planning, maintenance practices, and institutional support, guided by the Resilient Socio-Ecological Systems framework to capture social, technical, and ecological dimensions (Folke et al., 2010; Ostrom, 2009). Triangulation validated findings across data sources (Lew, 2023; Quinn et al., 2018).

Data integration followed a convergent parallel approach (Creswell & Plano Clark, 2018), merging quantitative and qualitative results during interpretation. Statistical evidence of flood reduction was contextualized with qualitative insights on community safety, shared responsibility, and empowerment, using joint displays to highlight convergence and divergence. As Denzin (1978) stated, this integrated analysis ensured that technical outcomes were interpreted within social realities, providing comprehensive, context-sensitive recommendations for sustainable flood resilience.

Ethical Consideration

This study strictly adhered to the research ethics and standards established by Mindanao State University – Iligan Institute of Technology (MSU-IIT), ensuring the protection, dignity, and rights of all participants throughout the research process. Prior to data collection, the researcher prepared formal letters addressed to the Municipal Mayor and the respective barangay local government unit's department (MDRRMO or MPDO), clearly outlining the study's objectives, scope, and significance. These letters served as official requests for access to relevant information and for permission to engage with community stakeholders, in line with institutional and local government protocols. Informed consent was a cornerstone of this research. Consistent with MSU-IIT's ethical guidelines, all participants were provided with the official MSU-IIT IERC Form No. 13 – Consent Form for Research Participants. The researcher explained the study's objectives, procedures, and potential risks and benefits in clear, accessible language. Participants provided their consent by signing the form. For those unable to write, a stamp pad was provided to affix their thumbprints, ensuring inclusivity and accessibility in the consent process.

To further uphold ethical standards, the researcher attached a letter to each consent form, reiterating the study's purpose and assuring participants that their responses and identities would remain strictly confidential. Personal information was securely stored, and pseudonyms were used in all reports to protect participant privacy. Respondents were also informed that the data collected would be used solely for academic purposes and to improve flood resilience projects in Carrascal, ensuring that their participation directly contributed to both scholarly understanding and tangible community benefits. Throughout the research, the principles of respect, beneficence, and justice directed all interactions with participants. The researcher stressed that participation was completely voluntary and that individuals could withdraw from the study at any time without penalty. By integrating these ethical safeguards at every stage, the study aimed to build trust, promote inclusivity, and establish genuine partnerships with the people of Carrascal, reinforcing the participatory and community-centered spirit at the core of the project.

Results and Discussion

Social Condition – Demographic Profile

Table 1 presents the socio-demographic profile of Carrascal, based on survey data, and indicates a predominantly stable, long-term-resident community with a mixed-gender composition and diverse, primarily low- to moderate-income livelihoods. Of 111 respondents, 62% were male, and 38% were female, indicating a gender imbalance. The vast majority (94%) have lived in Carrascal for more than 10 years, indicating a well-established and experienced population, while only 1% have resided in the area for less than a year.

In terms of household economics, 72% reported monthly incomes between 5,000 and 10,000 pesos, indicating the prevalence of lower-middle-income households; 14% reported incomes below 5,000 pesos, and another 14% above 20,000 pesos—indicating moderate economic diversity. Most households are moderately sized: 66% have 4–6 members, 21% have seven or more members, and only 14% have three or fewer members.

Furthermore, occupational data reveal a broad spread: significant shares are composed of working students (21%), housekeepers/housewives (18%), and truck/tricycle/delivery drivers (14%). Other groups include barangay captains (10%), vendors (8%), laborers (7%), LGU employees (6%), online sellers (6%), farmers (2%), and others in smaller proportions. This reflects a labor force that spans formal government roles, service sectors, informal sectors, and subsistence or micro-enterprise activities.

Social Condition - Resiliency

Carrascal's social condition shows a generally strong and resilient community supported by effective institutions and active citizen involvement. Findings indicate that, although overall resilience is high (mean = 4.04, "Agree"), trust between people and mutual support during floods remain moderate (mean = 2.79, "Neutral"). By contrast, one informant from Barangay Embarcadero noted uneven social cohesion among residents, which could undermine the community's preparedness. Other residents are not complying with early-warning and disaster-preparedness measures.

"It is really necessary always to be ready, to have a bag prepared to go when the barangay calls for evacuation. When warnings are given, you should not be stubborn or refuse to follow".

Table 1. *Social Condition – Profile of Research Respondents of Carrascal, Surigao del Sur*

Indicators	Frequency	Percentage %
Gender		
Male	69	62
Female	42	38
Other / Prefer not to say		-
Total	**111**	**100**
Length of Residence in Carrascal		
Less than 1 year	1	1
1 to 5 years	2	2
6 to 10 years	4	4
More than 10 years	104	94
Total	**111**	**100**
Monthly Household Income		
Less than ₱5,000	16	14
₱5,000 to ₱10,000	80	72
More than ₱20,000	15	14
Total	**111**	**100**
Number of People Living in Your Household		
1-3	15	14
4-6	73	66
7 or more	23	21
Total	**111**	**100**
Occupation		
Working/Student	23	21
Housekeeper/Housewife	20	18
Truck/Tricycle/Delivery Driver	16	14
Brgy. Captain	11	10
Fish/Fruit/Meat Vendor	9	8
Laborer	8	7
LGU Employee	7	6
Online Seller	7	6
Teacher	4	4
BHW	2	2
Farmer	2	2
Cashier	1	1
Midwifery	1	1
Total	**111**	**100**

Source: Survey 2025

On the other hand, information sharing about flood risks (mean = 3.72, "Agree") demonstrates a culture of communication, though it is not yet widespread. The municipality's main strengths are its institutional dimensions: capable local leadership (mean = 4.46), adequate support programs (mean = 4.53), and inclusive participatory planning (mean = 4.72). Together, these support Carrascal's disaster resilience through strong governance and civic involvement. This has been reinforced by an informant from Barangay Embarcadero, who stated, *"They help with what needs to be done, such as putting things here and solving problems at home when there are floods. They also help the people, and when disaster strikes, they immediately prepare."* The functioning local government and the inclusive, participatory approaches adopted are significant to Carrascal's resilience. Overall, the municipality's experience indicates that robust institutional and participatory systems support community resilience. However, ongoing efforts to foster neighborly trust and expand communication networks are essential to strengthening social solidarity.

Table 2. *Social Condition - Resiliency*

	Statement	Mean	Description
1.	People in my community trust and support each other during floods or emergencies.	2.79	Neutral
2.	Community members regularly share important information related to flood risks and safety.	3.72	Agree
3.	Local leaders and community groups actively collaborate to address flooding-related problems.	4.46	Strongly Agree
4.	There are sufficient social programs and services to support families affected by flooding in Carrascal.	4.53	Strongly Agree
5.	Residents feel involved in decisions about flood preparedness and disaster planning in our community.	4.72	Strongly Agree
Overall Result		**4.04**	**Agree**

Legend: 1.00 – 1.80: Strongly Disagree, 1.81 – 2.60: Disagree, 2.61 – 3.40: Neutral, 3.41 – 4.20: Agree, 4.21 – 5.00: Strongly Agree

Ecological Condition

Table 3 indicates that Carrascal's ecological condition is generally strong, characterized by high levels of community and local government stewardship of natural resources. Residents report very positive views of river, forest, and hill care (mean = 4.71, "strongly agree") and acknowledge active protection efforts by officials and civic groups (mean = 4.52). Most agree that maintaining healthy ecosystems is crucial for reducing disaster risks like flooding (mean = 4.56)—an informant from Brgy. Taga-anito emphasized the importance of favorable ecological conditions, stating, "*Our surroundings have many trees and plants which help provide fresh air. Even though there are canals and drainage systems, there are still some parts that get blocked because of trash and leaves.*" This reflects the local government's efforts to strengthen ecological conditions.

Despite these strengths, the community remains aware of ongoing threats. Residents often observe environmental decline—less tree cover, increased erosion (mean = 4.51), and visible damage such as garbage and clogged waterways (mean = 4.78)—linked to deforestation, mining, and urbanization. The overall weighted mean (4.62, "strongly agree") indicates that Carrascal combines strong ecological engagement and vigilance with a realistic understanding of vulnerabilities. This reflects national trends in which local stewardship, reforestation, and community action are vital to building disaster resilience.

Table 3. *Ecological Condition*

	Statement	Mean	Description
1.	The rivers, forests, and hills around Carrascal are well cared for and free from pollution.	4.71	Strongly Agree
2.	Over the past years, I have observed reduced tree cover and increased erosion in areas near Carrascal.	4.51	Strongly Agree
3.	Local government and community groups actively protect natural resources like forests and waterways.	4.52	Strongly Agree
4.	The current environmental conditions help reduce flooding in Carrascal.	4.56	Strongly Agree
5.	It is easy to see signs of environmental damage (such as garbage, clogged streams, or damaged vegetation) in our area.	4.78	Strongly Agree
Overall Result		**4.62**	**Strongly Agree**

Legend: 1.00 – 1.80: Strongly Disagree, 1.81 – 2.60: Disagree, 2.61 – 3.40: Neutral, 3.41 – 4.20: Agree, 4.21 – 5.00: Strongly Agree

Description of the Area

Carrascal, located in the northeastern part of Surigao del Sur, is a coastal and upland municipality with a total land area of 37,872 hectares, divided among 14 barangays. Its geography varies from low-lying coastal plains and rolling hills to steep, heavily forested uplands, with elevations as low as 8.9 meters in the town center and slopes exceeding 30 degrees in large sections of its territory. The largest barangay, Pantukan, accounts for over a third of the municipality, while key settlements and the local government seat are situated along the coast at Embarcadero. The area contains four major rivers and numerous streams, with mineral resources—especially iron and nickel—concentrated in barangays Adlay, Pantukan, and Bon-ot (MDRRMO Contingency Plan).

Carrascal's primary domestic water source is the LGU-managed Carrascal Waterworks Level III System, which sources spring water and drilled wells. Over the past decade, this system has expanded to serve more than 2,700 households, as well as commercial and institutional connections, in Poblacion, Gamuton, Panikian, Bon-ot, Bacolod, Saca, and nearby barangays. Latest municipal data indicate that 72.66% of households have access to safe water, although coverage remains limited in more remote rural barangays. The waterworks mainly depend on the Tigbabakod spring, with plans to add reservoirs and wells to support growth until 2030. After major flood events, water quality often decreases due to siltation, temporary contamination, and the vulnerability of open wells and surface sources (MDRRMO Contingency Plan).

Municipal Plan for Flood Control

Carrascal's Municipal Contingency Plan for Floods emphasizes a proactive, well-coordinated approach to disaster response to minimize casualties and property damage. It adopts an all-hazards, multi-cluster system that activates the Emergency Operations Center and Incident Command structure during major flood events. Core activities include rapid impact assessments, efficient resource deployment, preemptive evacuations, and targeted assistance for vulnerable groups. Operational clusters for health, logistics, shelter, and law enforcement work closely with national agencies, military units, police, and local volunteers. The plan also prioritizes continuous risk assessment, inventory management, inter-agency communication, post-disaster evaluations, and regular procedural reviews to ensure operational readiness—one barangay official from Brgy. Panikian emphasizes the government's efforts, especially in monitoring and planning flood control measures, saying, "*The MDRRMO monitors areas that are at*

risk of flooding and checks the condition of the people living there. They include these in their plans to ensure that the projects benefit the community and protect people, especially during floods. They also assist the poor and those who are easily affected by disasters."

Carrascal's flood control infrastructure—comprising dikes, riverbank protection, and drainage systems—is actively being expanded but still has limited coverage. Resource capacity includes critical communication tools, vehicles, medical kits, generators, and fuel reserves, supported by municipal, provincial, and national DRRM funds as well as private contributions from mining companies. Local response teams are well-trained but face ongoing challenges with funding, equipment, and replenishment during large-scale disasters. Overall, the plan presents a structured, adaptable framework that enhances local disaster preparedness while acknowledging current logistical constraints and vulnerabilities (MDRRMO Contingency Plan).

Challenges Experienced During Flooding

Carrascal faces multiple and intersecting challenges during flooding, as reflected in recent community survey data. Residents "strongly agree" that property damage is a near-constant experience (mean = 4.65), pointing to the widespread, direct impacts of floods on housing and assets. Access to clean water is also severely compromised, with a mean of 4.35, highlighting health and daily living concerns that sharply escalate with inundation. As emphasized in the story of a resident from Brgy. Doyos, saying "*For me, the fishing livelihood here is really affected because of the mud that gets into the water—sometimes, the fishermen really have no income*".

Economic disruption is a critical issue, with many reporting that their daily activities and income are adversely affected (mean = 3.44, "Agree"). Notably, seeking assistance from local authorities is another pronounced challenge; community members "strongly agree" (mean = 4.65) that help is hard to obtain during and after flood events—an indication of logistical or resource barriers within disaster response systems. As reflected in the story of a resident from Bgy. Saca, there is a strong need to maintain clean waterways to prevent flooding. The resident said, "*For us, we really evacuate to the barangay hall when there is flooding, the water really reaches our place. I think we should always clean our canals, even those built recently near Saca. The government also works hard so that no houses get damaged when there is flooding.*"

Health risks follow closely: the threat of waterborne diseases during and after floods is nearly universal, evidenced by a mean of 4.69 ("strongly agree"). Overall, the composite mean for flooding-related challenges is 4.36, signaling that these hardships are widely shared and substantial across barangays.

Table 4. *Challenges Experienced During Flooding*

	Statement	Mean	Description
1.	Flooding has caused damage to my home or property.	4.65	Strongly Agree
2.	My household has faced difficulty accessing clean water during floods.	4.35	Strongly Agree
3.	Flood events disrupt the household's daily activities and income.	3.44	Agree
4.	It is difficult to obtain assistance from local authorities during and after floods.	4.65	Strongly Agree
5.	Flooding causes health problems (such as waterborne diseases) for my household.	4.69	Strongly Agree
Overall Result		**4.36**	**Strongly Agree**

Legend: 1.00 – 1.80: Strongly Disagree, 1.81 – 2.60: Disagree, 2.61 – 3.40: Neutral, 3.41 – 4.20: Agree, 4.21 – 5.00: Strongly Agree

Flood Adaptation Strategies

Carrascal uses a layered approach to flood adaptation, combining household readiness with coordinated community and institutional efforts. Nearly all respondents at the household level "strongly agree" that they prepare emergency supplies—such as food, water, and medicine—in anticipation of floods (mean = 4.81). Additionally, families have clear action plans for what to do before, during, and after floods (mean = 4.65), and they implement physical modifications, such as elevating furniture and using flood-resistant materials, to reduce property damage (mean = 4.62). Brgy. Official from Brgy. Bon-ot mentioned that constructing a drainage system helps prevent flooding in the area, saying, "*The way we prevent flooding in our area is by making drainage systems or canals. We make canals or drainage, and we came up with the idea to build drainage or canals here because every time it floods, these help reduce the water.*"

Table 5. *Strategies Employed by Both Households and Communities*

	Statement	Mean	Description
1.	My household has prepared emergency supplies (food, water, medications) in the event of flooding.	4.81	Strongly Agree
2.	We have a clear plan at home on what to do before, during, and after a flood.	4.65	Strongly Agree
3.	Our community conducts drills and training to prepare residents for flooding.	4.80	Strongly Agree
4.	Households, including mine, have made physical changes to reduce flood damage (e.g., raising furniture, using flood-resistant materials).	4.62	Strongly Agree
5.	Community members collaborate to maintain flood-control systems, such as drainage canals and waterways.	4.49	Strongly Agree
6.	Local government and community groups provide support and information that help us adapt to floods.	4.68	Strongly Agree
7.	Reforestation, or planting trees near catchments or rivers, is promoted and practiced by the community to reduce flooding.	4.73	Strongly Agree
8.	Our community has developed early-warning systems to alert residents to potential flooding.	4.72	Strongly Agree
9.	My household and community can recover quickly after a flood event.	4.78	Strongly Agree
10.	I have participated in community activities aimed at reducing flood risk.	4.58	Strongly Agree
Overall Result		**4.79**	**Strongly Agree**

Legend: 1.00 – 1.80: Strongly Disagree, 1.81 – 2.60: Disagree, 2.61 – 3.40: Neutral, 3.41 – 4.20: Agree, 4.21 – 5.00: Strongly Agree

Communities further strengthen resilience through collective action. There is strong agreement on community-organized drills or training sessions for flood response (average = 4.80) and on widespread participation in maintaining flood-control infrastructure and drainage canals (average = 4.49). Local government and community organizations are consistently reported to provide support and information (average = 4.68), and reforestation or tree-planting near rivers and catchment areas is promoted and practiced (average = 4.73). Robust early warning systems are in place (average = 4.72), and a shared confidence in recovery is evident across the population (average = 4.78). Notably, residents actively participate in community risk-reduction activities (average = 4.58), reflecting a strong culture of civic engagement and mutual aid. An officer from MDRRMO noted that part of their preventive planning is to plant more trees in the catchment areas and to maintain the functionality of the drainage system. They stated, *"We plan to plant lots of trees in the mountains and catchment areas to help reduce flooding. We also want to build cleaner and larger drainage systems. We will organize training and awareness campaigns for the community so that everyone will be more prepared when floods occur."*

This high level of adaptive engagement—indicated by an overall weighted mean for "flood adaptation strategies" of 4.79 ("strongly agree")—shows that Carrascal's resilience relies on both autonomous household adaptation and coordinated community efforts. This integrated approach aligns with best practices recommended in international disaster risk reduction literature, which emphasizes that combining self-protection, collective action, institutional support, and ecosystem-based solutions (such as reforestation) produces the most effective and sustainable flood resilience (Gaillard & Mercer, 2013; Lasco et al., 2022).

Extent of Catchment System in Reducing the Risk of Flooding

Carrascal's catchment systems are vital for reducing flood risks through combined ecological and structural actions. The municipality has implemented watershed restoration, upland reforestation, and riverbank protection projects across its four main river basins—Bon-ot, Gamuton, Panikian, and Carrascal—covering a substantial portion of the local territory. These efforts enhance infiltration, reduce surface runoff, and trap sediment, thereby supporting established flood-mitigation principles. The Comprehensive Land Use Plan supports these initiatives by focusing on watershed protection, forest rehabilitation, and the restriction of harmful land uses, such as mining and logging. From 2015 to 2022, forest coverage grew from 74 to nearly 79 percent of the total land area, indicating improvements in catchment stability and ecological health. However, environmental challenges still exist. Landslides, erosion, and siltation are common in mining-affected catchments, underscoring enforcement gaps and the need for improved coordination among the mining, agriculture, and forestry sectors. Overlapping land rights and competing land uses continue to hinder sustainable watershed management. Overall, catchment systems—through forest conservation, reforestation, land-use regulation, and streamside management—significantly reduce flood risk by absorbing rainfall, buffering peak flows, and preventing soil erosion. However, to enhance their effectiveness, Carrascal needs to address land-use conflicts, invest in long-term watershed rehabilitation, and ensure consistent monitoring and enforcement—findings supported by recent research on ecosystem-based disaster risk reduction (Esteban et al., 2016; Lasco et al., 2022).

Catchment System in Reducing the Risk of Flooding – Readiness and Preparedness

Residents highly value Carrascal's catchment systems as essential components of flood preparedness. Survey results indicate strong public confidence in their performance and maintenance, with residents strongly agreeing (mean = 4.82) that drainage canals and reforested catchment areas are well managed prior to heavy rainfall. Respondents also confirm that these systems effectively lessen flood severity (mean = 4.49) and improve household preparedness (mean = 4.68). Community involvement is a key strength, with a mean score of 4.77 for resident participation in maintenance and monitoring. The local government also receives high praise for providing sufficient information and integrating catchment systems into flood management strategies, scoring 4.72 and 4.65, respectively.

Table 6. *Readiness and Preparedness*

	Statement	Mean	Description
1.	The catchment systems in Carrascal (such as drainage canals and reforested areas) are well maintained and prepared to manage floodwaters during heavy rainfall.	4.82	Strongly Agree
2.	These catchment systems help lower the chances of severe flooding in my neighborhood.	4.49	Strongly Agree
3.	I feel better prepared for floods because of the presence and maintenance of catchment systems in our area.	4.68	Strongly Agree
4.	Community members are involved in maintaining and monitoring catchment systems to ensure flood readiness.	4.77	Strongly Agree
5.	The local government provides sufficient support and information on catchment systems and their role in reducing flood risk.	4.72	Strongly Agree
6.	The catchment systems contribute to the community's emergency preparedness plans for flooding.	4.65	Strongly Agree
7.	Flood warnings and early alerts are more effective because catchment systems help reduce flood severity.	4.69	Strongly Agree
8.	After heavy rainfall, catchment systems help floodwaters recede quickly, allowing us to return to everyday life more quickly.	4.60	Strongly Agree
9.	I trust that the catchment systems are adequate to protect my household from future flooding events.	4.78	Strongly Agree
10.	The catchment systems have reduced flooding-related damage and losses in Carrascal.	4.73	Strongly Agree
Overall Result		**4.79**	**Strongly Agree**

Legend: 1.00 – 1.80: Strongly Disagree, 1.81 – 2.60: Disagree, 2.61 – 3.40: Neutral, 3.41 – 4.20: Agree, 4.21 – 5.00: Strongly Agree

Notably, respondents credit catchment systems with improving flood warnings and early alerts (mean = 4.69) and accelerating community recovery by enabling floodwaters to recede more quickly (mean = 4.60). The high level of trust (mean = 4.78) in the adequacy of catchment structures, along with the widespread belief that these systems have clearly lessened flood damage and losses (mean = 4.73), indicates both technical effectiveness and broad social approval. "Thus, the overall index for catchment system readiness and preparedness stands at a striking 4.79 ("strongly agree"), underscoring the systems' key role in Carrascal's proactive, community-driven flood risk reduction approach." While many communities in the Philippines traditionally rely on a top-down government approach, Carrascal's success indicates a strong integration of bottom-up (community-driven) efforts with effective local government support and information sharing. The local government's high ratings for communication and system integration into the flood management plan emphasize the importance of a two-way process in risk reduction, where local knowledge combines with institutional capacity (Fano & Takeuchi, 2010)

Catchment System in Reducing the Risk of Flooding – Effectiveness

Carrascal's catchment systems are considered highly effective at reducing flood risks and enhancing community protection. Survey results indicate that residents strongly agree these systems have decreased both flood frequency (average = 4.82) and floodwater severity (average = 4.47), with fewer reports of household damages (average = 4.48). Their ability to manage rainwater and prevent overflow into homes scores 4.62, while public confidence in their design and functionality remains high at 4.70. Regular maintenance ensures reliable performance (average = 4.75), and quick community recovery after flooding earns a strong 4.77. Respondents also note visible reductions in flood depth and duration (average = 4.63), connecting these improvements to active community partnerships (average = 4.47).

Table 7. *Effectiveness*

	Statement	Mean	Description
1.	The catchment systems in Carrascal have significantly reduced the frequency of flooding in our area.	4.82	Strongly Agree
2.	Floodwaters are less severe because of the catchment systems installed around Carrascal.	4.47	Strongly Agree
3.	Since the implementation of catchment systems, my household has experienced fewer damages from floods.	4.48	Strongly Agree
4.	The catchment systems effectively manage rainfall and prevent overflow into residential areas.	4.62	Strongly Agree
5.	The catchment systems are well designed and suitable for reducing flood risk in Carrascal.	4.70	Strongly Agree
6.	Catchment system maintenance is done regularly to ensure its effectiveness in flood prevention.	4.75	Strongly Agree
7.	The presence of catchment systems allows the community to recover more quickly after flood events.	4.77	Strongly Agree
8.	The catchment systems have decreased the depth and duration of floodwaters in my neighborhood.	4.63	Strongly Agree
9.	I have observed improvements in flood management in Carrascal since community partnerships began managing catchment systems.	4.47	Strongly Agree
10.	Overall, catchment systems are effective tools for protecting communities from flood risk.	4.70	Strongly Agree
Overall Result		**4.74**	**Strongly Agree**

Legend: 1.00 – 1.80: Strongly Disagree, 1.81 – 2.60: Disagree, 2.61 – 3.40: Neutral, 3.41 – 4.20: Agree, 4.21 – 5.00: Strongly Agree

Catchment System in Reducing the Risk of Flooding – Management

Carrascal's catchment system management is highly effective and a core element of its flood risk reduction approach. Survey data indicate a strong consensus (overall mean = 4.80) that regular maintenance ensures proper drainage and water retention during rain. Collaboration between local authorities and community organizations is also highly valued (mean = 4.55), supported by active public participation in planning, decision-making, and management activities (mean = 4.59). These results emphasize a well-coordinated, community-driven system that enhances the municipality's resilience to flooding.

Table 8. *Management*

	Statement	Mean	Description
1.	The catchment systems in Carrascal are regularly maintained to ensure effective operation.	4.81	Strongly Agree
2.	Local government and community groups collaborate effectively to manage catchment systems.	4.55	Strongly Agree
3.	Community members are actively involved in decision-making and activities related to catchment system management.	4.59	Strongly Agree
4.	There is clear communication from authorities about catchment system management and flood risk reduction efforts.	4.69	Strongly Agree
5.	Effective management of catchment systems helps prevent blockages that cause flooding.	4.71	Strongly Agree
6.	Funding and resources for catchment system maintenance are sufficient and well managed.	4.56	Strongly Agree
7.	Training and capacity-building in catchment management are provided regularly to community members and officials.	4.74	Strongly Agree
8.	Management plans for catchment systems are updated regularly to address changes in flood risk.	4.75	Strongly Agree
9.	The responsible organizations manage the catchment systems transparently and accountably.	4.77	Strongly Agree
10.	Overall, the current management of catchment systems helps reduce flood risks in Carrascal.	4.79	Strongly Agree
Overall Result		**4.80**	**Strongly Agree**

Legend: 1.00 – 1.80: Strongly Disagree, 1.81 – 2.60: Disagree, 2.61 – 3.40: Neutral, 3.41 – 4.20: Agree, 4.21 – 5.00: Strongly Agree

Strong communication, efficient operations, and high public trust characterize Carrascal's catchment management system. Authorities effectively disseminate information (mean = 4.69) and enforce protocols that prevent flooding-related blockages (mean = 4.71). Funding and resource management are viewed as adequate and well-managed (mean = 4.56), supporting long-term stability. Carrascal's success stands in sharp contrast to ongoing national issues. Numerous reports highlight a widespread lack of public trust stemming from procurement corruption, "ghost" projects, and substandard or incomplete flood-control work across various parts of the Philippines (UP CIDS, 2025). Additionally, residents and officials receive average training (4.74), and management plans are updated regularly (4.75), indicating a culture of continuous improvement. High confidence in transparency and accountability (average = 4.77) further boosts institutional credibility. Together, these elements ensure that Carrascal's catchment management remains effective, adaptable, and trusted as a foundation for flood resilience.

Conclusion

This study reveals that Carrascal is characterized by a socially cohesive and ecologically engaged community that actively participates in resilience-building initiatives. The municipality's strong local leadership, participatory decision-making processes, and extensive social support programs are vital to its resilience. However, levels of interpersonal trust and risk communication vary across barangays. On the ecological front, the municipality fosters a culture of environmental stewardship through proactive protection measures. Nonetheless, it continues to face pressures from deforestation, mining, and urbanization, which threaten the long-term effectiveness of flood control and water management. The challenges of flooding are complex, extending beyond physical damage to encompass issues of access to clean water, health risks, and economic constraints. These interconnected impacts highlight the necessity for integrated responses that connect health, infrastructure, and governance systems.

At the adaptation level, the community shows a strong culture of preparedness. Households maintain emergency plans and supplies, while barangays participate in collective efforts, including flood drills, reforestation, and system maintenance. Consistent government communication and collaboration among sectors reinforce this readiness, showing how community involvement and local partnerships help reduce risks sustainably. Additionally, catchment systems enhance Carrascal's resilience, as survey data indicate decreases in flood frequency, severity, and household impacts attributable to effective drainage and reforested buffer zones. Transparent management, community participation, and regular plan updates ensure continued efficiency and flexibility. While the municipality's integrated model is effective, sustained progress requires enforcing land-use policies in critical watersheds, sustaining ecological restoration efforts, and enhancing social cohesion and information sharing. Achieving enduring resilience will require aligning technical, social, and environmental strategies within a flexible, learning-oriented governance framework consistent with socio-ecological systems theory.

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