IOSR Journal of Applied Geology and Geophysics (IOSR-JAGG)
e-ISSN: 2321–0990, p-ISSN: 2321–0982.Volume 10, Issue 3 Ser. I (May. – June. 2022), PP 54-60
www.iosrjournals.org

Hydrometerological Disaster in Sintang: Environmental Degradation, The Rainy Season and La Nina Phenomena

Andi Mursidi
STKIP Singkawang, Indonesia

Abstract:
Background*: The climate change due to global warming is associated with the effect of the deforestation and La Nina phenomena and has many impacts, one of which is the flood in Sintang, West Kalimantan that occurred from 21 October to the end of November 2021. The flood in Sintang was the worst flood in the last 50 years, with water level of over 2 meters and lasting over 1 month.*
Materials and Methods*: The objective of this research was to evaluate the causes of flood in Sintang, its consequences, and the efforts to deal with it that need to be carried out so that there will be no more such heavy flood. This research used a survey method, and its data were analyzed using the Root Cause Analysis (RCA) technique. RCA is one of the instruments used to search for the root cause of a problem. With this technique, this research identified the root cause of the problem using a series of verbal models and techniques of 5 Whys analysis.*
Results and Conclussion*: The critical analysis carried out revealed that the flood in Sintang was caused by five main factors, namely: (1) Rainfall, (2) Deforestation and Environmental Degradation, (3)* ***River Siltation Due to Sedimentation, (4)*** *Changes in land use or land utilization, and (5) La Nina Phenomena**.** The Indonesian government, local governments and all multi-sector stakeholders in region management must collaborate, formulate and apply correct environmental management policies in order to minimize flood in the future.*
Key Word*: the worst flood in sintang; deforestation and environmental degradation; impact of la nina phenomena in indonesia.*

Date of Submission: 14-06-2022 Date of Acceptance: 29-06-2022

I. Introduction

Recent floods and their aftermath worldwide occur too frequently and threaten the continuous development of human settlement (Aderogba, 2012). The climate change and flood occurrences are environmental challenges that need intervention to ensure sustainable development (Mursidi and Sari 2017; Akolokwu, 2012). Flood is one of the main environmental crises that need to be faced in this century, especially in most of wetlands in the world (Bariwenie et al., 2012). The reason is the general rise in the sea level globally, as the consequence of global warming and wetlands' saturation in many parts of the world, including Indonesia. Flood occurs periodically in many rivers, that they overflow because of excessive rainfall. The good thing about river overflow is the fact that when this occurs, sand, mud and debris are deposited on surrounding land. After the water recedes and returns to flow normally, the materials deposited will help enrich and fertilize the soil. The organic matters and minerals deposited by the river flow keep the soil fertile and productive (Abowei and Sikoki, 2005).

The flood in Sintang Regency, West Kalimantan Province, Indonesia from the mid October to the end of November 2021 was the worst flood in the last 50 years. Flood is one of the most destructive natural disasters in the world, with death toll and property damage more than any other natural phenomena. One of the salient characteristics of flood is that it does not discriminate, but wipes out whoever rejecting to get ready to face it (Etuonovbe, 2011). Flood affects more people annually than any other forms of natural disaster, and various climatic and non-climatic processes affect flood process, producing various types of flood (Collins and Simpson, 2007). The recent rise of flood risk is acknowledged to be the most important threat of the climate change in various parts of the world (Dyson, 2002). Some researches state that extreme rainfall is the main cause of flood throughout the world, including Indonesia (Ologunorisa and Tersoo, 2006). The studies include Gobo (1988), McEwen (1989), Oriola (1994), Babatolu (1996), FMWRRD (1998), Odekunle (2001), Fowler and Kilsby (2003) and Ologunorisa (2004).

However, other authors have identified the extreme characteristics of rainfall related to the frequency of flood in Indonesia including duration, intensity, frequency, season, variability, trend and fluctuation (Olaniran, 1983; Ologunorisa, 2001; Ologunorisa and Diagi, 2005).

The nature actually benefits from natural flood more than without it. What makes natural flood a disaster is when the flood occurs in the areas inhabited by humans and in significant areas of human development. When it is left as is in its natural condition, flood has bigger benefits than its bad effects (Bradshaw et al., 2007). One of its benefits is increased fertility of agricultural land, as mentioned previously. However, too much sand deposit will have the opposite effects. For farmers with their plants along the river, they do not need to feel threatened by annual flood. This gives their agricultural land better consistency and keeps it fertile, leading to better harvest every year. Instead of preventing the natural flow of river flood, it may be beneficial in the long run when the flood is let flow to their land (Hill, 1976). However, there may be some limit to the extent the farmers can tolerate such a natural occurrence (O'Connor and John, 2004).

Therefore, the purpose of this paper was to study flood from different perspective and identify the causes and substantive consequences of flood in Sintang intending to evaluate the causes of flood in Sintang, its consequences, and the efforts to deal with it that need to be carried out so that there will be no more such heavy flood.

II. Material And Methods

This research used qualitative descriptive method and survey method. The survey covered the area condition and community behavior. The data collection techniques consisted of observation, interview, and documentation. The data used were primary and secondary data. The data analysis technique used was Root Cause Analysis (RCA). RCA is an instrument used to find the root cause of a problem. With this technique, the root cause of the problem was identified using a set of verbal models "whys", followed with visual models. The analysis result was the description of the main cause of flood the referred to field findings.

In general, the measures of RCA (Andersen, B., and T. Fagerhaug, 2000: Dogget, 2006; Latino Mark A., et all, 2020; Max Ammerman, 1998) are:

1. Measure 1 – Identify the problems: articulate question of the problem, and find out if the problem is a problem that is caused or made and then make logics to solve it.
2. Measure 2 – Collect data to clarify that occurs; investigate root cause in detail, find correct solution and focus on obtaining evidence and fact.
3. Measure 3 – Identify factors that cause the problem; verify and apply logics, identify and evaluate possible management, test efficient management and validate the effectiveness and final verification.
4. Measure 4 – Identify the root cause of problem; Focus on some critical preventive measures, identify the root cause system and resources and lastly measure the results.
5. Measure 5 - Why analysis 5; The 5 Whys is a simple and effective instrument for problem solving. The main objective is to find the exact reason that causes a certain problem by applying a set of "Why" questions. The 5 Whys technique helps focus on finding the root cause of a problem as shown in figure 1.

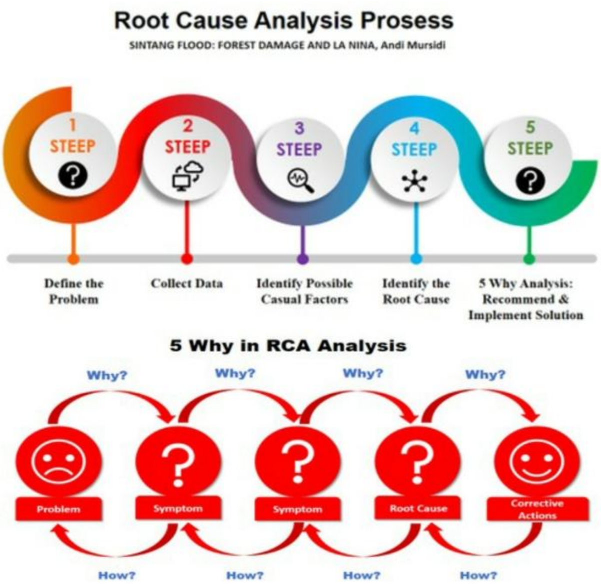

Figure 1: RCA of Process Analysis and 5 Whys Technique

III. Findings and Discussion

Flood and Its Impacts

The occurrence and recurrence of prolonged heavy rain have resulted in flood throughout the world (Pilgrim and Cordery, 1993; Christopherson, 1997; ActionAid, 2006; Adeaga, 2008; Wright, 2011; Aderogba, and 2012). Flood is caused by many factors: heavy rainfall, very rapid snowmelt, strong wind over the water, unusual tidal wave, tsunami, or dam, embankment, retention pool, or other structure failure. Flood worsens with increasing number of surfaces or other natural hazards such as forest fires, reducing the amount of vegetation capable of absorbing rainfall (Welch et al., 1977).

Bariweni, et al. (2012) summarize other causes of flood as follows; during relatively light rainfall, coastal lines of lake and bay can be flooded by strong wind like during storm that blows the water onto the coast. Coastal area is sometimes flooded by unusual tides, such as sea tide, especially under strong wind and wave storm. High tsunami and high wave are usually caused by underwater earthquake, volcano eruption or big explosion, causing seawater to flood and submerge buildings near the sea. Bariweni, et al. (2012) also adds that Climate Change is also an attribute of flood cause. Therefore, climate change will likely to increase the risk of flood significantly or progressively from time to time. Lowland coastal area is at particularly increasing risk, as sea level rises and areas that are currently not prone to fluvial flood or tide due to heavier rainfall cause a far higher risk of flood from surface runoff and drainage system getting overloaded.

Maryono (2005) states that floods occur continuously in Indonesia as the result of four things: 1) Heavy rain factor, but this factor does not necessarily cause flood, 2) Watershed's declining resistance to flood because of changes in land use, 3) River channel construction error factor, such as: river alignment, concrete wall and enforcement of river banks/borders, and 4) River siltation factor can cause decline in river's water containing capacity, thus water is unable to pass through it and overflows (flood). Flood is also caused by human activities, such as uncontrolled illegal logging, land clearing for agriculture and plantation, mine, and others. Such activities cause wider critical land, leading to wider open land dominated by grasses and shrubs. Rehabilitation for such critical land takes a lot of money and years of recovery. Such damage reduces watershed's capability to retain and release water, thus when rainfall increases, floods occur and, on the contrary, droughts occur in dry season.

The flood in Sintang City, Capital of Sintang Regency, West Kalimantan Province, besides caused by natural factor, was also caused by human factor as human activities were found in the field. Such activities, such as uncontrolled illegal logging, land clearing for agriculture and plantation, mine, and others, caused widening of critical land, leading to widening of open lands dominated by grasses and bushes. Rehabilitation of critical land takes a lot of money and years of recovery. Such damage reduced watershed' capability to retain and release water, thus when rainfall increased, floods occurred and, on the contrary, droughts occurred in dry season.

Based on categorization by NOAA (2013), the flood in Sintang was classified as River Flood: this occurred annually in many parts of the world, at a slower rate than flash floods. It occurs when run-off is collected on the river and finally overflows. When this occurs, the flood can cover a very wide area and affect downstream area even if there is not much rain. Even if river flood is predictable, its effects, even in a longer period, can cause extensive damage to settlement.

According to BPBD's data (Regional Disaster Management Agency) of Sintang Regency, the flood occurred in 12 districts. In 2021 there were three floods in Sintang. The first flood occurred in March 2021, with 3,682 families getting affected in two districts. The second flood occurred on 2 October 2021, with 8,693 families getting affected in six districts and the third flood occurred from 19 October to the end of November 2021, with 33,818 families getting affected in 12 districts. Besides in Sintang Regency, the flood also occurred in Melawi, Sekadau and Sanggau Regencies, through which Kapuas River passed.

In regard to the impacts of flood in Sintang, based on BPBD's data (Regional Disaster Management Agency) of Sintang Regency on 21 November 2021, the flood occurred for one month, with 33,818 families or 112,962 population getting affected, and 7,545 families or 25,884 population were evacuating. The evacuees were at 32 posts of shelter. The death toll was 4, there were 35,807 units of affected house, 5 units of heavily damaged bridges, 1 unit of moderately damaged bridge and power outage in 77 units of electrical substation.

The power outage affected the internet communication. The other impact was that many houses, household furniture, and electric appliances getting damaged. Likewise, many road infrastructures got damaged. Health impact; many people got sick that they lived in refugee posts. Social impacts; schools were closed for one month and the students could not have learning activities at school or online because the condition made it impractical. Figure 2 shows a stilt house whose floor was 2 meters from the ground getting drowned because of the almost one-month flood.

Figure 2: Flood Condition in Sintang, November 2021

Analysis on the Root Causes of Flood in Sintang

Based on the study on the flood causing factors, an analysis was then carried out on the main factors of flood causing factors, thus the root causes of flood could be found. The main factors that caused flood in Sintang were analyzed using a Root Cause Analysis. The root causes were analyzed sing "5-Whys", as illustrated in the flow diagram of the cause-effect of flood in Sintang.

Rainfall.

The heavy rainfall from the end of October to early November 2021 that was cumulatively 294 millimeter resulted in flood debit of 15,877.12 cubic meters per second. This amount exceeded the capacity of rivers of 12,279.80 cubic meters per second. Therefore, the run-off produced a very great debit of 3,597.32 cubic meters per second.

Deforestation and Environmental Degradation.

The reduction of natural forest land or deforestation in nine regencies/cities along the Kapuas watershed in West Kalimantan from 2014-2019 reached 151,517 ha. The coverage of natural forest in 2014 was up to 5,209,673 ha, while in 2019 it was only 5,058,156 ha. The nine regencies/cities in the Kapuas watershed in West Kalimantan were Kapuas Hulu, Sintang, Kubu Raya, Sanggau, Melawi, Landak, Sekadau, Mempawah, and Pontianak. It was recorded that the additional natural forest coverage only occurred in Kapuas Hulu of 10,074 ha. In 2014 the natural forest coverage was 2,378,924 ha, increasing to 2,388,998 ha. In the other eight regencies, however, there was deforestation.

Environmental degradation occurred, especially with the critical watershed condition. Sintang Regency had forest allocation of 59 percent of its size or about 1.3 million hectares out of total size of Sintang of 2 million ha. Based on the Kapuas Watershed and Protected Forest Management Agency’s data, out of about 14 million ha of watershed in West Kalimantan (including Sintang), about 1.01 million ha was in critical condition, including Kapuas watershed.

Based on the Global Forest Watch’s data, from 2002 to 2020, West Kalimantan lost 1.25 million hectares of wet primary forest, contributing to 36% out of total loss of tree coverage in the same period. The total area of wet primary forest in West Kalimantan decreased 18% in this period. The analysis by the Working Group of Reducing Degradation and Deforestation (REDD+) of West Kalimantan in 2020, meanwhile, stated that averagely the annual deforestation in West Kalimantan was 68,840 hectares and forest degradation of 10,837 hectares per year.

River Siltation Due to Sedimentation.

Sediment was transported by the flow physically through two contradictory mechanisms based on two types of load, namely suspended load consisting of fine sedimentary particles such as silt and clay and solid load, such as the bottom layer of the water like big and heavy particles such as stones, gravel, and sand (Ran D. et al., 2008; Sui J., et al., 2009).

There are some factors that caused sedimentation in the River (Rifardi, 2012; Algan O. et al., 2000). First, sea tide factor that occurs with two rises and two falls in a day which may cause water to circulate back and forth in the river, thus sediment does not move out of the estuary. The second factor is soil’s low sensitivity level because of deforestation upstream the river that will cause erosion. Heavy and high intensity of rain will worsen land erosion. When big land erosion is carried by the body of water into the river, it will cause thick sedimentation in the river. Sedimentation will affect shipping lanes in the river. More sedimentation will cause silting of shipping lanes, especially in the estuary. Estuary has big potential for sedimentation since it is the last place where sediment comes from upstream the river.

Changes in land use or land utilization.

Basically, Sintang is an area that will naturally be flooded, since it is in the middle of Kapuas watershed where there are some tributaries. However, in observation of the existing data, big floods occurred several times in 2021, while from 2017-2021 floods occurred every year. Only in 2019 there were no flood reported. Although it was relatively dry in 2018, but there was flood.

La Nina Phenomena

The La Nina phenomena in Pacific Ocean were predicted to cause anomaly in the weather in the form of increased rainfall in Indonesia. Most of the Indonesian territory has currently entered the rainy season from October to November 2021. The areas covered most of Sumatera, Java, Bali, Kalimantan, south part of South Sulawesi, south part of Southeastern Sulawesi, West Sulawesi, west part of Central Sulawesi, Gorontalo, most of North Sulawesi, North Maluku, north part of Buru Island, north part of West Papua, and central part of Papua. The peak of rainy season was predicted to occur in January and February 2022.

La Nina can generally be climatic phenomena which contradict El Nino or warming climatic phenomena or long dry season. El Niño occurrence is associated with the warming in the center and east parts of tropical Pacific, while La Niña occurrence it the opposite. Therefore, that occurs in La Nina phenomena is unusual cooling where the anomaly of temperature is over minus 0.5 degree Celsius in the same area with El Nino (Xie, S.-P. et al., 2016; Yulaeva, E., and J. M. Wallace, 1994). La Nina is an anomaly in the global system the frequently occurs with a repetitive period ranging from 2 to 7 years. The La Nina occurrence occurs when the Pacific Ocean and the atmosphere above it change from neutral (normal) condition in the period of two or more months.

Such change in the Pacific Ocean and the atmosphere above it occurs in a cycle called ENSO (El Nino – Southern Oscillation). At this time, the atmosphere and the sea interact with each other, strengthen each other, and create rotation that amplifies (strengthens) small changes in the sea. If the sea and atmosphere couple has been completely built, we can say that ENSO has been formed (Kamae, Y. et al., 2017; Okumura, Y. M., 2019). The La Nina formation mechanism starts when trade wind, warm sea pool can reach further into west Pacific, including. Thus, the Indonesian Waters are warmer than it usually is. The center part of Pacific Ocean will be cooler than it usually is and the thermocline will be shallower in the east. Cooler sea water from lower level rises onto the surface as upwelling strengthening.

The main impact of La Nina phenomena on the Indonesian climate or weather is the increase in rainfall. However, with the different topographic condition in Indonesia, the impacts of La Nina in Indonesia are not uniform throughout its territory. Based on the scientific study on the history of previous occurrences, the impact of La Niña is the increase in rainfall especially in the central and east regions of Indonesia. Climate change has made the La Nina phenomena occur more frequently at higher intensity, which may potentially cause various hydrometeorological disasters (Okumura, Y. M., et al., 2017). BMKG data indicate that La Nina in 2021 will be similar to that of previous year, causing an increase of rainfall of up to 70% from the normal condition. It is from that similarity that we analogize that the rain this year in December, January 2022, and February 2022 is highly similar to that in La Nina 2020-2021.

IV. Conclusion and Recommendation

The recent heavy flood occurrences in Sintang had claimed lives, damaging infrastructures and properties, inflicting economic and environmental loss, and causing health and social impacts. The prospective measures to reduce the dangers and protect the environment are proposed as follows:

1. Specific policies, programs and resources and guidelines on the mitigation, protection, and adaptation are needed to reduce long-term loss, increase ecosystem services, and encourage community security and resilience.
2. In maximizing the use of natural system and process to reduce flood, development and infrastructure projects need to include non-structural and natural based approach for flood risk management.
3. Including uncertainty and changing condition into flood plan and flood risk communication means subject to uncertainty and changes over time. Considering the evidences of shift of flood in many locations, risk analysis that assumes static condition may means underestimating current and future flood risks.
4. Flood related policies and risk management must recognize uncertainty and past trend, while predicting future condition.
5. To give flood risk information that can be followed up to the community, including for current and future condition. The community needs a clearer and more complete description of their flood risk and what they can do to solve it. Comprehensive flood risk information is very important to support plan, mitigation, and funding as well as policy priority. Comprehensive flood risk information must encourage communication, plan, mitigating measures, policies and funding priority between all stakeholders.

6. A project that uses the features of the nature or imitates the process of the nature can also provide significant additional benefits (such as water quality, habitat, and recreation). If possible, any infrastructures and development that may destroy natural protection system should be avoided.
7. The involvement of all stakeholders from multiple sectors in area management is urgently needed to formulate the right environmental management policy to minimize flood in the future.

Competing interests

The author declared that he has have no financial or personal relationships that may have inappropriately influenced him in writing this article.

Author's contributions

N.A.N. contributed to the design and implementation of the research, analysis of the results, and writing of the manuscript.

Disclaimer

The views and opinions expressed in this article are those of the author and do not necessarily reflect the official policy or position of any affiliated agency of the author.

References

[1]. Abowei, J.F.N., and Sikoki, F.D., 2005, Water Pollution Management and Control, Double Trust Publications Co,, Port Harcourt, Pp, 236.
[2]. ActionAid, 2006, Climate change, urban flooding and the rights of the urban poor in African cities, A Report by Action-Aid, Nigeria, Retrieved October 2006.
[3]. Adeaga, O., 2008, Flood Hazard Mapping and Risk Management in Parts of Lagos, M,Sc dissertation, Department of Geography, Faculty of Environmental Sciences, University of Lagos, Akoka, Lagos, Nigeria.
[4]. Aderogba, K.A., 2012, Substantive Causes and Effects of Floods in South Western Nigeria and Sustainable Development of the Cities and Towns,Journal of Emerging Trends in Educational Research and Policy Studies 34, 551-560.
[5]. Akolokwu, S.A., 2012, Overview of the 2012 Flooding in Nigeria, a Situation Analysis, Paper presented at the 1st Colloquium Organized by the Federal Ministry of water Resources, Abuja, 10th December, 2012.
[6]. Algan O., Gazioglu C., Yucel Z., Cagatay N., Conencgil B., 2000, Sediment and Freshwater Discharges of the Anatolian River into the Black Sea, IOCBSRC Workshop "Black Sea Fluxes", Workshop Report No, 145, Paris, UNESCO, 38–50.
[7]. Andersen, B., and T., Fagerhaug, 2000, Root cause analysis, Simplified tools and techniques, Milwaukee, ASQ Quality Press.
[8]. Babatolu, J.S., 1996, Recent Changes in Rainfall Patterns and its Implication for Flood Occurrence in Ondo, Nigeria, Ondo Journal of Arts and Social Sciences 11, 125–136.
[9]. Bariweni, P.A., Tawari, C.C., and Abowei, J.F.N., 2012, Some Environmental Effects of Flooding in the Niger Delta Region of Nigeria, International Journal of Fisheries and Aquatic Sciences 11, 35- 46.
[10]. Bradshaw, C.J., Sodhi, N.S., Peh, S.H., and Brook, B.W., 2007, Global evidence that Deforestation Amplifies flood risk and severity in the developing, Also a flood has Recently hit Pakistan which is said to be more devastating than the Tsunami of2005 world, Global Change Biol, 13, 2379-2395.
[11]. Christopherson, R.W., 1997, Goesystems, An Introduction to Physical Geography, London, Prentice Hall, 3rd Edition, 423.
[12]. Collins, E., and Simpson, L., 2007, The Impact of Climate Change on insuring flood risk, Institute of Actuaries of Australia, New Zealand, 1-38.
[13]. Dogget, A.M., 2006, Root Cause Analysis, A Framework for Tool Selection, The Quality Management Journal 124. https://doi.org/10,1080/10686967,2005,11919269.
[14]. Dyson, L L 2002, The Heavy Rainfall and Flood of February 2000, A Synoptic Overview of Southern Africa Floods of February 2000, Department of Civil Engineering, Pretoria, University of Pretoria.
[15]. Etuonovbe, A.K., 2011, The Devastating Effect of Flooding in Nigeria, Hydrography and the Environment Innocent Chirisa, Zimbabwe Inclusive Cities and Housing, Analysis of stewardship instruments in Epworth, Zimbabwe FIG Working Week, Bridging the Gap between Cultures Marrakech, Morocco, 18-22 May 2011.
[16]. FMWRRD 1998, Managing Flood Problems in Nigeria, Federal Ministry of Water Resources and Rural Development FMWRRD October, 1998.
[17]. Fowler, H.J., Kilsby, C.G., 2003, Implications of Changes in Seasonal and Annual Extreme Rainfall, Geophysical Research Letters 3013,17–20.
[18]. Gobo, A.E., 1988, Relationship Between Rainfall Trends and Flooding in the Niger–Benue River Basin, The Journal of Meteorology 13132, 318–324.
[19]. Hill, A.R., 1976, The environmental impacts of agricultural land drainage, Journal Environment Management 4, 251-274.
[20]. Kamae, Y., W, Mei, S,-P, Xie, M, Naoi, and H, Ueda 2017, Atmospheric rivers over the Northwestern Pacific, Climatology and interannual variability, Journal Climate 30, 5605–5619.
[21]. Latino Mark A., 2020, Root Cause Analysis, Improving Performance for Bottom-Line Results, Fifth Edition, Florida, CRC Press.
[22]. Maryono, A, 2005, Menangani Banjir, Kekeringan, dan Lingkungan, Gajah Mada University Press, Yogyakarta.
[23]. Max A., 1998 The root cause analysis handbook a simplified approach to identifying, correcting, and reporting workplace errors, Productivity Press, New York.
[24]. McEwen, L.J,, 1989, Extreme Rainfall and its Implication for Flood Frequency, A Case Study of the Middle River Tweed Basin, Scotland.
[25]. Mursidi A., and Sari D.A.P, 2017, 2017, Management of Drought Disaster in Indonesia, Jurnal Terapan Manajemen dan Bisnis 3(2), 165-171. http,//dx,doi,org/10,26737/jtmb,v3i2,273.
[26]. NOAA 2013, Types of Flood, National Flood Safety Awareness Week, March 18-22, 2013, US National Oceanic and Atmospheric Administration NOAA.

[27]. O'Connor, J.E., and John E.E., 2004, The World's Largest Floods, Past and Present, Their Causes and Magnitudes,Washington, D,C,, U,S, Department of the interior, U,S, Geological Survey.
[28]. Odekunle, T.O., 2001, The magnitude and Frequency Characteristic of Rainfall in Ondo, South-western Nigeria, Ife Research Publications in Geography 8, 36–41.
[29]. Okumura, Y.M., P, DiNezio, and C, Deser, 2017, Evolving impacts of multiyear La Niña events on atmospheric circulation and U,S, drought, Evolving impacts of multiyear La Niña, Geophys, Res. Lett., 44, 11614– 11623.
[30]. Okumura, Y.M., 2019, ENSO diversity from an atmospheric perspective, Curr, Climate Change Rep 5, 245–257.
[31]. Ologunorisa, T.E., 2004, Rainfall Flood Prediction in the Niger Delta, Nigeria Abstract, International Conference in Hydrology, Science and Practice for the 21st Century, London, U,K.
[32]. Ologunorisa, T.E., and Tersoo, T., 2006, The Changing Rainfall Pattern and Its Implication for Flood Frequency in Makurdi, northern Nigeria, Journal Appl. Sci. Environ. Mgt, 103,97– 102.
[33]. Oriola, E.O., 1994, Strategies for Combating Urban Flooding in a Developing Nation, A Case Study of Ondo, Nigeria, The Environmentalist 14, 57–62.
[34]. Pilgrim, D.H., and Cordery, F.S., 1993, Flood Runoff, In, D, R, Maidment Handbook of Hydrology 1st Edition New York, McGraw-Hill Inc, Pp91–94.
[35]. Ran D., Luo Q., Zhaou Z., Wang G., And Zhang X., 2008 Sediment retention by check dams in the Hekouzhen Longmen Section of the Yellow River, Int. J. Sediment Research, 23, 159–166.
[36]. Sui J., He Y., and Liu C., 2009, Changes in sediment transport in the Kuye River in the Loess Plateau in China, Int. J. Sediment Research 24, 201–213.
[37]. Welch, H.E., P.E.K. Symons and D.W. Narver, 1977, Some Effects of Potato Farming and Forest Clear Cutting on New Brunswick Streams, Fisheries and Marine Service Environ, Canadian Technical Report No, 745, St, Andrew's New Brunswick.

Andi Mursidi. "Hydrometerological Disaster in Sintang: Environmental Degradation, The Rainy Season and La Nina Phenomena." *IOSR Journal of Applied Geology and Geophysics (IOSR-JAGG),* 10(3), 2022, pp. 54-60.