GIS Based Flood Hazard and Risk Assessment: A Case of Sibu Sire Woreda Oromia Region, Ethiopia

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ABSRACT

Floods are probably the most recurring, widespread, disastrous and frequent natural hazards of the world. However, human activities in many circumstances change flood behavior. Activities in the flooded area such as land clearing for agriculture may increase the magnitude of flood which increases the damage to the properties and life.

Sibu Sire Woreda is one of the most severely flood affected areas in Oromia region in general and Indris Catchment in particular. The Woreda is situated in the downstream part of Indris, Jalale and Gewiso rivers. Due to the rapid increase of population in this area, people are exploiting natural vegetation and extending cultivation, which have led to land degradation and vulnerable to flood hazard. Hence, in order to manage such problem, a complete understanding of hazard identification and risk analysis is very crucial. Therefore, the present study was carried out to assess the flood risk in Sibu Sire Woreda with the application of Multi Criteria Evaluation (MCE) technique in GIS environment. To do this causative factor were developed in the GIS and Remote Sensing environment. Then, weighted overlay analysis in multi criteria evaluation (MCE) technique was used in order to arrive at flood hazard and flood risk mapping.

The findings of the study revealed that 22.42% of the Woreda is under high and very high flood risk. Thus, the study will help the concerned authorities to formulate their development strategies according to the available flood risk to the area. The existing KAP study is very necessary to raise the awareness level of the society. To conduct the analysis the SPSS software was important using the KAP data collected through the semi-structured method. Hence, this study was conduct to high up the awareness level of the society to any disaster and plan good strategies to the available disaster Preparedness.

Key words: *Flood, Hazard, Risk, GIS, Remote Sensing, MCE, Sibu Sire Woreda, Indris Catchment, SPSS, KAP.*

I. INTRODUCTION

1.1. Background of the Study

Flooding is a natural process that will remain a major hazard as long as people live and work in flood prone areas. Floods normally occur when the streams or rivers flow out of their confines. Similarly, river flooding is also a natural process and part of the hydrological cycle of rainfall, surface and groundwater flow and storage. Floods occur whenever the capacity of the natural or manmade drainage system is unable to cope with the volume of water generated by rainfall. Floods vary considerably in size and duration. Flood can be defined as any relatively high-water flow that overtops the natural or artificial banks in any portion of a river or stream. Flooding is the most common environmental hazard due to the widespread geographical distribution of river valleys and coastal areas. By attraction of human beings to such areas for settlements and farming make it as a fatal obstacle to social progress both in developing and developed countries (Jayaseelan, 2001) .

Flooding causes billions of dollars' worth damage of properties and thousands of deaths and injuries each year worldwide (Keith Smith and Roy Ward, 1998). Asia is one of the most flood affected (prone) continents in the world where high percentage of damage to property and loss of life is registered every year.

According to (DPPA, 2006) topographically, Ethiopia is both a highland and lowland country. It is composed of nine major river basins, the drainage systems of which originate from the centrally situated highlands and make their way down to the peripheral or outlying lowlands. The country experiences two types of floods: *flash* and *river floods*. Flash floods are the ones formed from excess rains falling on upstream watersheds and gush downstream with massive concentration, speed and force. Often, they are sudden and appear unnoticed. Therefore, such floods often result in a considerable toll; and the damage becomes especially pronounced and devastating when they pass across or along human settlements and infrastructure concentration. The recent incident that the Dire Dawa City experienced is typical of flash flood. On the other hand, much of the flood disasters in Ethiopia are attributed to rivers that overflow or burst their banks and inundate downstream plain lands. The flood that has recently assaulted Southern Omo Zone and South Gondar (mainly Fogera Woreda) Zone is a typical manifestation of river floods. Therefore, owing to its topographic and altitudinal characteristics, flooding, as a natural phenomenon, is not new to Ethiopia. They have been occurring at different places and times with varying magnitude.

Some parts of the country do face major flooding. Most prominent ones include: extensive plain fields surrounding Lake Tana and Gumara and Rib Rivers in Amhara Regional State; areas in Oromia and Afar Regional States that constitute the mid and downstream plains of the Awash River; places in Somali Regional State that fall mainly along downstream of the Wabishebelle, Genalle and Dawa Rivers; low-lying areas falling along Baro, Gilo and Akobo Rivers in Gambella Regional State; downstream areas of Omo River in the Southern Nations, Nationalities and Peoples Regional State (DPPA, 2006). Due to the rapid increase of population in Sibu Sire Woreda, people are exploiting natural vegetation and extending cultivation, which have led to land degradation and deterioration of the ecosystem. As a result, the area has become susceptible to erosion and flood events. The Woreda has diverse topography ranging from very flat to mountainous. Such relief types are fairly distributed, while the flat to undulating plain part of the area in Woreda takes about 40 % of all areas. Such a topographic setup is believed to have been generating heavy flooding at the low. Most rivers as well as their numerous tributaries in the Sibu Sire Woreda initiate their courses from relatively higher elevations and the immediate Catchment areas are poorly covered exposing the flat areas to heavy flood during the rainy season.

Although flooding cannot be wholly prevented, its impacts can be reduced through appropriate planning and management. Damaging effects of flood disaster on lives and property can be reduced by structural dams and non-structural (legal instruments, public awareness, forecasting and early warning systems and rescue operations) measures.

Hence, the agricultural and other development activities carried in the area requires flood protection measures. Therefore, to reduce the flood impacts on economic and human settlements, flood hazard and risk mapping needed and analysis of the existing awareness level of society about the flood disaster. Geographical Information Systems (GIS) is one of the techniques that can be used flood level forecasting and management in order to assist in the reduction of human and economic losses through the delineation of the areas at risk of being flooded. This was in mind; this study was conducted to analysis the flood risk of Sibu Sire Woreda by using multi-criteria evaluation technique in Geographical Information Systems (GIS) environment. SPSS software is very important to analysis the existing KAP study of the society and used to increase the awareness level society.

1.2. Statements of Problem

There was information gap related to flooding in the Study area due to the knowledge about the cause of flood event such as, afforestation, overgrazing, sand sedimentation, soil erosion, land degradation and flood protection of the area and human settlement or location planning strategy. Flooding and poor drainage conditions are major environmental problems known to the Indris catchment. High flood which is due to the intensive rainfall over the area, low drainage density, gradually decreasing slope towards the River course, and poor drainage systems are major threats to the localities living within the affected area and surroundings (Woreda Agricultural and Rural Development , 2013).

This condition directs towards post flooding event action-oriented strategy without good prior knowledge on flood hazard and risk zonation. Some kebeles are located on the lower topographic position in Sibu Sire Woreda are annually inundated especially during the period from July to September. Considerable number of farmers in the study area have got plots located in the inundation area. Their farming is constrained by the risks of crop losses by floods that occurs several times every rainy season.

This has aggravated the flood hazard disaster in the rainy seasons. The sociological damages caused by inundation are also serious. Some settlements are often isolated during the rainy season due to flood and inundation and the life is completely disrupted. This is witnessed on the last flood hazard disaster for instance agricultural land was also damaged.

Recently for nearly the whole month of August, 2013 a major flood swept through Jarso Wama kebeles and all surrounding peasant areas, resulted in the loss of life, property, structural facilities, housing and livelihoods. Although the most severe flood occurred at some intervals, floods and inundation of known areas in the Woreda were happens every year causing loss of animal life, damage to property and infrastructures.

1.3. Objectives of the Study

The ***general objective*** of this study is to assess the flood hazard and risk in Sibu Sire Woreda using Arc-GIS software. In connection with the above general objective the following ***specific objectives*** are outlined to:

- Identify and develop factors relevant for flood hazard and risk analysis.
- Analyze flood hazard, vulnerability and risk in Arc-GIS environment for study area.
- Evaluate the awareness of flood hazard, vulnerability and risk on livelihoods of the people in study area

- Recommend some mitigation measures for the recurrent flood risks.

2. Description of the Study Area and Flood Related Facts

2.1 Indris River Catchment Overview

Sibu Sire District is one of the Woredas of East Wollega administrative zone of the Oromia national state, Ethiopia. The Woreda is bordered to East by the Gobu Sayo Woreda, to North by Gudeya Bila and Guto-Gida, to the South by Wama Hagalo and Billo Boshe and to the West Wayu Tuqa woreda of East Wollega of the Oromia national state. The Woreda is located according to UTM coordinate system at about 240000m East to 280000m East and 9880000m North to 1040000m North. The Woreda consists of 19 rural and 2 urban Kebeles. The capital town of the Woreda is Sire which is located at 281 Km distance from the national capital, Addis Ababa and 50km distance to east of Nekemte, the administration town of East Wollega Zone. Elevation in the Woreda ranges from 1336 m to 2500 m. The total area of the Woreda is 1,048.56 Sq.km (104,845.6 hectares). Sire Catchment, drained by Indris and Jalale Rivers, is located according to UTM coordinate system at about 230000m East to 280000m East and 980000m North to 1050000m North.

This Catchment is part of the Abay Basin. It has an area extent of about 157,173.2 hectare. Sibu Sire Woreda is totally lies in this Catchment. This Woreda is found in the downstream part of the Indris rivers. Overflow of these rivers frequently flooded this Woreda than other Woredas in the Catchment, and therefore selected for detailed flood risk study.

3. Data Source, Materials and Methods

3.1 Data Source

These describes detail about the data requires for the study and the causative factors required for flood hazard and risk. So these materials are the data collected from their sources includes; data layers, data format, data sources, scale (resolution) of data and purpose of the layer (data). It also includes the software necessary for the study such as, Arc GIS software, Erdas Imagine-2014, Idris-32, SPSS and MS Words. The data and their sources used to generate flood hazard of Indris Catchment and flood risk map of Sibu Sire Woreda are reported below (table 3.6).

3.2 Materials and Software

Software used in this study is selected based on the capability to work on the existing problems in achieving the predetermined objectives. Hence, software package like ERDAS 2014 was used for image processing activities on satellite images for the preparation of land use/ land cover types. The factor map development was carried out using ArcGIS10.1 software package. The factors that are input to for multi-criteria analysis should be pre-processed in accordance to the criteria set to develop flood hazard analysis. So using Spatial Analyst, some relevant GIS analyses were undertaken to convert the collected shape files. Eigen vector for the selected factor was computed using Weight module in IDRISI-32 software. SPSS used for statistical frequency analysis of the KAP data for the existing awareness level analysis of the society of the study area.

II. METHODOLOGY

Flood Risk assessment requires an understanding of the causes of a potential disaster which includes both the natural hazard of a flood, and the vulnerability of the element at risk.

According to Ken Granger, *2002, t*he terms hazard, vulnerability, element at risk, and risk are defined as follows:

H***azard (H)*** *means the probability of occurrence, within a specified period of time in a given area, of a potentially damaging natural phenomenon.*

Vulnerability (V) *means the degree of loss to a given element at risk or set of such elements resulting from the occurrence of a natural phenomenon of a given magnitude…*

Elements at risk (E) *mean the population, buildings and civil engineering works, economic activities, public services, utilities and infrastructure, etc., at risk in a given area.*

Risk (R) *means the expected degree of loss due to a particular natural phenomenon* Risk analysis can be defined as "*a systematic use of available information to determine how often specified events may occur and the magnitude of their likely consequences" (*Ken Granger, *2002).*

Flood risk of the Woreda was analyzed from the following general risk equation (Shook, 1997).

Risk = (Elements at risk)*(Hazard*Vulnerability)...…………..…………..………Equation 1.1

The approach adopted in this study in order to reach the objectives of the study is reclassifying, weighting and run Multi Criteria Evolution (MCE).The flood causative factor map development was carried out using Arc-GIS 10.1 software package. The factors that are input to for multi-criteria analysis should be pre-processed in accordance to the criteria set to develop flood hazard analysis. So Eigen vector for the selected factor was computed using Weight module in IDRISI-32 software. The selected flood hazard causative factors such as elevation, slope, drainage density, Land use/land cover, soil type, geology and rainfall. To run MCE, the selected factors were developed and weighted. Then weighted overlay technique was computed in ArcGIS10.1 Model Builder to generate flood hazard map (fig 4.13). The input datasets are organized in personal geo-data base and then processed to the suitable format, classified, weighted and analyzed. The resulted coverage is created by overlay of these layers and produce flood hazard map.

Considering the degree of loss to be total for the study area, the vulnerability is assumed to be one. Then to generate flood risk map of the Woreda, elements at risk layer (land use land cover and population density) and the flood hazard map were overlaid using weighted overlay analysis technique in ArcGIS10.1 environment.

III. DATA PROCESSING AND ANALYSIS

3.4.1 Data Processing

3.4.1.1 Database design creation and Field survey

3.31. Database Design

All the factors were stored in the geo-database in order to store the collected data and the analysis results in a logical arrangement. The factors involved were examined according to their relative importance towards delineating areas of high flood risk and flood hazard and assigned weights. The classes in each factor layers were also compared one another and ranked by their contribution to the output.

The geographic database (geo-database) is a core geographic information model to organize a spatial data in to thematic layers and spatial representations. Two types of geo-database architectures are available under ESRI's Arc-GIS package: Personal Geo-database and Multiuser Geo-database. In this study, Personal Geo-database was designed in Arc-Catalog to include all the input datasets, their analysis and the final flood hazard, risk map and flood risk impact map. In addition to these, a personal geo-database is used to protect the data from lost and easy access in the GIS tool. Thus, vector files were exported to the corresponding feature data sets and the raster files were exported as individual raster datasets in the personal geo-database (Fig. 4.1). The coordinate system selected to be used for analysis was projected coordinate system, UTM. Thus, the geo-database was set to this spatial reference and all the maps were projected to it while exporting to the geo-database.

IV. RESULT AND DISCUSSIONS

4.1. Flood Hazard Assessment

In this study, the flood hazard maps (Fig 5.1 & 5.2) below shows that the detail results of flood hazard assessment of Indris catchment were 16431.63, 14487.48, 17671.13, 16231.33, 7551.18 hectare and 6542.20, 13256.11, 16369.10, 16000.01, 7322.21 hectare area of Sibu Sire Woreda were subjected respectively to very low, low, moderate, high and very high flood hazards as shown in (table 5.1) and (table 5.2).

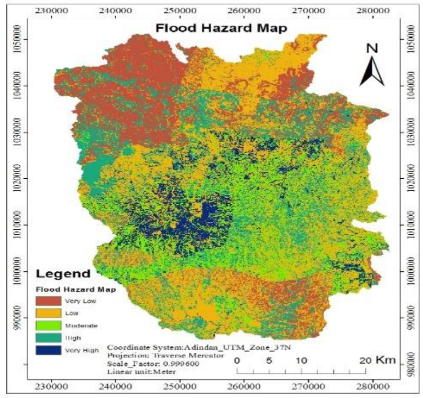

Fig. 0.1. Flood hazard map of Indris Catchment.

Hence, for further information the flood hazard detail analyzed of Sibu Sire Woreda were assessed as per existing Kebele and Land use / Land cover using the area tabulation of spatial analyst in Arc-GIS environment. (Fig.5.2), shows the study area flood hazard map as per the existing Woreda Kebele boundary. Area tabulation was done in spatial analyst tool using Arc GIS software and the result was summarized as area tabulation of flood hazard versus land use/land cover (table 5.3), and flood hazard versus kebele boundary, (table 5.4).

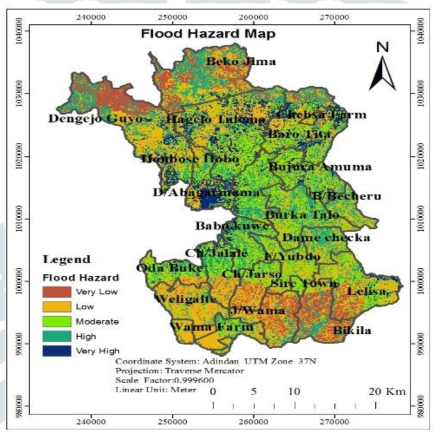

Fig. 0.2. Flood hazard map of Sibu Sire Woreda

4.2. Flood vulnerable Assessment

Vulnerability is directly related to the degree of exposure and inversely related to the capacity to cope and recover or adapt (Finan et al, 2002). Therefore, not only is it important to identify high risk areas, it is critical to identify vulnerable populations, understand what causes people to be vulnerable, and assess the measures that can reduce vulnerability (Blaikie, 1994). The result is a flood vulnerability or hazard map showing the most vulnerable areas to flooding within the study area. The results of this stage of analysis are shown in (Fig.5.2). As depicted in (table 5.2) above, the results show that almost a 15.2% of the total Sibu Sire Woreda was prone to "high" and or "very high" flood hazards. These areas are those that are close to the rivers and generally laying at low elevations within the settled/paved regions. Conversely, 84.8% of the study area was prone to "very low" to "moderate" level of flood hazards. Most of these areas tended to be on the higher grounds and further away from the high drainage density areas.

4.3. Flood Risk Assessment

Flood risk mapping and assessment was done for Sibu Sire Woreda by taking population and land use/land cover elements that are at risk combined with the degree of flood hazards of the Woreda. According to the flood risk map, it was estimated that 2586.61, 46216.26, 26561.61, 27448.2 and 2032.92 hectares areas of Sibu Sire Woreda were subjected respectively to very high, high, moderate, low, and very low flood risk as revealed in (fig.5.3.).

Elements at risk considered in this study show different levels of risk. The Woreda Kebele that are about large hectare their area under high to very high flood risk include Eastern part kebele Baro Tita (3206.34 hectare), B/Amuma (1452.15 hectare), Northern part Beko Jima(3312.99 hectare), Hagelo Tulema (4647.24 hectare), Centre part Burka Talo (1363.32 hectare), Sourthern part Jarso wama(1315.89 hectare), Weli-galte (818.64 hectare) and Western part Jafe Jalale(1153.26 hectare),Oda Buke(826.74 hectare), Dengejo Guyo (3943.8) detail in (table 5.5.) With regard to the other element at risk, land use/land cover, 89.1 hectare water body, 520.56 hectare Settlement, 5898.24 hectare agricultural lands, 14688.18 hectare Scrub/Fallow land, 8285.31 hectare Dense/Sparse vegetation were under high to very high flood risk (table 5.4).

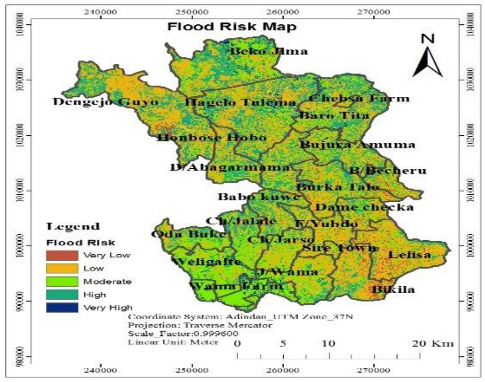

Fig. 0.3. Flood risk map of Sibu Sire Woreda

According to the flood risk map (Fig. 5.3), it was estimated that 7925.074, 35436.42, 51886.28, 8493.961, and 2003.864 hectare areas of Sibu Sire Woreda were subjected respectively to very high, high, moderate, low, and very low flood risk. Finally, the results of interpretation and analysis show that areas about 2.11 percent of the total area of Sibu Sire Woreda is falls under very high flood risk zone. Of the total study area, about 23.11 percent falls under the category of moderate flood risk potential; while the area covered under the very low and low flood risk zone category, which occupied approximately 69% area of the Sibu Sire Woreda. Since 9.88% of the Woreda is under high and very high (extreme) flood risk, adoption of suitable conservation measures seems to be inevitable.

4.4. Existing Awareness Level Assessment

(Palp & Werner, 2006), defines risk awareness as an everyday subjective assessment process that is based on experience and on available information without referring to reliable data, series and complex models. The existing awareness level analysis of society was important for mitigation plan. Considering the degree level of awareness of loss to be total for the study area, the flood hazard, vulnerability and risk were assessed through the KAP using the SPSS software pre and post flood event.

4.4.1. Knowledge of flood Hazard before and after flood

Knowledge of society towards the flood hazard and risk was collected from respondents of study area society. Table 5.8. depicted the result of knowledge of respondents to the flood hazard from the descriptive frequency analysis of the SPSS before the event happen as 20%, 42.5%, 30%, 7.5% and 0% to the rank of very low(1),low(2),moderate(3),high(4) and very high(5) respectively.

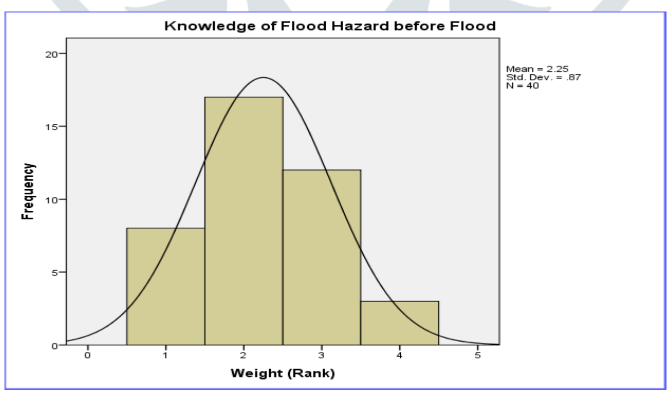

Fig. 0.4. Graph for knowledge of flood hazard before flood

The knowledge of people about flood hazard was increase after the events happen, was 32.5% was moderate and more than 67.5% were high and very high in (table 5.7.), and also (fig. 5.5), show the histogram graph of knowledge after the event.
Table 0.7. Knowledge of flood hazard after flood event.

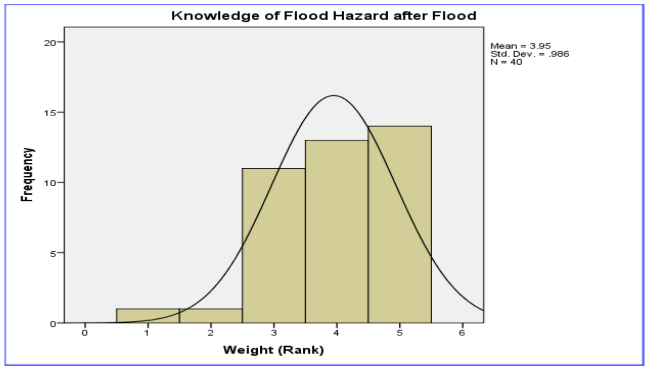

Fig. 0.5. Graph for knowledge of flood hazard after flood

4.4.2. Knowledge of flood vulnerability before and after flood

Vulnerability can be reduced by identifying, helping, and empowering those who are most vulnerable (Hewitt, 1997). In the hazards and disaster field, there was growing recognition that there was a need to reorient emergency management systems to be more proactive in reducing losses (life and property) and future hazard impacts through mitigation, preparedness, response, and recovery rather than focusing on rescue and post-event clean-up. This was based on the growing recognition that the degree to which populations are vulnerable to hazards is not merely dependent on the exposure to the hazard proximity to the source of the threat or the physical nature of the hazard, but it is also socially constructed and based on social, economic, and political factors that have a role in defining vulnerability.

Some population subgroups because of disparities in wealth, socioeconomic status, and housing have an increased potential for losses due to hazards as they have less ability to adapt cope or respond. Access to resources, be they economic, social, or political, are fundamental to the adaptation process and differential access to resources to mobilize to adapt influences vulnerability of households, individuals, and communities. Adaptation relies on human and financial capital (knowledge and money) and changes and readjustments in social organization (investments in social and political capital) to reduce vulnerability (Blaikie, 1994).

Knowledge of the flood vulnerability before and after events of flood can analyses by the descriptive analysis of the SPSS software. During data collection knowledge of the respondents to the vulnerable, is very highly and then ranked as class 5, whereas, the answer of the respondent very low or almost not know the vulnerable of flood was ranked as 1, (table 5.8.) and (fig.5.6.) shows the result detail.

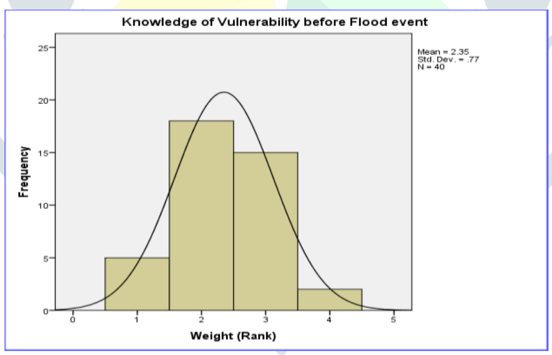

Fig. 0.6. Graph for knowledge of vulnerability before flood

According to descriptive frequency analysis of SPSS software the knowledge of respondents to flood vulnerability after the events was increase from 0% for very low(1) to 35% for very high (5) (table 5.9.). (Fig. 4.7.), shows the graph of respondents' knowledge to flood vulnerability was increases after the events happen than before. General, the preparedness of population of Sibu Sire Woreda to flood vulnerability was very low before the events and increased after the events.

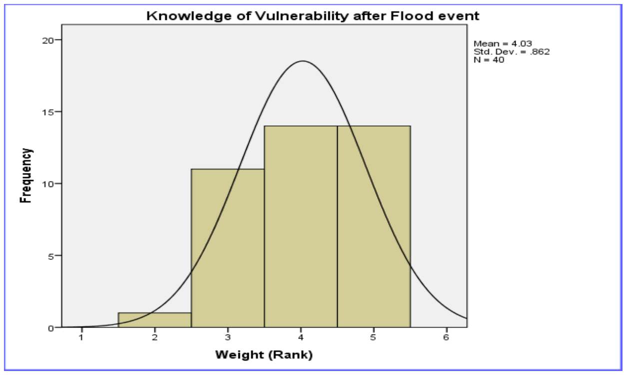

Fig. 0.7. Graph for knowledge of vulnerability after flood

4.4.3. Knowledge of flood Risk before and after flood events

Risk (R) is defined as expected degree of loss due to a particular natural phenomenon (Shook, G., 1997).So, knowledge of the people about the natural phenomenon is very important and it used safe a life and property. In this study, it is necessary to analysis the awareness level of population to the flood risk for the mitigation measurement due the particular phenomenon. The descriptive frequency analysis of SPSS value of data collected knowledge of flood risk before the flood events from the sample respondents who are represents the whole population of the Woreda. Knowledge of flood risk before flood events was 25%-30% for very low to low whereas, 0% for very high rank (5) or almost the society not understand the flood risk (table 5.12), and (fig.5.8), shows the histogram graph of the analysis result.

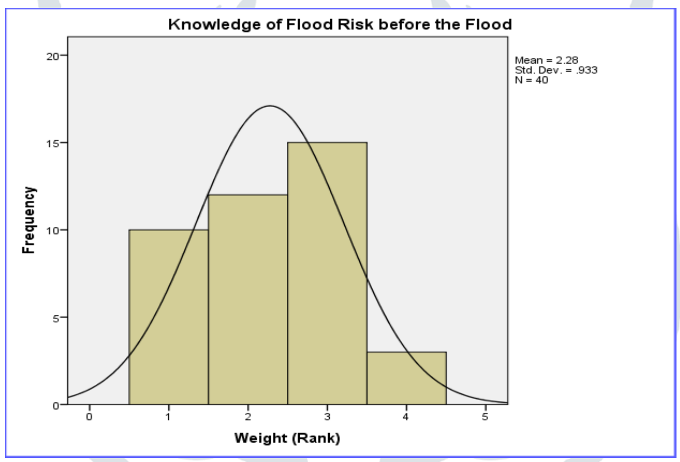

Fig. 0.8. Graph for knowledge of flood risk before flood

(Table.5.11), show that, the Knowledge of flood risk after the events happen was increase from 7.5 % to 22.5% for high rank, and from 0% to 7.5% for very high rank, means that the preparedness of society toward the risk was increase after event. The SPSS analysis result was depicted in (fig.5.9).

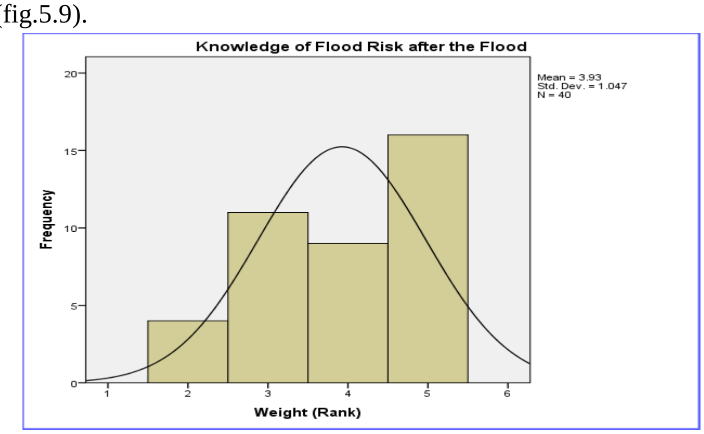

Fig. 0.9. Graph for knowledge of flood risk after flood

4.4.4. Attitude to flood disaster before and after flood happen

The term 'attitude' is used to refer to the perception or way of thinking about something.

The major assumptions regarding the interrelationship between KAP are as follows:

- Positive action (practices) regarding flood disaster is largely the function of positive attitudes.
- Positive attitudes regarding flood disaster are the functions of awareness of contemporary population knowledge issues, value of awareness, awareness of opportunities and affordability to access such opportunities.

Using the descriptive frequency analysis of SPSS software evaluate the positive and negative attitude of Sibu Sire Woreda population due to flood disaster before and after flood event happen in the Woreda. (Table 5.12), shows that the value of attitude analysis before flood happen ,17.5%,40%,32.5%,10% and 0% were represents very low(1),low(2), moderate (3),high (4) and very high (5),respectively. The people have negative attitude thinking to the flood disaster before events of flood in the Woreda and the awareness level was very low.

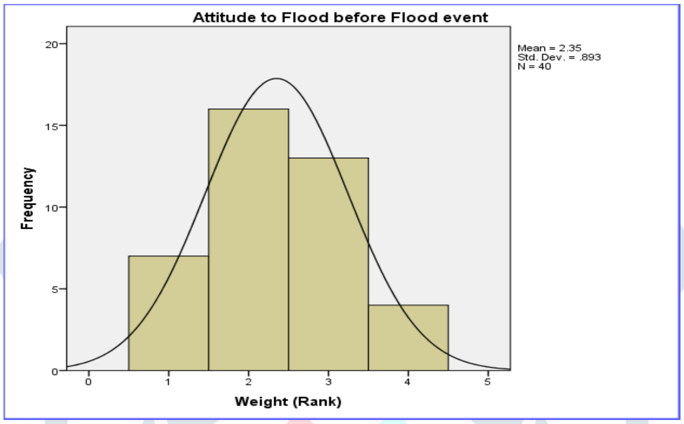

Fig. 0.10. Graph for attitude to flood before flood

(Table 5.13), and (fig.5.11), below, shows that the value of attitude analysis after flood disaster happen in the Woreda, 0%, 2.5%, 32.5%, 42.5%, and 22.5% were represents very low(1),low(2), moderate (3),high (4) and very high (5),respectively. Means that the positive attitude of society due to the flood disaster after events of flood in the Woreda was increased and the awareness level was moderate.

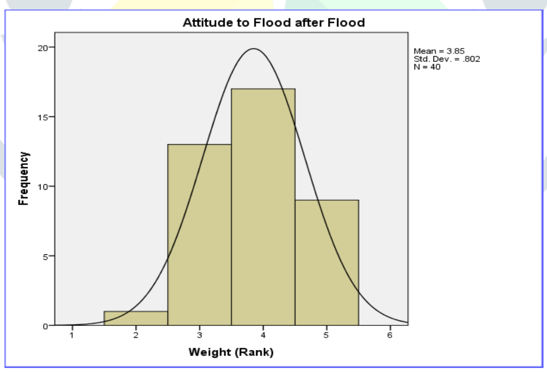

Fig. 0.11. Graph for attitude to flood after flood

4.4.5. Action (Practice) to flood disaster before and after flood events

The term 'performance' is used to refer the actions or behavior relating to knowledge of flood disaster. From the above assumptions the Positive action regarding flood disaster is largely the function of positive attitudes. For positive action, either the existing awareness can be altered or relevant programs can be introduced to minimize the effects of such determinants. The existing action of people to the flood before the event was evaluate in the table 5.14 below, as,17.5%,42.5%, 27.5%,12.5% and 0% were represents very low(1),low(2), moderate (3),high (4) and very high (5),respectively. (Fig.5.12) graph show the result of descriptive analysis of KAP respondents.

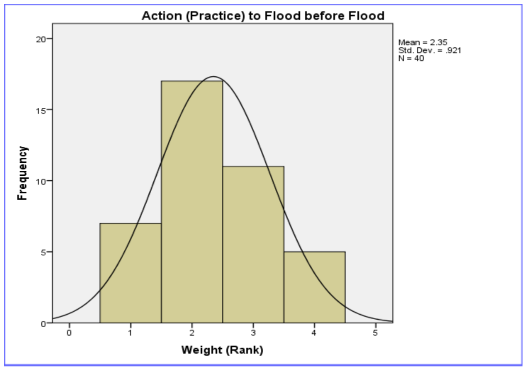

Fig. 0.12. Graph for action to flood before flood

Whereas, the existing action or performance of people to minimize disaster after the event was evaluate in the (table 5.15), and (fig.5.13), below, as,0%,12.5%, 15%,32.5% and 40% were represents very low(1),low(2), moderate (3),high (4) and very high (5),respectively.

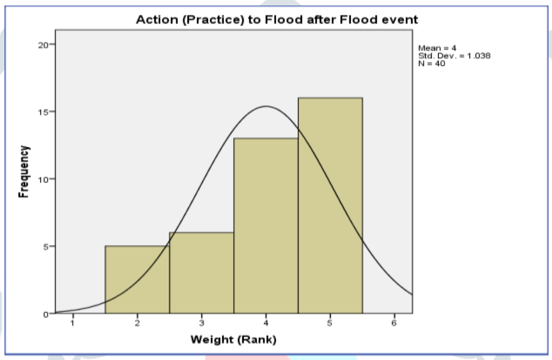

Fig. 0.13. Graph for action to flood after flood

Generally, as shown from the descriptive frequency analysis result of the SPSS software of the KAP data collected from respondents before and after the floods event, the awareness level of society was low due to the flood hazard and risk in Sibu Sire Woerda before the events and increase after the events. Hence, concluded as society of the Woreda doesn't have preparedness before the any disaster and the awareness level was very low.

V. CONCLUSION AND RECOMMENDATIONS

Conclusion

The basic idea of flood hazard, vulnerability and risk analysis and mapping as undertaken in this study is to regulate land use by flood plain zoning in order to restrict the damages. In the light of above discussion, it can be said that flood risk mapping, being an important non-structural flood management technique, will go long way in reducing flood damages in areas frequented by flood.

The study also reviewed the role of GIS in decision-making and then outlined the evaluation approach for many criteria in decision process. The design of multi criteria environment attempted to use a variety of evaluation techniques to data from GIS and present them in a manner familiar to decision makers. By integrating the evaluation techniques with GIS, it was intended that the effective factors would be evaluated more flexibly and thus more accurate decision would be made in a shorter time by the decision makers. By evaluating the criteria, the values of the criteria were classified to explain the opinions and preferences.

The study indicated that 7.26% and 2.16 % of the area of the Sibu Sire Woreda was very high flood hazard and risk zone respectively. Using Arc-GIS after analysis the flood hazard and risk depending on their causative factors the KAP study is applied to evaluate the awareness level of the Woreda society to the flood disaster by descriptive frequency analysis of SPSS software and concluded as their preparedness to any disaster is low.

Recommendations:

This investigation provides information on flood hazard at a Catchment, Woreda level and flood risk at Woreda level that could be used for reducing vulnerability to flood disaster in Sibu Sire Woreda in particular and that of the Indris Catchment at large with the following recommendations:

- Sibu Sire Woreda blessed with ample land resources, which is one of the most agricultural development areas in Ethiopia, but its proper agricultural development has been hindered by inundation, floods and poor drainage condition. Therefore, the responsible bodies of the Woreda as well as the region should use this flood hazard and flood risk map for better management of their agricultural development.
- The flood hazard and risk map can assist in policy decisions during a land use planning as it shows the environmental risk zone of flood. Therefore, local planners and policy makers should make use of hazard and risk zone model out puts as a decision support.
- Creating more awareness among the society concerning optimum use of natural resources, conservation systems and their benefits by concerned bodies could play significant role in minimizing of environmental risk zone. In addition, since most important factor for the land cover change in the Ethiopia, particularly in the study area is the increase in population, continuing the current efforts of introducing family planning to make the people aware of consequences of population pressure should be carried out intensively.
- Raise awareness level of society towards any natural hazard.
- More studies should be undertaken to establish new techniques for evaluating the criteria.

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