Mitigating Flash Flood Risks: A Study of Control Measures in Dalican, Datu Odin Sinsuat, Maguindanao

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Abstract

This study aimed to examine the history of flash floods in Dalican, Datu Odin Sinsuat, and a framework for flood control measures was proposed to assist local authorities and stakeholders in addressing these issues. A systematic approach to identify area-specific solutions for future flood prevention was intended, and this was considered essential for planning and policy formulation. Community workshops, focus group discussions, interviews, and site visits were conducted to identify various factors contributing to flash floods, including peak rainfall, watershed characteristics, and land management practices. Flash floods in Dalican were found to be triggered by heavy rainfall, with the worst occurrences recorded in 2003 and 2008. The watershed, which spans about 13,000 hectares, was observed to be narrow and long, leading to significant water accumulation. Several creeks, including Dalican, Sibuto, and Benolen Creeks, were identified as contributing to flooding in lowland areas, such as the MSU-Maguindanao Campus and nearby communities. It was found that poor land management practices, such as slash-and-burn farming and timber poaching, exacerbated soil erosion and increased the risk of landslides during heavy rains. Inadequate drainage infrastructure, such as undersized culverts, was also identified as a factor that worsened flooding in Poblacion and other areas. Control measures were proposed, including reforestation efforts, improving upland farming techniques, replacing undersized culverts with larger box-type structures, and desilting canals. In addition, a three-pronged solution involving infrastructure rehabilitation, social interventions, and watershed restoration was recommended. The need for the LGU of Datu Odin Sinsuat to lead efforts in implementing these flood control measures was emphasized by the study.

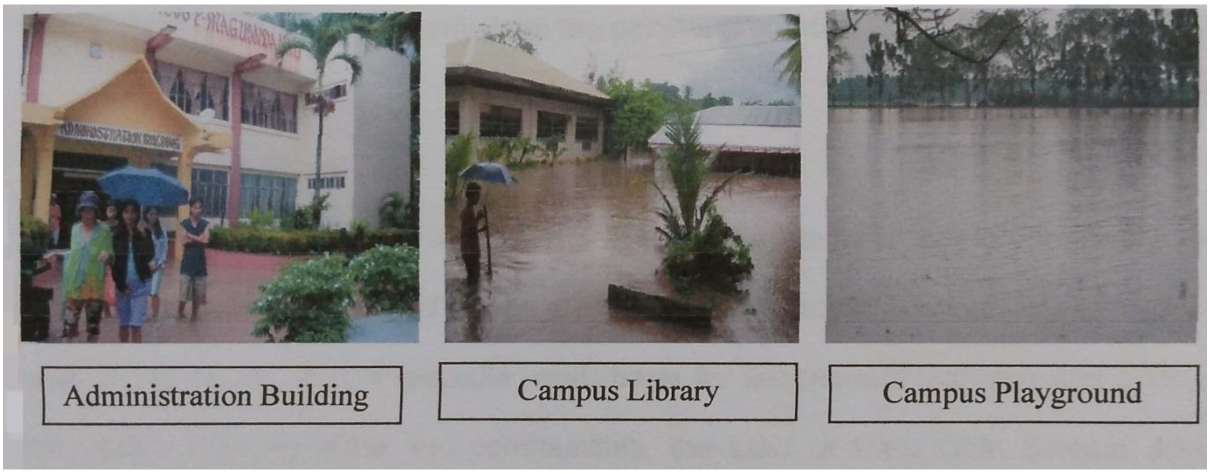
Keywords: Control measures, Flash flood, Reforestation.

1. Introduction

Barangay Dalican, also known as Poblacion, is the seat of the Local Government Unit of Datu Odin Sinsuat Municipality, Maguindanao. It is located on a plain at the foot of the sprawling hills of the prominent Mount Blit. Together with the adjoining lowland barangays, Dalican spans both hillside barangays and low-lying areas that extend to the Ibpanan Marsh. Due to these geographical features, Dalican serves as the convergence point for a system of creeks and tributaries from a relatively long watershed, referred to in this study as the Dalican Watershed. As a result, flooding is a common occurrence, impacting people's lives, properties, livelihoods, and public infrastructure.

The 2003 flood in this barangay was severe (Exhibit 1), but there is concern that even worse flooding may occur in the future unless appropriate mitigating measures are implemented. This study is a deliberate effort to thoughtfully analyze and propose long-term, concrete solutions to this problem.

Figure 1. Images Taken at MSU Maguindanao Campus during the 2003 Flash Flood



Five barangays of the town of Datu Odin Sinsuat, which comprise the Dalican watershed, were covered by this study. These include Barangay Dalican or Poblacion, where flooding occurs, and the four upland barangays: Benolen, Neketan, Sibuto, and Kinebeka.

1.1 Statement of the Problem

This study aimed to trace the history of past flash floods in Dalican, Datu Odin Sinsuat, and develop a logical framework for potential control measures and development in the area. Specifically, it addressed the following questions:

1. What is the history of past flash floods in terms of magnitude and return period?
2. What were the causes of those floods?
3. What were the effects of the floods on the socio-economic condition of the people and the environment?
4. What is the condition of the current drainage facilities in controlling floods?
5. What potential interventions can be implemented to control future flash floods and minimize adverse effects on people, properties, and the environment?

1.2 Objectives of the Study

The main objective of the study is to systematically, comprehensively, and effectively identify area-specific control measures for future flash floods in this town. It serves as a requisite and basis for subsequent planning and policy formulation to guide the communities, the LGU of Datu Odin Sinsuat, concerned agencies, and other stakeholders in addressing the flash flood problems.

Specifically, the study aims to:

1. Collect and analyze biophysical, socio-economic, and cultural data;
2. Determine data gaps related to the occurrence, causes, and effects of flooding and plan measures to address them;
3. Prepare thematic maps based on the resource survey;
4. Validate the accuracy and completeness of biophysical, socio-economic, and cultural information and completed maps;
5. Assess the status of existing interventions by the LGU and line agencies; and
6. Formulate a logical development framework to address flash flood problems and related development interventions.

1.3 Importance of the Study

The assessment of the watershed and communities is crucial for planners and policymakers in the LGU of Datu Odin Sinsuat Municipality and concerned line agencies. It will help identify appropriate measures to reduce the magnitude and impact of future floods, as well as measures to protect biophysical resources from further destruction. Practical, area-specific sustainable development interventions to address flash flood problems can also be identified.

The findings of the study will benefit the communities and people affected by flash floods. Knowledge of past flood patterns will serve as a warning of potential future threats. Communities may become aware of human factors that aggravate floods and be motivated to support resource protection and conservation, which are natural means of flood mitigation. Additionally, the study can raise awareness about the risks of disaster if people remain unprepared or neglectful of their responsibility to the environment.

1.4 Scope of the Study

This study covered the Dalican watershed ecosystem and the communities most affected downstream. It focused on determining the socio-economic, cultural, and biophysical resource conditions that influence or contribute to flooding in the area. Potential social and environmental development interventions were also identified.

The area of coverage included Barangay Dalican and the four upland barangays of Benolen, Neketan, Kinebeka, and Sibuto. Heads of families and barangay officials, chosen purposively, were the respondents for the survey and community workshops, respectively.

The duration of the study was three months. The project was launched in the first week of October 2010, and the final report was submitted on December 31, 2010.

1.5 Definition of Terms

Some terms used in this study are defined operationally for clarity:

Backflow: A rise in water level due to the clogging of a drainage structure meant to drain water.

By-pass Channel: A man-made channel used to redirect water flow and avoid obstructions or communities.
Flood: The accumulation of water in low-lying areas or depressions, resulting from excessive rainfall, overflow from a body of water, or backflow from a clogged drainage structure.
Flash Flood: A sudden flood caused by intense rain over a large area of a watershed with poor vegetative cover.
Flood Control: Any measure, typically infrastructure, used to reduce the impact of flooding.
Gabion: A corrosion-resistant metal basket filled with stones, used to protect riverbanks against overflow and erosion.
Levee: An earthen embankment or dike along a river or creek to prevent floodwater overflow.
Runoff: The portion of rainfall that, after interception by vegetation and infiltration into the soil, flows over land toward bodies of water.
Runoff Flood: Flooding caused by the accumulation of runoff in streams, leading to overflow in adjacent low-lying areas.
Sub-watershed: A small area that drains into a tributary of a larger or main drainage system within a watershed.
Watershed: A defined area of land that serves as the source of water for a body or system of bodies of water.

2. Review of Related Literature

This chapter presents a collection of materials related to the research problems of the study. It covers topics about flooding, the factors perceived to be the causes, such as biophysical, demographic, and socio-economic characteristics of the watershed, the effects of floods, and some flood control measures.

2.1 Flood: Definition, Types, and Occurrence

Schwab et al. (1993) defined a flood as an overflow or inundation from a river or other body of water. Most floods occur on the floodplains adjacent to rivers and streams and result from natural causes such as excessive rainfall and melting snow. Floods are classified into large-area floods and small-area floods. Large-area floods occur from storms of low intensity lasting a few days to several weeks, while small-area floods occur from storms of high intensity lasting one day or less.

A rapid flooding of geomorphic low-lying areas, rivers, dry lakes, and basins is called a flash flood. Flash floods are caused by heavy rain associated with storms, hurricanes, or tropical storms, or by meltwater from ice or snow flowing over ice sheets or snowfields. Flash floods can also occur after the collapse of natural or debris dams, or a human-made structure such as a dam. Flash floods are distinguished from regular floods by a timescale of less than six hours (Wikipedia).

2.2 Causes of Flooding

Floods result from many interconnected and interdependent causes, such as high-intensity rainfall, heavy runoff, watershed shape and orientation, drainage channel and structure flaws, and human activities like deforestation, poor land management, and inadequate waste management (Linsley et al., 1992).

2.3 Rainfall and Runoff

Flooding can occur due to runoff from rainfall (surface or subsurface flow) that finds its way toward streams, channels, lakes, or oceans. This is termed flood runoff, which depends on rainfall duration, intensity, and aerial distribution. Storms of short duration may produce little or no runoff, whereas storms of the same intensity but of long duration will result in runoff. A flood that rises rapidly, with little or no advance warning, is called a flash flood. Flash floods usually result from intense rainfall over a relatively small area, or if the area was already saturated from previous precipitation.

The total volume of runoff is greater for intense storms, even if the total precipitation for the two storms is the same. Generally, the maximum rate and volume of runoff occur when the entire watershed contributes. However, an intense storm in one portion of the watershed may result in greater runoff than a moderate storm over the entire watershed (Schwab et al., 1993). When flood runoff is too large for a waterway, floodwaters overtop channel embankments in portions without natural protection and bends. In areas with flood controls, overflow may occur at weak portions of reservoirs, levees, or floodways.

The Municipality of Datu Odin Sinsuat has a Type IV climate, where rainfall is evenly distributed throughout the year. The dry months receive relatively low rainfall, with an annual average of 120-135 mm. Maximum rainfall occurs from May to June, averaging 210 mm (PAG-ASA Weather Station, Awang Field Station). Typhoons are rarely experienced in the area since it is bounded by the mountain ranges of the municipalities of Talayan and Upi on the southwestern side.

2.4 Watershed Characteristics

Flood runoff is also affected by the size, shape, orientation, topography, geology, and surface culture of the watershed. According to Schwab et al. (1993), both runoff volumes and rates increase as watershed size increases, but both the rate and volume per unit of watershed decrease as the runoff area increases. Long, narrow watersheds are likely to have lower runoff rates than more compact watersheds of the same size. Furthermore, watersheds with extensive flat areas or depressed areas without surface outlets have lower runoff than areas with steep, well-defined drainage patterns.

An important parameter to consider in flood studies is the design runoff rate, which refers to the capacity of structures that must carry runoff. Runoff volume is also important for predicting the volume from a watershed during a design flood. It is of primary interest in the design of flood control reservoirs (Schwab et al., 1993). A number of empirical formulas have been developed to describe the magnitude of extreme floods. Thise formula take the form:

$q=KA\times$

where q =the magnitude of the peak runoff (L^3/T),

K=a coefficient dependent on various characteristics of the watershed

A=the watershed area (L^3),

X=a constant for a given location.

2.5 Channel and Structure Failure

Flooding occurs during peak flows when the flow overtops the bank of the channel, either due to obstructions caused by the accumulation of silts or large debris, usually in loose and unprotected bends of the channel. When drainage structures such as culverts and bridges fail to pass the peak flow across roads, the water level rises over the channel banks and spreads over adjacent areas, taking time to subside. This is called backflow.

Highways cross many natural drainage channels, and the waters carried by these channels must be conveyed across the highway without obstructing the flow in the channel upstream of the road. Flooding occurs when the capacity of these structures is small compared to the peak flow and when cross-drainage structures are clogged at the openings by large debris, accumulated waste, or siltation. The capacity of a culvert (Hromadka et al., 1987) when the slope of the conduit is greater than neutral slope and the outlet is not submerged can be calculated by:

$q=a\,C(2gh)^{1/2}$

where: a =cross-sectional area (L^2)

h=head to the center of the orifice (L) (either Sl or English units)

2.6 Deforestation and Poor Land Management

Deforestation contributes to flooding as it increases the risk. Flood duration decreases in areas with natural forest cover due to high infiltration and deep percolation. Proper land management, which maintains favorable soil surface conditions, also retards runoff. About three times as much runoff occurs from heavy soils as from permeable, loose soils. Deforestation amplifies the incidence and severity of floods (Schwab et al., 1993).

2.7 Effects of Flash Floods

Flood damage may be classified as: (1) direct losses to property, crops, and land that can be quantified in monetary values; (2) indirect losses, such as depreciation of properties, traffic delays, and loss of income; and (3) intangible losses not subject to monetary evaluation, including community insecurity, health hazards, and loss of life. Agricultural losses are often greater in headwater areas than downstream, while the reverse is true in urban areas.

Rapid water runoff causes soil erosion and concomitant sediment deposition elsewhere (such as further downstream or down a coast). The spawning grounds for fish and other wildlife habitats can become polluted or destroyed. Prolonged high floods can delay traffic in areas that lack elevated roadways. Floods can interfere with drainage and economic use of lands, such as farming (Linsley et al., 1992).

Structural damage can occur in buildings, roads, bridge abutments, bank lines, sewer lines, and other structures within floodways. Farmlands and stream channels are often destroyed by floodwaters with high velocities. In some instances, waterway navigation and hydroelectric power generation are often impaired.

The worst cases of flooding in the Philippines were caused by the typhoon codenamed Thelma, which passed through the Philippines on November 5, 1991. It caused a flash flood that hit Ormoc City in Leyte province, killing at least 3,000 people, and destroying the homes of 50,000 others. In September 1984, a typhoon codenamed "Nina" killed 1,300 persons, while in 1995, typhoon "Angela" killed 700 people. On August 3, 1999, heavy torrential rains caused a landslide that killed 58 people and buried over 100 houses in Cherry Hills Subdivision in Antipolo City. On November 9, 2001, a typhoon locally named "Nanang" caused a flash flood that buried 350 residents of Mahinog in the island-province of Camiguin. The highest death toll during a weather disturbance was reported in Bangladesh when a strong cyclone (typhoon) killed nearly 300,000 people in Novembe 1970 (http://www.txtmania. Com/trivia/disasters.php).

Many people tend to underestimate the dangers of flash floods. What makes flash floods particularly dangerous is their sudden nature (http://en.wikipedia.org/wiki). Being in a vehicle provides little to no protection against being swept away; it may make people overconfident and less likely to avoid the flash flood. More than half of the fatalities attributed to flash floods are people swept away in vehicles when trying to cross flooded intersections. As little as two feet of water (60 cm) can be enough to carry away most SUV-sized vehicles. The U.S. National Weather Service reported in 2005 that, using a national 30-year average, more people die yearly in floods (127 on average) than from lightning (73), tornadoes (65), or hurricanes (16). In deserts, flash floods can be particularly deadly for several reasons (http://en.wikipedia.org/wiki). First, storms in arid regions are infrequent, but they can deliver an enormous amount of rain in a very short time. Second, these rains often fall on poorly absorbent and often clay-like soil, greatly increasing the amount of runoff that rivers and other water channels have to carry. Third, many desert waterways are usually dry, and people tend to forget that when rains fall, those channels can quickly fill with raging waters.

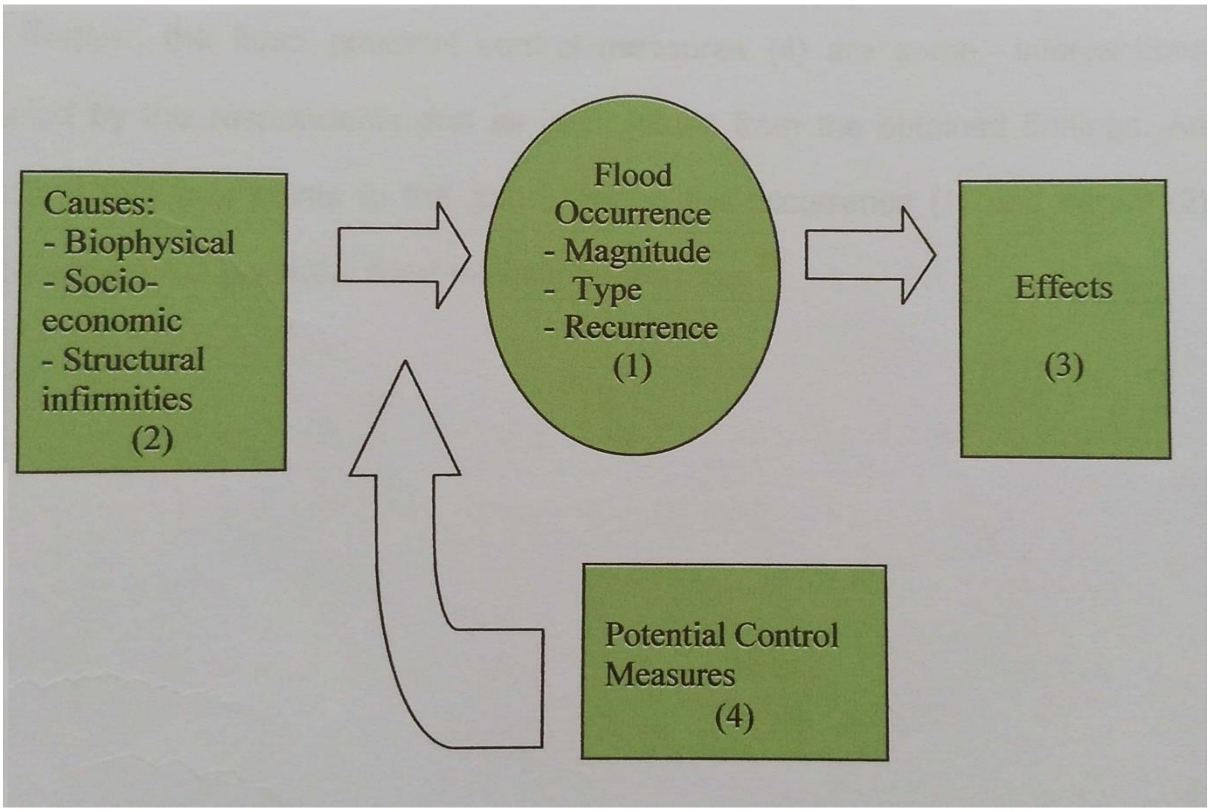
2.8 Flood Control Measures

Flood control measures are taken to reduce the damage caused by floods, especially in regions with frequent flooding. There are two primary approaches to flood control: structural and non-structural measures. Structural measures include the construction of levees, floodwalls, dams, and reservoirs to hold back floodwaters, as well as improved drainage systems to manage stormwater runoff. Non-structural measures focus on land use planning, zoning regulations, and public awareness campaigns to mitigate the impact of floods.

2.9 Conceptual Framework

The study was anchored on the natural relationships of the variables involved in the study as espoused in the foregoing review and the research problems presented earlier. These variables and their relationships are shown in the scheme below.

Fig.2. Schematic Diagram Showing the Conceptual Framework of the Study.



This study is of descriptive type and the scheme is not of the conventional "cause-effect" design used in experimentation but rather a simple analytical framework to describe the process of analysis to generate the obtained findings. It represents the sequential steps undertaken by the researchers in organizing and presenting the output of the study as shown in the diagram, the occurrence of flash floods serves as the main variable or the main subject of the study is contained in the circle (1). This serves as the core of the data collected prior to further analysis. The causes of floods are on the left-hand box (2) with an arrow-head pointing to the first box. These are the pre-identified factors based on the related literature reviewed. The effects of the floods on the right-hand box (3) which is pointed by an arrow-head from the left-hand box (2). These are adverse effects brought by the floods as experienced bythe residents as revealed by the respondents.

Further, the flood potential control measures (4) are some interventions suggested by the respondents and as implications from the obtained findings. An arrow from this box points to the gap between the occurrence (1) and cause (2) since these are the potential flood mitigating measures.

3. Methodology

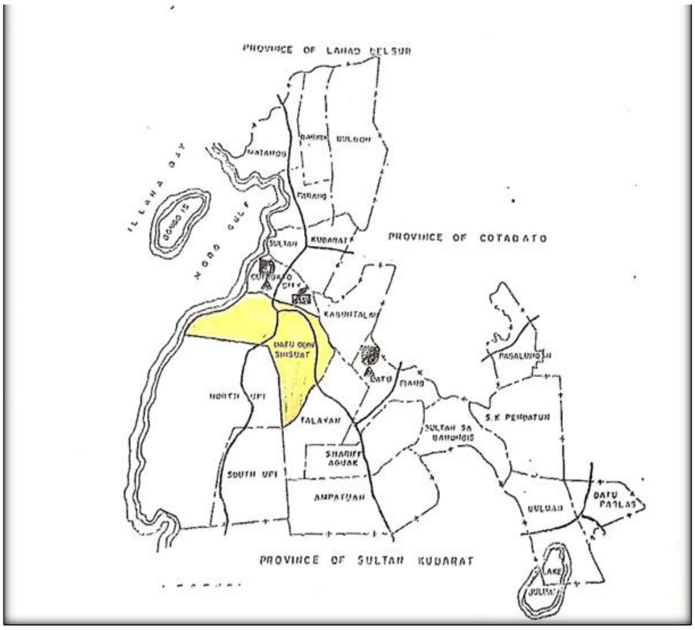
The study adopted the descriptive method of research, with the procedures for each concern discussed below.

3.1 Locale of the Study

Dalican is the last barangay of Datu Odin Sinsuat along the National Highway from Cotabato City, heading south. To the west of Dalican are the four hilly and mountainous villages of the town-Benolen, Neketan, Kinibeka, and Sibuto—which comprise a sub-watershed that drains towards Dalican and then into the catch basin of Liguasan Marsh, located in the adjacent municipalities of Talitay and Kabuntalan to the east. The most prominent natural landmark of the site is Mount Blit, which is visible from nearly all points in the study area and has a highest peak of 1,080 meters above sea level (ASL). It is where the headwaters of the major waterways in the watershed are situated.

The municipality, formerly called 'Dinaig,' was established as a municipality on August 18, 1947, by virtue of Executive Order No. 82, which originally covered the municipalities of Upi, South Upi, and parts of Talayan, Lebak, and Kalamansig, which are now under Sultan Kudarat Province. Later, it was renamed Datu Odin Sinsuat on December 15, 1994, by virtue of MM Act No. 29, in honor of the late Datu Odin Sinsuat, the first elected mayor of the town (DOS 2008-2010 CDP ELA).

Figure 3-Location map of Datu Odin Sinsuat Municipality



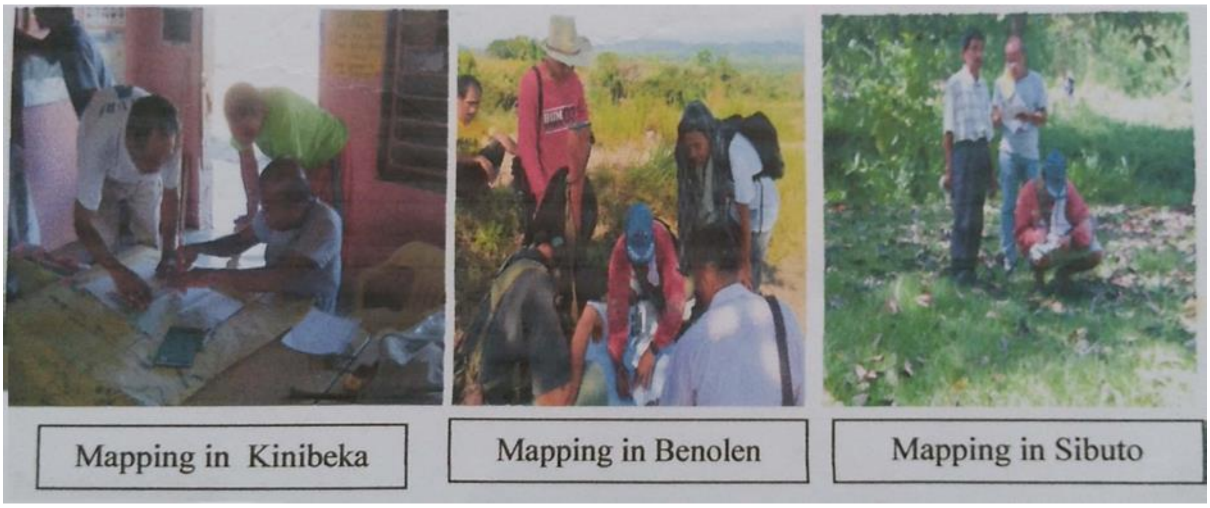
3.2 Socio-economic Profiling

A sample of about 10 percent of households was randomly selected from each barangay. Only primary socio-economic data were collected from the respondents, including information on demography, economic activities, and land management practices. Profiling was conducted during the community workshops. Groups of participants from various sitios were engaged as key informants/respondents. Data gathering was carried out through focus group discussions facilitated by members of the study team.

Figure 4. Community Workshops Conducted

A group composed of barangay focal persons and representatives from each sitio was organized to facilitate sketch mapping. The outputs of the sketch mapping included sketches of administrative centers, drainage, vegetative cover, hazards, and existing projects. A topographic map (scale 1:50,000) was used as a guide in the preparation of the maps.

Figure 5. Sketch Mapping Activities



Initial assessment of resources was done during the mapping process such as the indicative areas or percentage of forest lands, grass lands, agricultural lands open areas location of community centers, infrastructures, waterways, and hazardous areas.

3.3 Transect Walk

A team was organized to go on-site for a transect walk to conduct a visual assessment of the resources identified during the workshop. This aimed to validate the on-ground information generated during mapping, including coordinates and elevations using a GPS unit.

Figure 6. Transect Walk/Field Validation

3.4 Flood Survey
Focused group discussions and interviews were conducted. Key informants were asked about the dates of occurrence, magnitudes, estimated damages, perceived trends, and perceived causes.

3.5 Thematic Maps
Thematic maps were prepared on tracing paper with a scale of 1:50,000, including an administrative and settlement map, an infrastructure map, a vegetative cover map, a watershed and drainage map, a flood map, and a proposed flood control infrastructure map.

3.6 Approaches and Strategies
The study mainly adopted a participatory approach for each component. This approach was deemed important to ensure the sustainability of future interventions. Active participation from all stakeholders, especially community residents, was sought so that they would realize they are part of making important decisions for themselves. Thus, it promotes a sense of ownership of the study's outputs. Traditional courtesy calls to community leaders were conducted to adhere to local customs and traditions.

3.7 Research Timetable
Table 1. The Study Team was Guided by the Following Schedule in the Conduct of Major Activities to Complete the Project:

Activity	**Brief Description**	**Target Date**
Team Planning	Prepare implementation plan and tasking	October 1,2010
Courtesy Call	Courtesy calls the Mayor and Barangay Chairmen	Oct 3,2010
Collection of Secondary data and maps	Visit to LGU and Line Agencies and request for data.	Oct 4-5,2010
Community Workshops and Biophysical Assessment	Project Team, barangay officials, sitio representatives	Oct 24 -Nov 6, 2010
Profile Writing and Map Preparation	Project Team	Nov.7-19,2010

Final Report writing	Study Team	Dec.6-15,2010
In-house Presentation	Team Leader and members, Council members	Dec.18,2010
Presentation to LGU and other stakeholders	Study Team, Barangay Officials, Municipal officials	Dec.20,2010
Submission of Final Report	Study Team	Dec.23,2010

4. Presentation of Findings

Presented are the results of the investigation from the field as answers to the research questions posed earlier. A discussion of each of these results is also included.

4.1 History of Recent Floods

Many floods of varying intensities have occurred in Dalican over the years. For the purposes of this study, the most recent floods with distinct intensities were identified and investigated. Five floods were named by the key informants according to the year of occurrence: the 1988 flood, the 1993 flood, the 1998 flood, the 2003 flood, and the 2008 flood. Table 2 summarizes the characteristics of these floods, including perceived (or arbitrary) magnitude, type, affected areas, and reported damages.

4.2 Recurrence and Trend

Data in Table 1 also imply an occurrence interval of high-intensity flooding in Dalican, as well as the observed trend. By observing the data, the interval of occurrence appears to be every five years. This means that floods of this magnitude are likely to recur every five years in Poblacion Dalican.

There is an indication of a trend in the magnitude of recent floods. From the 1988 flood up to the most recent (2003), the trend in magnitude has been increasing. This can be explained by the fact that, to date, there have been no known attempts to reduce or stop the contributory causes of flooding. Instead, indicators show an increase in these causes, such as further tree cutting, deforestation, and expanding areas of hillside cultivation.

Table 2. Summary of Characteristics of Recent Floods in Dalican, D.O.S. Municipality

Flood Identity	Perceived Magnitude	Type	Area Affected
2008 Flood (June)	Moderate	-Overview of Dalican Crek banks -Sheet runoff along Sibuto road -Backflow from the National Highway drainage structures.	MSU-Maguindanao . Campus and adjacent farm lands
2003 Flood (June 16)	Intense	-Overview on Dalican Crek banks. -Backflow, associated with mud (Brar) creek, Kinipotan, Makir channel. -Flood overtopped the National High way	MSU-Maguindanao Campus, municipal hall (2 ft deep) and plaza, Purok IV and Kinipotan -Agricultural lands in Benolen

1998 Flood	Less intense	-Overflow of Dalican creek almost overtopping the highway -Overflow of Makir man-made channel with muddy water	Whole of Poblacion including public market area was flooded
1993 Flood	moderate	-Overview o Makir man-made channel	-DPES all flooded (2 feet)-Old market and public market partially flooded
1988 Flood	Less intense	Overflow of Makir man-made channel	Partially flooded DPES area and Old Market area

Source: FGD by the Study Team on December 13,2010

Figure 7. Pictures Taken During 2003 Flood in MSU Maguindanao

4.3 Types of Floods and Location of Sources

Floods that occurred in Dalican are of three types: overflow, backflow, and sheet runoff. As shown in Table 2, overflows take place at three flash points: Sibuto Creek near Damagi, the convergence of Dalican Creek and Sibuto Creek, and the bank of the man-made channel at the back of the Rural Health Unit during peak runoff. The primary reason for the overflow is the excessive volume of flood runoff, which exceeds the capacity of the channel or its structure, compounded by siltation. Excess flow overtops low stretches of the banks and occurs at bends.

Another form of flooding that affects Poblacion is sheet runoff coming from the slope of the hill in Damagi. This runoff has no defined channel; instead, it is conveyed over the Sibuto Provincial Road and accumulates in the low-lying area near the District Hospital, eventually draining toward the Kinipotan Culvert. In some cases, this sheet runoff combines with overflow from Sibuto Creek, producing a large volume and relatively deep floodwater in the affected areas, especially when backflows are also occurring.

The third form of flooding is backflow, which usually occurs in areas near drainage structures (culverts) across the national highway. This type of flood happens when the volume of floodwater exceeds the capacity of the flood control structure, often due to clogging by debris that reduces or blocks the inlet. The MSU-Maguindanao and the adjoining community are particularly prone to this kind of flooding, which originates from the Benolen Creek Pipe Culvert and Brar Bridge. Additionally, the community near the Kinipotan drainage structure is also vulnerable to this type of flooding.

Table 3. Summary of Flood Types, Sources and Places Affected

Type	Location of Source	Place/s Affected
Overflow	Sibuto Creek near Damagi	Sibuto Provincial Road, community near the District Hospital, Purok 4, and Kinipotan Community
	After Convergence of Sibuto Creek and Dalican Creek (bend)	Agricultural Lands in Benolen and Upstream part of Poblacion
	Sibuto Creek Banks	Poblacion
	Bank of Man-made Channel at the back of Rural HealthUnit	Dalican Pilot Elementary School, adjoining community, and Old Market area
Sheet Runoff	Damagi hillside	Sibuto Provincial Road, community near the District Hospital, Purok 4, and Kinipotan Community
Back flow	Near MSU Gym Pipe Culvert (Benolen Creek)	MSU-Maguindanao Campus, Pendaliday compound
	Kinipotan two-row Pipe Culvert	Plaza, Municipal Hall, Purok Kinipotan and Purok 4
	Brar Creek	MSU-Maguindanao Campus

Figure 8. Map Showing the Location of Flood Sources and Flood-prone Areas

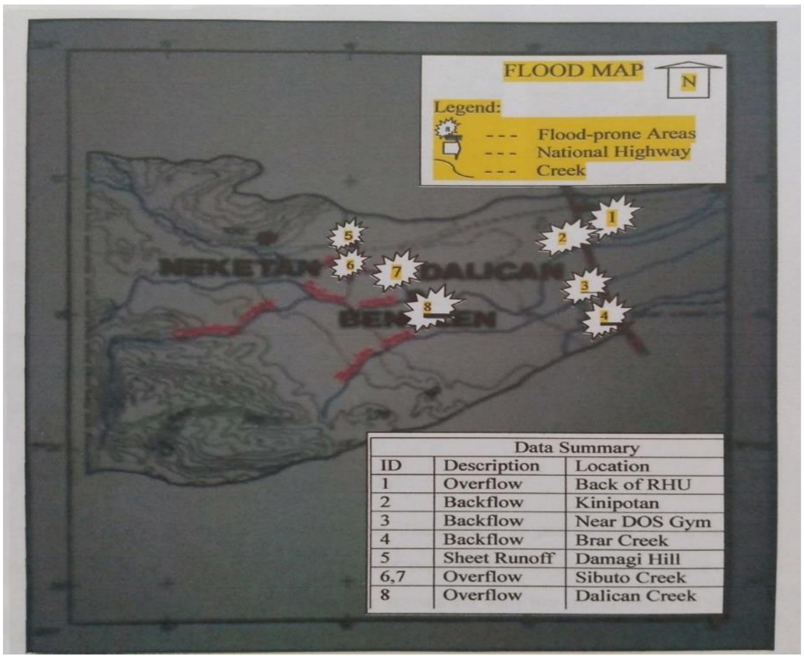


Figure 9. Photographs of Sites of Floods

4.4 Causes of the Flash Flood in Dalican

The causes of flooding are grouped into the biophysical characteristics of the watershed, deficiencies in drainage structures, and environmentally destructive human activities. Therefore, this information was investigated to see how it correlates with the occurrence of floods in the area.

4.5 Bio-physical Characteristics

Peak Rainfall. Rainfall over the Dalican Watershed is presented in Table 4, showing the months of peak rainfall (shaded blue and green). As can be seen, the occurrence of floods is directly correlated with peak rainfall. Two of the worst floods were the 2003 and 2008 floods, as reported by the respondents, which coincided with the peak rainfall months (May to July). The findings indicate that flooding in Dalican occurs when rainfall over the Dalican Watershed exceeds 250 mm in three successive months, and it worsens if rainfall exceeds approximately 380 mm, as was the case during the 2003 and 2008 floods. This supports the idea of Schwab et al. (1993) that the total volume of runoff is greater during intense storms.

Table 4. Monthly rainfall (mm)over the Dalican Watershed from 2001 to 2010

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2010	86	58	17	126	309	342	414	179	235	153	318	_ _
2009	207	83	126	225	172	188	208	104	180	202	78	32
2008	114	220	292	168	225	380	214	164	231	205	189	75
2007	152	55	85	64	246	377	251	231	111	153	149	101
2006	27	159	194	86	178	184	131	274	205	190	87	78
2005	45	33	84	33	269	288	269	181	142	90	114	307
2004	162	92	41	43	322	190	385	78	179	201	46	125
2003	16	66	182	46	265	377	250	177	276	223	100	124
2002	81	137	120	91	437	253	191	172	276	94	173	55
2001	116	115	200	91	123	85	203	99	180	318	276	101

Source: Data Collected Using Non-Recording Rain Gauge at Sibuto by SS Luminog

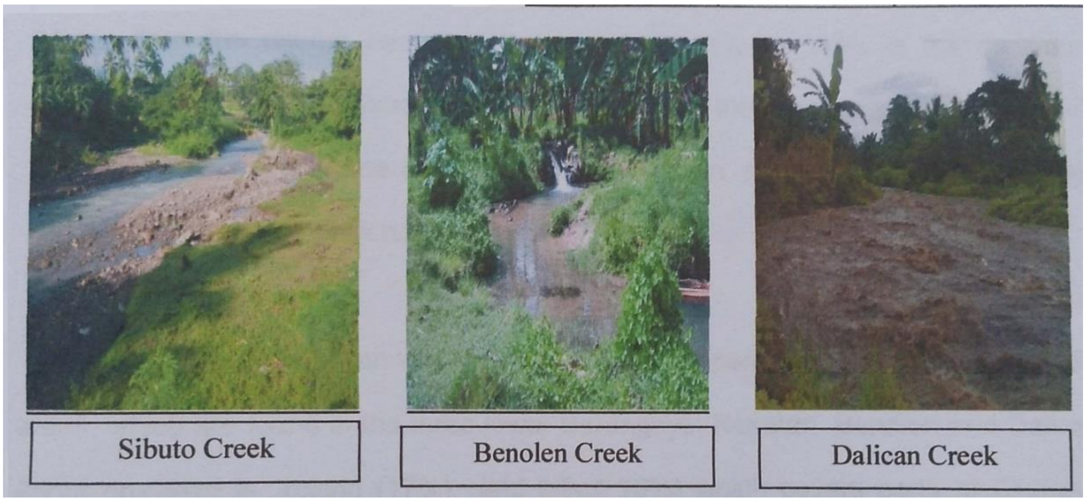
Watershed Size, Shape, and Drainage. Another factor that contributes to runoff flood volume is the size and orientation of the watershed. As indicated in Table 5, the watershed drainage area is approximately 13,000 hectares and is about 17 kilometers long. Thus, runoff rates are expected to be lower, but the large area can discharge a significant volume of flood runoff. According to Schwab et al. (1993), long and narrow watersheds are likely to have lower runoff rates than more compact watersheds of the same size.

The Dalican watershed has a drainage system in which Dalican Creek serves as the major drainage channel, drawing runoff water from the upland barangays. Sibuto Creek serves as the main tributary, while there are other smaller tributaries from various points of the watershed. Benolen Creek does not drain toward Dalican Creek, at least on the upper side of the National Highway. This drainage system has been effective upstream but is less effective upon reaching the convergence point of Dalican Creek and Sibuto Creek in Poblacion, as well as at the National Highway, where bridges and culverts are located and where overflow and backflow usually occur.

Table 5. Characteristics of Dalican Watershed

Name of Creek and tributaries	Length	Elevation		Slope, percent	Drainage Area
		Head	End		
Sibuto Creek Sub- watershed **-NorAm creek** **-Kagol creek** **-Sapandayan** **- Kinibeka creek**	16,500 m	920 m	10.0 m	5.5	6,187.50 has,
Dalican creek Sub- watershed **- Blit creek** **- Adaon creek** **- Tabungen creek** **- Seman creek** **- Columboy creek**	17,250 m	820 m	9.0 m	4.7	6,875.00 has
Dalican Creek Watershed (Total)				5.2 (ave.)	13.060.50 has
Benolen or Mantueg Creek Sub-watershed	3,000 m	60.0 m	9.0		1,500 has

Figure 10. Major Creeks in Dalican Watershed



There are two other creeks that also influence flooding in Poblacion, although they are not part of the Dalican Watershed but rather from adjacent sub-watersheds. One of these is Brar Creek, which is located at the southern end of the town and traverses the national highway beside the MSU-Maguindanao Campus. This causes flooding on the campus during excessive runoff due to backflow at the Brar Bridge. The other source of flooding is Makir Creek, located at the northern end of the Dalican Watershed. Its headwater is situated in Barangay Makir, and it traverses the national highway in this barangay. Flooding occurs in this creek due to large runoff from the hills near its headwaters, with the Public Market Site and the Pilot School (DPES) being the usual areas affected due to overflow at the man-made portion behind the RHU. Siltation and obstruction of the channel by houses were the primary reasons given by the respondents.

Peak Runoff. Applying the Rational Method (q = 0.0028CiA), considering the land area of the watershed as 12,000 hectares, a peak rainfall of 50 millimeters per hour, a runoff coefficient of 0.02, and an aerial rainfall distribution of fifty percent of the area, the design peak runoff (q) is 168 m^3/sec. This is the maximum expected theoretical discharge of Dalican Creek at the point of convergence with Sibuto Creek after the time of concentration. For Benolen, assuming similar data (1,000 hectares), the design peak runoff (q) is 14 m^3/sec.

Topography. The Dalican watershed has about 41 percent plain and relatively flat areas, which are found in the three lower barangays: Neketan, Benolen, and Dalican. About one-third is rolling (17%) and hilly (19%), covering parts of Kinibeka, Sibuto, and Neketan, while the rest is mountainous (21 percent), primarily in Mt. Blit in Kinibeka.

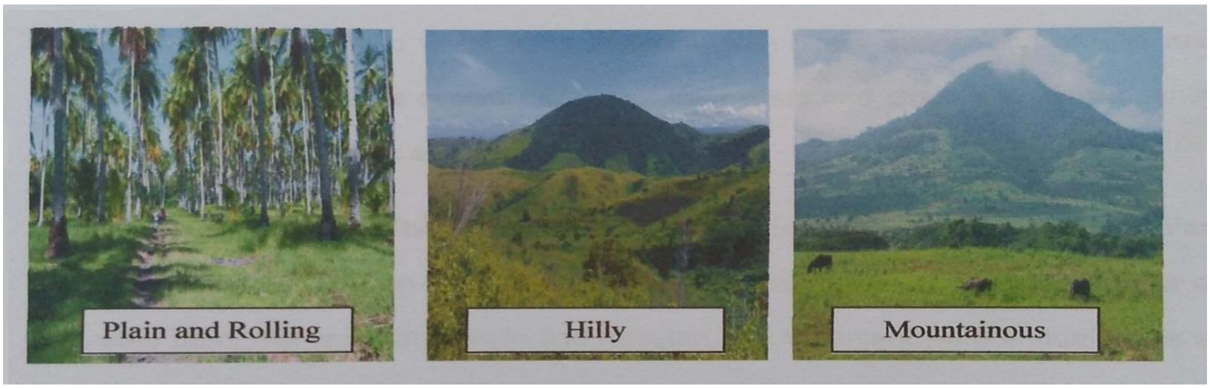
Table 6. Distribution of the Watershed's Topography by Barangay

Category	Barangay					Average (%)
	Kinibeka	Sibuto	Neketan	Benolen	Dalican	
Mountainous (30-50%)	0.50	0.20	0.20	0.15	0	21.00
Hilly (18-30%)	0 .30	0.35	0.25	0.15	0	19.00
Rolling (6 to 18%)	0.20	0.40	0.15	0.10	0	17.00
Plain and relatively flat 0 to 8 %	0	0.05	0.40	60	1.00	41.00

Source: FGD conducted by the Study Team, November 2010.

Sibuto. Mt. Blit (elevation 1,081 meters ASL) mountain ranges have steep and well-defined drainage patterns and are located at the most remote point of the watershed. Areas with these features are likely to produce larger runoff (Schwab et al., 1993).

Figure 11. Typical Topography of the Watershed



Soil Erosion. The generally sloping terrain is susceptible to soil erosion during heavy rainfall. Soil erosion contributes to crop destruction and low farmers' productivity. In lands with a slope of up to 8 percent, the rate of erosion is minimal, especially if covered by vegetation. These are areas under permanent vegetation (coconut) in Barangay Dalican and Neketan.

In areas with slopes greater than 8 percent, the rate of erosion ranges from moderate to severe. Moderate erosion was observed in hilly, rolling forested areas and brushlands in the upper barangays. However, severe erosion was observed on the steep slopes cultivated with annual and seasonal crops, mainly on the side slopes of Mt. Blit. Brushlands on the mountain ranges located in Sitio Kagol (western part of Mt. Blit) and Sitio T'noy (eastern part of Mt. Blit) exhibit these types of erosion. Residents in nearby communities claimed that landslides occur every time heavy rainfall hits these sites, and marks of past landslides are also very evident.

The problems of soil erosion and landslides magnify the effects of flooding on crops and homes, as floodwater turns brownish with heavy suspension of silt and pollutants. These materials accumulate over farmlands and crops, adversely affecting their growth and yield.

Vegetative Cover. The watershed has 9.20 percent open canopy forest, located mostly in Kinibeka, Benolen, and Sibuto. About one-fourth of the total area consists of cultivated perennial crops in Dalican and Neketan, while 33.00 percent consists of annual crops in all upland barangays. About 24 percent is brushland, also in upland barangays.

Finally, 9.4 percent is open and built-up areas, mainly in Poblacion. As shown in Table 7, only 9.20 percent of the watershed is left with open canopy forests, indicating that this very important natural resource is dwindling. It also implies that the water-holding capacity of the watershed has decreased tremendously after previously forested areas were steadily denuded. As a result, more runoff flood rushes to the streams and low-lying areas in Dalican.

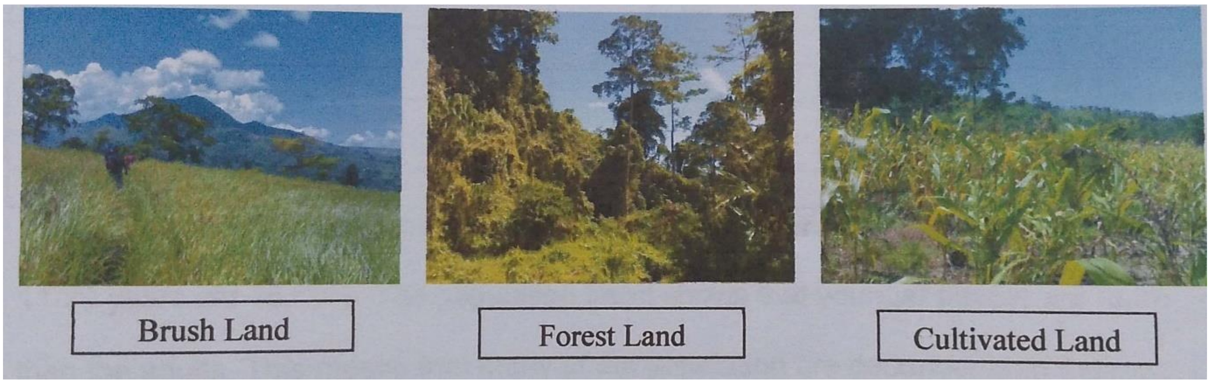
The decreasing areas of forest also connote an expansion of areas for the cultivation of agricultural crops. Given this condition, soil loss with runoff also increases unless appropriate land management practices are adopted by farmers. Unfortunately, very few farmers are aware of or adopting soil conservation practices. This situation, compounded by the loss of forests, really aggravates the problem of flooding in the lowland areas.

Table 7. Distribution of Watershed's Vegetative Cover by Barangay

Type of Cover	Name of Barangay					Average
	Kinebeka	Sibuto	Neketan	Benolen	Dalican	
Open Canopy Forest	10.00	14.00	2.00	20.00	0.00	9.20
Brush land	30.00	35.00	28.00	25.00	0.00	23.60
Cultivated Perennial Crops	15.00	16.00	20.00	13.00	60.00	24.80
Cultivated Annual Crops	40.00	30.00	45.00	40.00	10.00	33.00
Open or no vegetation/Built Up	5.00	5.00	5.00	2.00	30.00	9.40

Source: FGD Conducted by the Study Team, November 2010

Figure 12. Typical Vegetal Cover Found in Dalican Watershed



4.6 Demographic Characteristics

Population and Households. The five barangays covered by the Dalican watershed have a population of 30,146 and 5,251 households. The average household size is 5 individuals.

Table 8. Population and Number of Households by Barangay

Name of Barangay	Population	Number of Households	Average size of Household
Benolen	3,481	465	7
Dalican	22,000	3,667	6
Kinibeka	1,358	279	5
Neketan	2,357	550	4
Sibuto	950	290	3
Total	**30,146**	**5,251**	**5**

Source: FGD Conducted by the Study Team, November 2010

Age Structure. Age 25 years and older tops the percentage of the age structure with 38.50 percent, followed by college school age (19-24) with about 17.65 percent, then by elementary school age (6-12) with 15.69 percent, then by high school age (13-18) with about 15 percent and finally the least is 0-5 years old with 14.22 percent.

Table 9. Population by Age Structure (Percent)

Age Group	Name of Barangay					Percent
	Benolen	Dalican	Kinibeka	Neketan	Sibuto	
≥25	34.47	49.50	38.55	42.00	33.63	38.50
19-24	16.37	22.27	17.08	16.36	16.16	17.65
13-18	16.12	17.72	10.53	11.49	18.84	14.94
6-12	15.80	11.36	15.85	18.92	16.53	15.69
0-5	17.24	10.00	17.98	11.21	14.68	13.22
Total						**100.00**

Source: FGD Conducted by the Study Team, November 2010

11-20 years old 15.69%. The population trend shows that younger people are more than the adults. This means that many of the population are dependents to their parents.

Socioeconomic Characteristics and Activities. Farming is the most typical occupation of people, particularly of age 25 years old and above. Next to Farming is studying with about the same percentage.

This is the group of youth from the elementary level to college level. This shows that parents are sending their young ones to schools. Household chores represent about 10 percent which is mostly mothers. It is interesting to note however that still a number of individuals are firewood gatherers and charcoal makers. Although the number is small but these represents individuals who most frequently cut trees as source of their living and largely contributing to the continued denudation of the forest.

Table 10. Occupation of People by Barangay

Type	**Name of Barangay**					**Percent**
	Benolen	**Dalican**	**Kinibeka**	**Neketan**	**Sibuto**	
Employment	1.70	4.04	2.20	2.60	2..00	2.51
Student	26.11	25.00	23.00	25.00	25.00	24.82
Farming	31.60	12.00	39..45	18.85	28.40	26.06
Farm Labor	15.44	7.25	5.00	10.00	2.60	8.06
Non-farm labor/Technician	11.00	10.60	3.98	11.72	5.60	8.58
Firewood Gathering/Poaching	6.44	1.00	8.30	8.50	2.80	5.41
Charcoal making	1.17	1.00	6.94	6.36	8.80	4.85
Trading/buy and sell	2.87	26.11	5.90	6.36	10.00	10.25
Housekeeping	14.00	10.00	5.23	10.61	12.40	10.45
Others	5.71	3.00	0	0	2.40	2.22

Source: FGD Conducted by the Study Team, November 2010 Household Income.

The income of farmers is mainly from farming such as com, ginger and vegetables. They also earn from raising of chicken, cows, and backyard gardening but not on regular basis. Based on the farm produce with two cropping per year, the estimated average yearly gross income of the households in covered barangay is Php 78,400.00 pesos or Php 6,533.33 per month.

The farmers, however, claimed that at least 20 percent of the proceeds of their harvest goes to transportation cost due to the bad condition of the Provincial Road and Farm-to-Market Roads. Hence, it can be deduced from their income is below the poverty threshold. This also supports their claim that indeed poverty is one of the major community's problems.

Table 11. Average Annual Gross Household Income

Barangay	Income/year
Benolen	Php 80,000.00
Dalican	Php 92.000.00
Kinibeka	Php 70.000.00
Neketan	Php 90,000.00
Sibuto	Php 60,000.00
Average Income	Php 78,400.00

Source: FGD Conducted by the Study Team, November 2010

Land Management Practices. Table 12 shows the distribution of farming practices the farmers are adopting in relation with land management. As seen, slash-and -burn is still practiced by about four percent. Use of herbicide for land preparation is practiced by a significant number of farmers (19 percent) but conventional tillage is still so far, the most typical practice. It is sad to note that nobody in all the barangays has adopted contour tillage which would somehow prevent excessive loss of soil during the tillage phase of farm operation.

Data show that the practices the farmers were adopting are not favorable for soil conservation but instead will accelerate soil erosion. Hence, by implication, farming activities in the upland aggravate the problem of flooding in Poblacion. The more the soil is manipulated during land preparation and crop maintenance stages, the heavier will be the sediment that will go with the floodwater, making the impact to lowland farms worse.

Table 12. Land Management Practices of Farmers by Barangay

Practices	Name of Barangay					Percent
	Benolen	Dalican	Kinibeka	Neketan	Sibuto	
Slash-and-bum	5.0	0	10.0	2.0	5.0	4.4
Tero Tillage (Herbicide)	15.0	5.0	15.0	40.0	20.0	19.0
Minimum Tillage/Zone Tillage	2.0	15.0	55.0	20.0	65.0	31.4
Contour Tillage	0.00	0.00	0.00	0.00	0.00	0.00
Conventional Tillage (plow-harrow)	78.0	80.0	20.0	38.0	10.0	45.5
Total						**100.00**

Source: FGD Conducted by the Study Team, November 2010

4.7 Effects of the Flash Flood

The recent floods affected crops, livestock, and properties (documents), houses infrastructure and public convenience. In 2008 Flood the lowland part of MSU- Maguindanao Campus was submerged and office records, supplies, some electronic equipment, and furniture were damaged. Holding of office function was temporarily hampered and brought inconvenience to some residents. The nearby community (Pendaliday Compound) was also directly affected with their houses under flood water for a while. Farm lands in Benolen were submerged and destroying standing rice and corn plants.

The 2003 Flood was the worst of all floods in Dalican in terms of extent and cost of damages to crops and properties but more than these the trauma on the affected residents could have been more costly. Mostly affected were MSU- Maguindanao Campus (2 to 5 feet deep) and nearby community, municipal hall (2 feet deep) and adjacent places and Kinipotan (about 10 feet deep) and Purok IV were all under deep muddy flood water. In MSU, major portions of its fence collapsed and office records, documents, furniture, and equipment were destroyed. Homes in Kinipotan were under flood water, one house burned and 4 houses at the Dalican creek bank were carried away by the flood. In Benolen, the Salam Bridge across Dalican Creek collapsed and agricultural lands with standing rice and corn crops were destroyed by the muddy water. Two carabaos were also reported to have carried away by the flood in Neketan.

The 1998 Flood hit badly DPES area, Old Market sites and partially the public market area. The DPES and Old Market site were under 2 to 3 feet deep flood water. Culvert across road to DPES was damaged some properties of the residents in their homes were reported damaged. Makir Creek was the principal source of this flood although other creeks also flooded MSU-Maguindanao Campus and the nearby village and destroying standing agricultural crops.

The 1993 Flood also hit DPES and surrounding area by 2 feet deep flood water. Whole of Poblacion including public market area was partially flooded. Some agricultural crops were also reported damaged in Neketan, Benolen and Poblacion. Makir Creek was also the principal source of flooding in DPES and public market areas. The flood in other areas of Poblacion was from overflow from Sibuto and Dalican Creeks.

Lastly, the 1988 Flood Partially flooded DPES and Old Market areas. In other parts of poblacion like MSU-Maguindanao Campus and adjacent village were less affected and no severe damages were reported.

4.8 Condition of Existing Flood Control Facilities

A rapid assessment of some existing flood control facilities of the town was conducted to determine the status in relation to their functions and the current study. The result of the assessment is summarized in Table 13. Three pipe culverts were observed problematic and need replacement. These are (1) Two-row 48-inch Pipe Culvert in Kinipotan Creek crossing Highway, (2) One-row 36-inch Pipe Culvert in Benolen Creek Crossing Highway and (3) the 60-inch Pipe Culvert along Makir Canal crossing Prov'l Road. Respondents claimed these structures can no longer cope with the volume of flood water and they suggested for changing it by box culvert to prevent clogging.

Makir-Public Market Canal crossing populated area was observed heavily silted, obstructed by houses, garbage, without well-defined banks and reported as prone to overflow.

Table 13. Result of Assessment on Existing Flood Control Facilities in Poblacion

Facility	**Location**	**Maximum Discharge**	**Observed/reported Problems**
Bridge with trapezoidal channel: b=8m, B=19 m, d=3.45, v=1.5 m/s	Along Highway Crossing Dalican Creek	90 cu m /s	No over flow, no backflow
Two-row 48-inch Pipe Culvert	Kinipotan Creek crossing Highway	3.96 cu m /s	Prone to clogging by debris, no barrier
Kinipotan Creek	¤ Notre Dame Site	-	obstructed by houses, prone to backflow, disposal of garbage
One-row 36-inch Pipe Culvert	Benolen Creek Crossing Highway	1.23 cu m /s	Prone to clogging by debris, no barrier
One-row 60-inch Pipe Culvert	Makir Canal crossing Prov'l Road	1.50 cu m /s	Faulty installation, prone to overflow
Makir-Public Market Canal	Crossing Populated area	-	Silted, obstructed by houses. Low embankment, prone to overflow, disposal of garbage
Lined Drainage Canal	Along Highway	-	No reported problem

It is noteworthy to recall that the theoretical runoff of Dalican -Sibuto creeks combined is 168 m^3/sec while the combined capacity of Dalican Bridge and Kinpotan Curvet is only 94 m^3/sec. Similarly, Benolen Creek has a peak runoff of 14 m^3/sec but the only drainage structure (36-inch Pipe Culvert) across the highway can only drain 1.23 cu m /s. Excess flood water is expected to stay for hours before existing outlets can flush it out. Hence, the clamor for the change of the existing pipe-type culverts to a bigger box-type culverts is very reasonable

4.9 Potential Flood Control Measures

Suggestions for controlling flood in Poblacion from respondents varied. Many respondents, both in upland barangays and in Poblacion, were aware that cutting of trees in the upland by loggers during the 60's and 70's and now by timber poachers as the principal cause of increasing volume of flood in Población. Aside from denuding the forest, branches of cut trees and other debris are also because clogging of creeks and culverts and in turn cause back flows. The typical suggestion is to stop the operation of the timber poachers and charcoal makers and instead start replanting particularly fruit trees. A respondent in Poblacion claimed that the LGU Chief Executive and the SB Members (Councilors) are key persons, through their legal authority and influence, to cut the nefarious activities of timber poachers and as well as to spearhead campaign for reforestation.

Only very few were aware of the ill-effects of the use of herbicides for land preparation and improper tillage practices as causes of increasing flood runoff. Few have heard of soil conservation technology such as Sloping Agricultural Land technology (SALT)and agroforestry. Hence, nobody seems applied such technology in their farms. During the community workshops, the researchers introduced briefly to the farmer-respondents these technologies as their way of contributing to flood control as well as for improving productivity of their farms. The farmers had suggested for the DA-ARMM personnel or the MAO to teach and help them adopt appropriate farming techniques and assist them with farm inputs.

Respondents from upland barangays also alarmed the Study Team about the threat of landslide from Mount Blit mountain ranges (Sitio T'noy on East and Sitio Kagol on the West sides). In the past, landslide occur every time heavy downpour hits these sites. This is the reason for the muddy flood water in the past flooding in Poblacion. The respondents suggested for DENR intervention for vegetative treatment of these landslide-prone areas because individual farmers will have
extreme difficulty to undertake.

In Barangay Poblacion, the respondents were one in saying that the size of culverts along the national highway are too small for the floodwater. Aside from limited capacity to convey floodwater they are prone to clogging. Thus, they have suggested for replacement by bigger size box-type culverts.

For the problem of overflow in the man-made canal across the public market, the respondents suggested for clearing and desilting and repair or replacement of canal structures. However, the Study Team proposed a bypass canal along the DPES Road in addition to the clearing and desilting of the canal. This bypass canal will divert larger portion of flood flow to the Old Market Site. It is believed to be a more effective measure to contain flood in the public market and DPES school area.

On the problem of overflow of Sibuto Creek, the respondents suggested for increasing the cross-section (depth and width) of the creek by backhoe excavation. The study team appreciated such intervention but commented that such kind of measure may require regular desilting since siltation on the site of improvement is very potential. The Team suggested for or may be in addition to their suggestion is an earth embankment with bank stabilization (gabion and bamboo) along the stretch of creek bank where overflow takes place affecting Poblacion proper and Benolen. The same treatment is considered by the Study Team for problem of backflow in Brar Creek that affects MSU Maguindanao Campus.

Finally, the respondents of Poblacionn suggested for social intervention to get the support of the people. They claimed that unless people will cooperate the problem of flooding cannot be completely resolved since the people are part of the problem. They pointed out the practice of indiscriminate disposal of waste (solid wastes, plastics, etc.) even on the creeks and drainage canals. Hence.

They suggested for active campaign through community meetings and IEC materials for proper solid waste management and sanitation. Other suggestions by the Study Team are presented on the section under Recommendations.

5. Summary of Findings, Conclusion and Recommendations

The study aimed to trace the history of the past flash floods in Dalican, Datu Odin Sinsuat and develop a logical framework for potential control measures for future flooding. This is to have a systematic and effective identification of area- specific control measures of flash floods in this town. It is a requisite and basis for subsequent planning and policy formulation that will guide the communities, the LGU of Datu Odin Sinsuat and concerned agencies and other stakeholders in dealing with the flash flood problems.

To achieve these objectives, the study team conducted community workshops where focus group discussion, sketch mapping and interviews were performed. Ocular visit and photo documentation were made after community workshops to validate data shared by the key informants. Relevant data were collected such as history of the recent flooding in Dalican, bio-physical characteristics of the watershed, demography, and socio-economic profile of the communities. Thematic maps were prepared based on the data supplied by the respondents.

5.1 Summary of Principal Findings

Data analysis yielded the following major findings:

1. Many floods of varying intensities have occurred in Dalican over the years. Five were identified by the key informants according to the year of occurrence, as follow: (a) 1988 flood, (b) 1993 flood, (c) 1998 flood, (d) 2003 flood, and (e) 2008 flood. The interval of recurrence or return period was every five years and there is an indication of an upward trend in the magnitude of the recent floods from the 1988 flood up to 2003 flood.

2. Flooding in Dalican are of three types and in different flash points, namely:

(a) Overflow: Overflows take place on three flash points: Sibuto Creek near Damagi, before the convergence of Dalican Creek and Sibuto Creek, after the Convergence and at the bank of man-made channel at the back of the Rural Health Unit.

(b)Backflow: Backflows usually take place on areas near the drainage structures (culverts) across the national highway. This happens when the volume of flood is more than the capacity of the structure and due to clogging by debris causing a reduction or blockage of the inlet. MSU-Maguindanao, the adjoining community and community near Kinipotan drainage culvert are prone to this kind of flooding.

(c)Sheet runoff. Sheet runoff comes from the slope of the hill in Damagi. The runoff has no defined channel and so it is conveyed over the Sibuto Provincial Road and accumulates in the low-lying area near the District Hospital and finally drained towards Kinipotan Culvert.

3. Occurrence of floods can be correlated with the occurrence of peak rainfall. Two of the worst floods were the 2003 and 2008 floods as reported by the respondents coincided with the occurrence of peak rainfall (May to July). Flooding in Dalican occurs when rainfall over Dalican watershed exceeds 250 mm in three successive months and worse if rainfall exceeds about 380 mm as in the case of 2003 and 2008 floods.

4. Dalican Watershed has very large drainage area of approximately 13,000 hectares. It is narrow and about 17 kilometers long. Thus, runoff rates are expected to be lower but can accumulate very large volume of runoff flood.

5.The watershed has three major creeks, forming a drainage system that supplies the total runoff in Poblacion, namely (a) Dalican Creek which serves as the major drainage that draws runoff water from the upland barangays; (b) Sibuto creek which serves as the main tributary while there are other smaller tributaries from various points of the watershed; and (c) Benolen creek which does not drain towards Dalican creek at least at the upper side of the National Highway.

Two other creeks which do not belong to the Dalican Watershed also contribute to the flooding:(a) Brar Creek which is the source of the backflow that inundates the MSU campus and (b) Makir Creek which inundates the public market by overflow. These systems of drainage are the principal sources of the flood water in Poblacion.

6. The theoretical discharge (q) of Dalican Creek at the point of convergence with Sibuto Creek was 168 m^3/s while Benolen Creek had 14.0 m^3/s.

7. Dalican watershed has a very rough topography that can produce larger runoff. About one-third is rolling (17%) and hilly. (19%) which covers parts of Kinibeka, Sibuto and Neketan and the rest is mountainous (21 percent) main in Mt. Blit in Kinibeka and Sibuto. Only about 41 percent is plain and relatively flat areas which are found in Neketan, Benolen and Dalican Mt. Blit (Elevation 1,081 meters ASL) mountain ranges have steep and well-defined drainage patterns.

8. Moderate erosion was observed in hills and rolling forested and brush lands but severe erosion was observed in the steep slopes cultivated with annual and seasonal crops, mainly on the side slope of Mt. Blit. Brush lands on mountain ranges located in Sitio Kagol (Western part of Mt Blit) and Sitio T'noy (Eastern Part of Mt. Blit) have these types of erosion and are prone to landslides during heavy rain over these sites.

9. The watershed has only 9.20 percent open canopy forest located mostly in Kinibeka, Benolen and Sibuto and as a result more runoff flood rushes to the streams and to the low-lying areas in Dalican. One-fourth (24.80 percent) consists of cultivated perennial crops in Dalican and Neketan and one-third (33.00 percent) with annual crops in all upland Barangays. About one-fourth (24 percent) is brush land also in upland barangays and 9.4 percent is open and built-up areas mainly in Poblacion.

10. The five Barangays covered by the Dalican watershed had a population of 30,146 and 5,251 households or an average household size of 5. Age 25 years and older tops the percentage of the age structure with 38.50 percent and majority of whom are farmers. Household income is below the threshold.

11. Practically all land management practices (slash-and-burn, herbicide land preparation, timber poaching, charcoal production, and conventional tillage) of the farmers contributes to more soil erosion that aggravates the problem of floods. None is practicing contour tillage while very few are engaged on planting of permanent crops/trees on the upland.

12. The recent floods caused heavy losses on crops, live stocks, properties, important documents, houses, and infrastructures which might cost millions of pesos. Unfortunately, nobody was able to formally assess and document the losses.

The 2008 flood submerged the lowland part of MSU-Maguindanao Campus and the adjacent community. Office records, properties and standing crops were damaged.

Farm lands in Benolen withstanding crops were also submerged.

The 2003 Flood was the worst of all floods in Dalican in terms of extent and cost of damages to crops and properties. Mostly affected were MSU-Maquindanao Campus (2 to 5 feet deep) and nearby community, municipal hall (2 feet deep) and adjacent places (about 10 feet deep) and Purok IV were all under deep muddy flood water. Major portions of MSU fence collapsed and office records, documents. Furniture's and equipment were destroyed. Number homes in Kinipotan were submerged a bridge across Dalican Creek collapsed. Agricultural lands withstanding rice and corn crops were destroyed and two carabaos were also reported to have carried away.

The 1998 Flood hit badly DPES area, Old Market sites and partially the public market area. The DPES and Old Market site were under 2 to 3 feet deep flood water. Culvert across road to DPES was damaged some properties of the residents in their homes were reported damaged.

The 1993 and 1988 floods hit DPES and surrounding area. Poblacion including public market area were flooded. Some agricultural crops were also reported damaged in Neketan, Benolen and Poblacion, other parts of poblacion like MSU-Maguindanao Campus and adjacent village were less affected and no severe damages were reported.

13.Assessment of some existing flood control facilities of the town yielded the following: (a) The three pipe culverts along the national highway are undersize and need replacement, these are the two-row 48-inch Pipe Culvert in Kinipotan Creek, single-row 36 inch Pipe Culvert in Benolen Creek and the single-row 60-inch Pipe Culvert along Makir Canal; (b) Makir-to-Public Market Canal crossing populated area was heavily silted, obstructed by houses, garbage, without well-defined banks and reported as prone to overflow.

14.The potential control measures suggested to be adopted by upland barangays were: (a) To stop the operation of the timber poachers and charcoal makers and instead start replanting particularly fruit trees; (b) Appropriate upland farming technologies should be adopted by the farmers as their way of contributing to flood control as well as for improving productivity of their farms; (c) The DA- ARMM personnel or the MAO to teach and help them adopt appropriate farming techniques and assist them with farm inputs; and (d) The DENR to undertake vegetative treatment on landslide-prone areas in Mount Blit.

In Poblacion, the following were suggested: (a) replacement of existing pipe-type culverts by bigger size box-type culverts; (b) bypass canal along the DPES Road in addition to the clearing and desalting of the existing canal tol divert larger portion of flood flow to the old Market Site; (c) an earth embankment with bank stabilization (gabion and bamboo) along the stretch of Sibuto Creek, Dalican creek and Brar Creek where overflow occur; and (d) an active campaign through community meetings and IEC materials for proper solid waste management and sanitation.

Conclusion

The foregoing findings show that the threat of flood in Dalican is real. The threat remains and the last recent five intense flooding in the last decade indicate an uptrend of intensity of future flooding in Poblacion. The causes of the problem remain unattended and in fact becoming more potent.

As the population grows begin the mountain ranges of Mount Blit, continuing loss of vegetal cover is very evident as the farmers expand their areas for agricultural production, Sad to note, however, that the upland farmers are not aware or simply indifferent on technology that would preserve the soil while making a living. Unknowingly, these practices aggravate the problem in the Poblacion by increasing the flood volume.

Existing drainage facilities in Poblacion were constructed during the 80's and 70's and were perhaps designed based on the current situation during that period unfortunately, a lot of conditions have changed, our erstwhile forests are gone. The capacity of these structures can no longer hold the present

increased flood volume. Clogging of these structures by debris coming from community wastes worsens the problem. If these drainage facilities remain as they are, then the problem of flooding will continue, more so if people will remain indifferent on disposal of solid wastes on the drainage systems.
The main purpose of this study was to determine potential measures to effectively address the problem of flooding in the Poblacion. The findings of the study show that the problem of flooding in Poblacion can be effectively resolved and these potential solutions are presented and discussed as recommendations of the study.

6. Recommendations

A three-pronged permanent solution is suggested to resolve the problem of flooding in Poblacion, all focusing on addressing the root causes. These include social intervention, vegetative treatment of the watershed and re-inventing the drainage infrastructures. Social intervention is necessary to draw people's support. Vegetative treatment of the watershed is likewise imperative to cure the so many problems of the ecosystem including flooding. Infrastructure intervention is indispensable to cope with the present and future needs of the watershed.
Based on the foregoing premises, the following are strongly recommended:

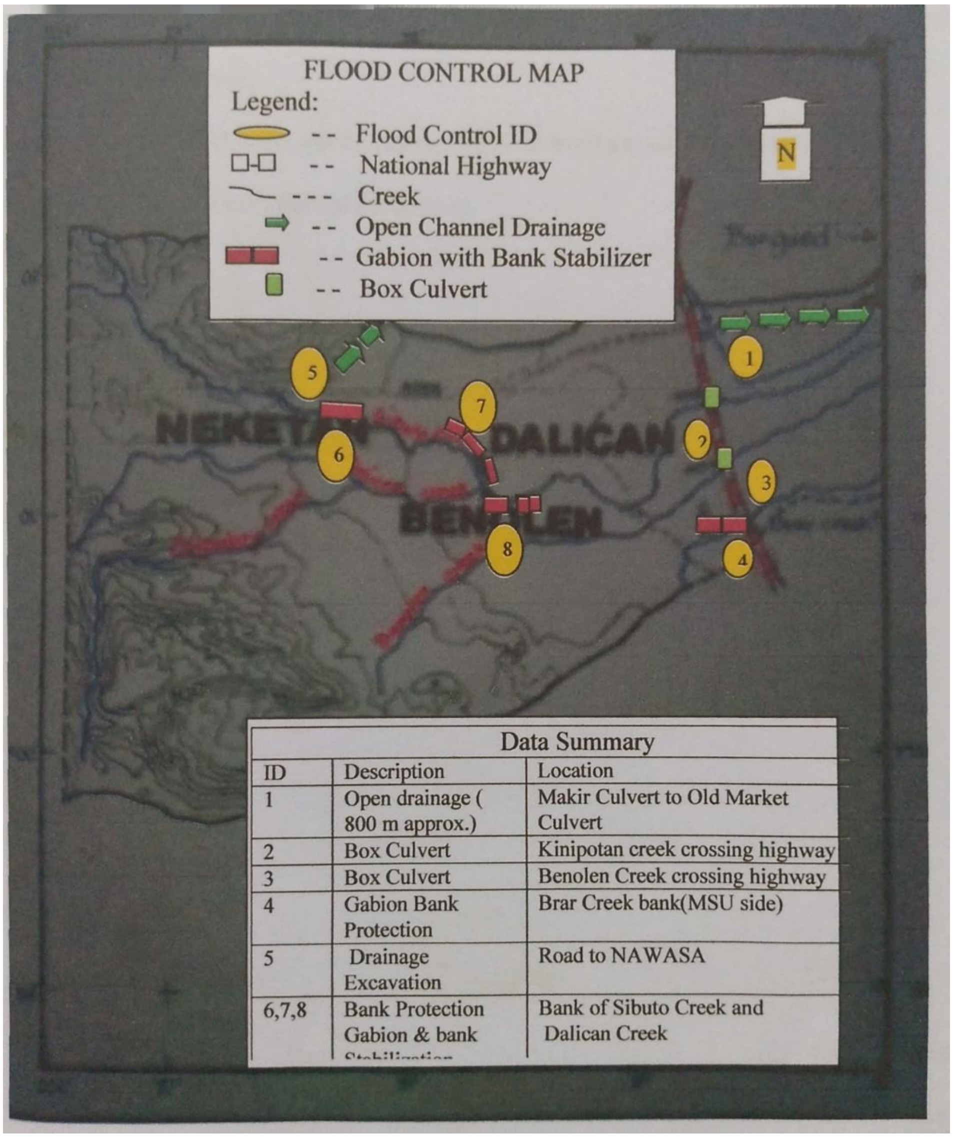
1. The LGU, through its Planning Office (MPDC) and Engineering Office (ME) to include as priority development projects the proposed flood control Infrastructure interventions, shown in Table 14 and map (Fig.13).

Table 14. Matrix of the Recommended Interventions for Controlling Future Flooding

Project and Location	Objective	Office/Agency Responsible
(1) Construction of by-pass Lined open channel from the RHU to Old Market Bridge (about 800 m)	To provide additional channel of capacity and free from clogging	LGU: MPDC, ME. Budget Office, LCE -Funding Agency
(2) Construction of Box Culvert in Kinipotan creek cross in highway(replacement) **(3) Construction of Box culvert in Benolen Creek crossing highway(replacement)** **(4) Brar Creek embankment with Bank Protection by (Gabion)**	To increase capacity and minimize clogging and prevent backflow	LGU: MPDC, ME, Budget Office, LCE -Funding Agency
(5) Excavation of Road Drainage from Sibuto Road to Makir Creek	To intercept runoff coming from Damagi hillside to Makir creek	LGU: MPDC, ME, Budget Office, LCE -Funding Agency
(6) Bank Protection (Gabion)with bank stabilization (bamboo) treatment on critical points and stretches in Sibuto Creek	To restore vegetal cover, minimize erosion and revive the dried-up creeks	LGU: MPDC, ME, Budget Office, LCE -Funding Agency

(7) Bank Protection (Gabion)with bank stabilization(bamboo)treatment on critical stretches in Dalican Creek (near convergence point).		

Figure 13. Map of Proposed Flood Control Infrastructure



2. The LGU, through its MENRO, to proposed to the DENR civil culture Treatment of the landslide prone areas in Mount Blit.
3. The LGU, in partnership with barangay officials, to campaign through community meetings and IEC on sanitation, proper solid waste disposal and environmental protection.
4. The LGU, through the MAO and in partnership with barangay officials, to pilot agroforestry project by barangay coupled with Technology transfer on upland farming technologies.
5. The LGU, through its police force, to enforce strictly forestry laws and Ordinances on environmental protection

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