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Sunyani's Flood Risk Landscape: An In-Depth Examination

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ABSTRACT

Disaster is the only event that can set back most goals achieved in decades in just an event. The ability to cope with the onset and aftermath of flood disasters poses a great challenge for municipal administrators around the world. Sunyani Municipality is vulnerable to flood disasters because of its growing population, dependency on climate for livelihoods, low-income levels, non-existence of insurance policies, weak government institutions, and inadequate funds to manage the municipality. Sunyani Municipality lacks a flood risk management plan to deal with mitigating the hazard, managing it when it occurs and restoring normalcy after the event. Flood-prone map was generated using digital elevation, hydrological datasets, land use maps of Sunyani coupled with flood models which were informed by the land use and Spatial Planning Unit regulation. A questionnaire was used to ascertain information from persons leaving within the flood-prone area. A total of one hundred and fifty (150) respondents. Major hazards Identified are climate hydrological (Riverine and urban flooding). The spatial location of the riverine flood is along the major rivers in the municipality. The other type of flood in the municipality is the urban/flash floods. Although, the areas experiencing the flash floods are built-up or residential areas, field visits indicated that most of the residential buildings are currently sitting in a flow accumulation path, which impedes the movement of rainwater after downpours. As such, the easy spillage of water into houses and shops. The flooding of some of the municipality's major routes will affect economic activities.

INTRODUCTION

With all the challenges presented by disasters, presents the greatest problem is the sustainability and resilience of cities against these disasters (United Nations Department of Economic and Social Affairs, 2018). According to Munich Re, (2019), this is due to the fact that disaster is the only event that can wipe-out all development and infrastructure by cities within short period of time. The rate of disasters has increased globally with rates at an all-time high from 1880 to 2018 (Achakulwisut *et al*., 2019). In 2018, the world witnessed over 800 climate-related disasters with 700 fatalities and damages worth over $1.7billion (Munich Re, 2019). High intense rainfalls and storms expose the vulnerability of Africa.

An estimate of over 140 mm of rainfall in just 48 hours in November 2019 led to over 9 deaths and 30,000 affected households in Djibouti (Floodlist, 2019). Another 500,000 people according to Floodlist (2019), in Malawi and Mozambique were also affected by floods. In Zimbabwe in the year 2017, severe floods from intense rainfall and cyclone killed 117 and left thousands homeless (Galvin & Writer 2017). The effects of a warming world on seasonal rainfall in East Africa are unclear, but rainfalls in the early part of 2019 killed 30 people and affected over 500,000 people (Ravallion, 2008). Adaptive capacity to the onset of flood and increasing effects is low resulting in huge economic burden and health-related effects (United Nations Department of Economic and Social Affairs, 2018).

According to Deng *et al*, (2010), Sub-Saharan Africa countries are faced with diverse problems of corruption, inadequate personnel, limited technological knowhow, and disaster management equipment's to manage disasters. Dilling *et al*, (2019), indicated that most countries disaster management institutions lack comprehensive disaster management plans and toolkits to tackle the issue of increasing disasters. At the household level, poverty levels are high, housing conditions are poor, knowledge on disasters are also low, there is lack of insurance and not enough savings to help bounce back from disaster.

Cities in Ghana are also witnessing the intense effect of storms and rainfall. Changing rainfall patterns and intensity is causing huge flood effects. About 12 children were reported dead as a result of floods in the Ashanti Region, 29 people in Upper East in 2019 (Twum & Abubakari, 2019). The effects of flooding in Ghana goes beyond the loss of lives to impact on socio-economic activities. Erman *et al* (2018) estimate that the economic impact of floods in Accra for 2015 generated over US$100 million in damages. Climate change is blamed for increasing disasters in Ghana. Twum & Abubakari (2019) claims that one of the major causes of flooding in Ghana is the non-adherence to land use planning policies and poor waste management systems.

The development of unregulated physical structures in waterways likely the cause of the increased incidences of flooding in the Sunyani Municipality. As the municipality's population continues to expand, and residents express strongly prefer to reside in the city center, we are witnessing increasing encroachment upon the River

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Nsansanim and Tano watersheds.

Also, most drains in the municipality are filled with loads of sediments impeding the free flow of rainwater. In June 2019, the municipality witnessed great flooding causing great levels of frustration as most persons were stranded in their homes with the destruction of most office and household items.

The occurrence of flood in Sunyani is not expected to recede as the municipality physically grows, and the influence of climate change intensifies. Currently, the municipality lack any empirical assessment of the nature of flood disasters.

There is no available flood disaster map to inform planning. Vulnerability statistics of the number of persons and properties likely to be affected is also not available. Disaster can only be managed effectively when there is available disaster maps to inform spatial and land use planning and deter development in waterways. In addition, disaster risk maps can even serve as the underlying bases for developing of flood insurance risk to help families recover after major flood events. The availability of a comprehensive emergency plan to deal with the onset of flooding and aftermath is a challenge. The Sunyani Municipality needs an emergency plan to help develop prevention measures, adaptive and coping strategies to flood and storm disasters.

LITERATURE REVIEW

Size and Location

Sunyani Municipality is located within the bounding coordinates 2.390W, 7.380N to the North West and 2.220W, 7.280N to the South East. It shares broader with Sunyani West to the North, the South with Tano North District, East to Sunyani west and West to Asutif North District (Figure 1). The entire Sunyani Municipality covers an estimated area of 46,161.8_acres (186.8_km2). Urban Sunyani is densely populated and with most physical infrastructure within the municipality (Sunyani Municipal assembly, 2020).

Elevation and Hydrology

The minimum elevation for Urban Sunyani is about

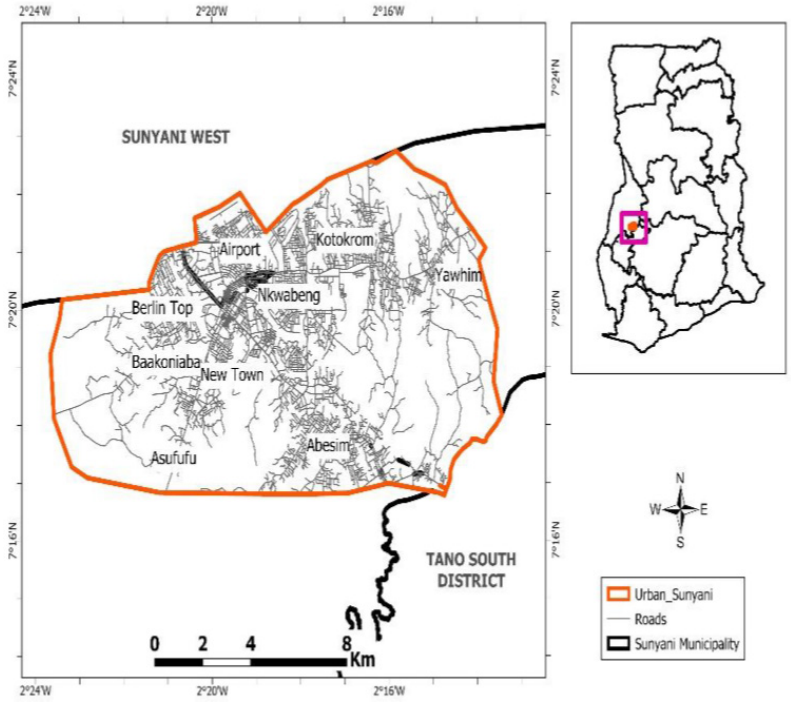

Figure 1: Study Area (SMA, 2018)

230m and a maximum of 407m above sea level (Sunyani Municipal assembly, 2018). Urban Sunyani lies within two major river basins in Ghana that is the Black Volta River Basin to the north and Tano River Basin to the South. The major rivers in the area are Tano, Amoma, Kankam, Benu, Yaya and Bisi. The drainage pattern can be described as dendritic. Most of the rivers are seasonal and overflow their banks during the rainy season because of their shallow channels and width. Also, physical developments have impacted the river flow and channel within Urban Sunyani.

MATERIALS AND METHOD

To assess the vulnerability of elements at risk a flood zone map was generated using digital elevation, hydrological data sets and land use map of Sunyani obtain from Sunyani Municipal Assembly. The flood model was also informed by the Land Use and Spatial Planning Unit regulation on developments along waterways in Ghana. Historical flood area mapping was conducted in most of the flood-prone zones through the overlaying a photo image with a transparent material to enable easy drawing of flood zones by households in flood zone. The output

from the historical mapping was compared with the hydrological model to ascertain the overlaps in the model and reality so as to develop a more realistic flood map for Sunyani.

A structured questionnaire were used to ascertain information from persons leaving within the flood prone area. The sample size for a research survey with a household population of 233,790 in Sunyani. the formula for sample size calculation is commonly used (Cochran, 1977). According to Cochran's formula for sample size calculation

Sample Size = $(Z^2 * P * (1 - P)) / E^2$

Where:

Z = Z-score corresponding to the desired confidence level

P = Estimated response rate

E = Margin of error

Using these parameters, the sample size calculation becomes:

Sample Size = $(1.96^2 * 0.5 * (1 - 0.5)) / 0.05^2$

Sample Size ≈ 384.16

A total of three hundred and fifty (384) respondents were interviewed. Information on their building and household characteristics, flood experience, damages and assets and GPS location were collated. An estimate of the number of physical elements, population, the socio-economic impact of hazards was assessed. Information on households' assets collected through questionnaires was used to estimate the economic cost of the future floods.

Interviews were conducted with National Disaster Management Organization (NADMO), Ghana Police Service, and Ghana National Fire Service, to solicit information of their strengths and weaknesses in managing disasters in the municipality.

Hazard maps (flood area and wind storm zones) generated were overlaid with land used map and buildings footprints of Urban Sunyani. In this process, an estimate of the number of physical elements, population, the socio-economic impact of hazards was assessed. Information on households' assets collected through electronic questionnaires was used to estimate the economic cost of the future floods. Security impact of a worst-case scenario of a disaster in the Urban Sunyani was assessed using the number of the person likely to be affected.

In assessing the adaptive capacity of persons at risk to disaster risk the consultant will depend on questionnaires. Questionnaires were used to solicit information from persons in hazard zones on strategies they adopt to cope with disasters. Individual households adaptive capacity were measured from the data solicited from the questionnaire. In addition, observation as a data collection technique was employed to ascertain the coping ability of elements like buildings and other structures to hazards.

Information on hazard maps, vulnerable elements at risk and adaptive capacity was merged spatial through the technique of spatial multi-criteria evaluation. This technique was to concurrently and simultaneously merge the three variables through the process of data inputting, standardization, weighting and slicing. The final output of this spatial multi-criteria will be a map showing the disaster risk map of the Sunyani Municipality

RESULTS AND DISCUSSIONS

Flood

Flood prone areas identified in Sunyani are Penkwase, Nkwarbeng, Baakoniaba, Abesim, Kootokrom, Newtown, Estate, Yawhima and Bosoma Market. These areas are low lying, and are close to water channels due to the topography of the area. The average flood area is about 6,985acres (2,826.89 hac) with the largest flood zone area covering through Berlin Top to Baakoaniaba with an area of about 1,064acres (430.9hac). One main cause is changing climate in Ghana and Sunyani at large. Although the United State Agency for International Development Climate Risk Profile of Ghana (2017) espouses that the precipitation in Ghana will decrease by 4.4% in 2040, it projects that precipitation will be more erratic with intense rainfall during the wet season and lower precipitation levels during the dry season.

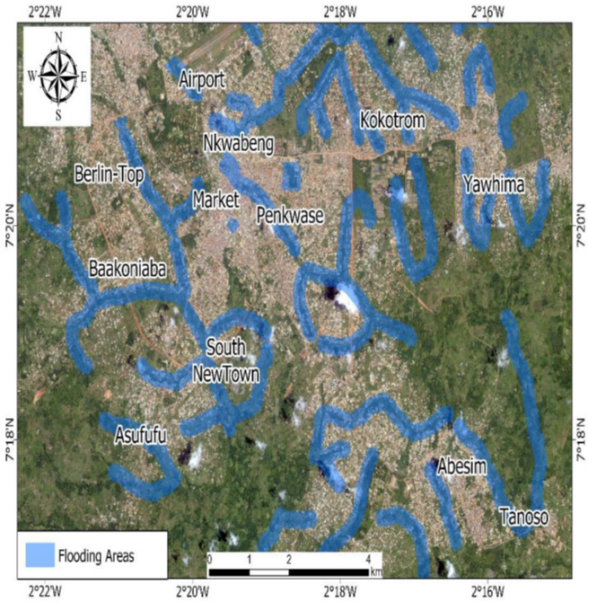

Figure 2: Flood Prone Areas

The intensity of the rainfall being experienced inundates river channels within the municipality to overflow their banks. However, anthropogenic activities further worsen the overflow of river banks. Developers and settlers within these zones are often conscious of the liability of the zone to flood as the underground water table is near the surface of the ground. Flooding in Abesim and Asufufu are low because physical development is yet to take complete hold of the flood zone. The intensity of rainfall experience within the months of May- June and in recent times August-September brings lots of rainwater which exceed the capacity of groundwater absorption with the municipality considering the fact that most of the flood areas have near-surface groundwater table.

Flash Flood

Flash floods are sudden and rapidly occurring floods that typically result from intense rainfall, rapid snowmelt, or dam failure (Smith, 2018). They are characterized by their swift onset and high-water levels, posing a significant threat to life, property, and the environment. Flash floods can occur in various geographic regions and can be particularly hazardous in urban areas due to limited drainage capacity. Areas around Sunyani Market through Twene Amanfo Senior High School, some parts of Kotokrom, Nkwabeng, Sacred Heart School, and Yawhima area are the hot spots for flash floods indicated in figure 2. The flood extents for the flash floods are mostly small relative to the riverine flood which is elongated and covers banks of rivers in the municipality. In Nkwabeng the flood extent covers about 35.68ac (14.44hac) while Sacred Heart School area can be covered by a flood zone of 54.23ac (21.94hac).

The Sunyani Market area has the least flash flood extent with an area of 12.38ac (5.01hac) although is potential flood damage because of the commercial nature of the area. The cause of the flash floods is inefficient drains around these areas. The width of the drains is small to carry the quantity of flow during heavy rainfall. Another contributing factor is that most of the drains are blocked with plastic rubbers and household wastes which prevent the free flow of water through the drains. Drains in areas experiencing flash floods are not well connected at their confluence.

Hazards Assessment

Element at risk to the climate in the Sunyani municipality are people, animals, structures, activities that will be affected during a hazard event. The onset of hazards in the municipality are physical element, essential facility, transportation, population, socioeconomic activities and environmental elements. With regards to the flood prone areas in the municipality, element at risk are residential, residential and commercial, commercial and institutional structures.

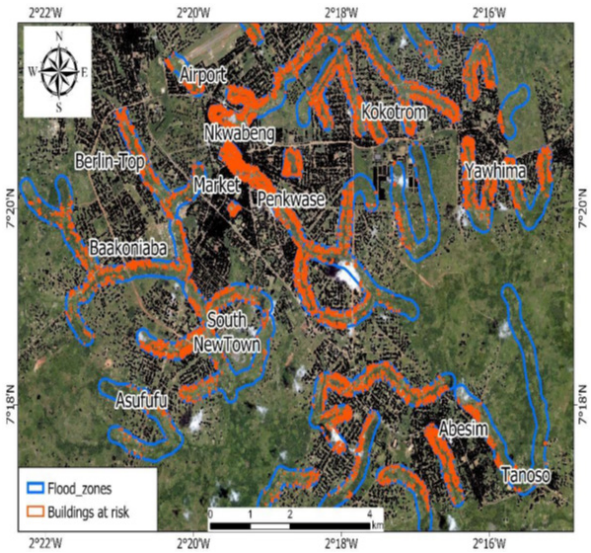

Figure 3: Structures/Buildings in Flood Prone Area

Structures/Buildings were mapped with information on building material, foundation material. A total number of 7,695 buildings in the municipality were exposed to flood events (Figure 7). About 87% of these building were mainly residential buildings.

The nearest building to a river in the municipality is 0.02m while the farthest building in the flood zone to rivers is 792m with an average distance of 103.4m. About 54.6% of buildings in flood zone were in a distance below 103.4m away from river body. A tally of items owned by households interviewed revealed that are over 17,945 items at risk with an estimated cost of 11,925,453 Ghana Cedis. Over 1069 sheeps, 38 cattles, 135 rodents and 8781 poultry were at risk to flood.

People at Prone Areas

An estimated number of 38,475 people are at risk to flood in the municipality. The number of people at risk at this time period should be less than 10,000 people. Between the hours of 3:30pm to 7: 00am, the estimated number of people at risk to flooding is more than twice the day population. This time period is when most households are returning or have returned from their busy socio-economic activities through the municipality.

Facilities at the Prone Areas

The number of essential facilities identified within the risk zones was schools, religious facilities. Twene Amanfo Senior High School and Sacred Heart High School fall directly within flood zones. Churches at risk to flood are the Latter Days Saint Church, Sacred Heart Catholic Church, apostolic church of Ghana. Respondents in these areas attested to frequent flooding.

Transport System at the Prone Areas

The major roads to be off when an imtense flood in the Sunyani Municipality are the main Sunyani-Berekum Road (from the Ghana Post roundabout to passing through the Sunyani Parks and Garden) see Figure 8. The N12 road thus Little Wood Road through to J.H. Owusu Acheampong Street is exposed.

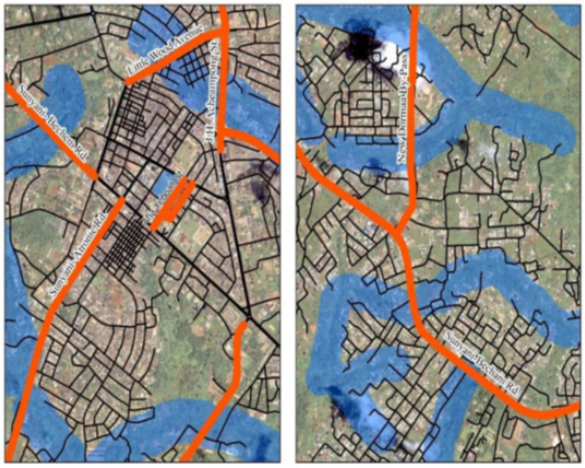

Figure 4: Transport System

Parts of the road to Atronie is within the flood zone. The main J. H. Owusu Acheampong Street is the most likely to be flooded because of the low lying nature.

Other major roads that bring the municipality to a standstill is the main Sunyani-Berekum road (Figure 4). The New Dormaa by-pass constructe to ease vehicular traffic on roads in the Sunyani Municipality is also at risk to flood. These roads at risk areas major concern because it will cut the movements from Kumasi to Berekum and the northern parts of the country.

Vulnerability Levels

Level of physical vulnerability for the most part of the Urban Sunyani was low with areas within the flood zone as moderate (Figure 5).

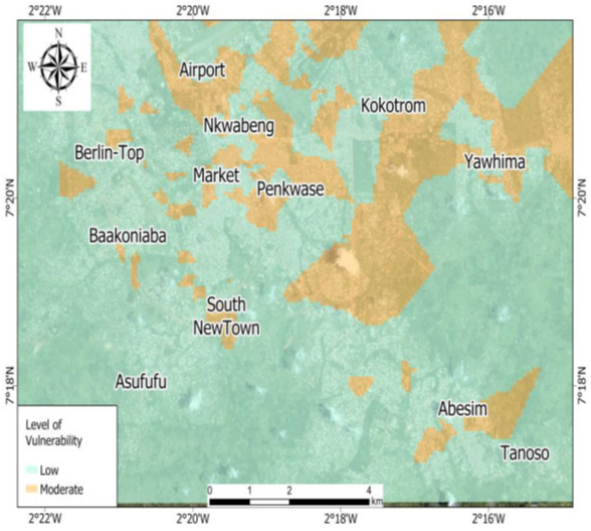

Figure 5: Physical Vulnerability

The foundation material of buildings was mostly blocks with about 82% of the buildings while 5.8% had Bricks. The walls of buildings were mainly blocks with over 87% of it area while just under 2% had adopted and used unconsolidated materials. The average age of the buildings was 14_years making them resilient to flood. But their vulnerability will increase after 30 years. The buildings are vulnerable to flood as the average flood depth was 27.8m while the foundation of the buildings above street level was 19.7m.

Factors accounting for the high social vulnerability was only 33% while respondents were members of a social organization who can provide them with support after a hazard. In terms of social amenities, only 39% had access to Wash rooms. Majority depended on pit latrines (42.7%), open-pit (14.1%) and open spaces/bush (3.9%). These toilet facilities pose risk to households during the flood. Faeces can easily find its way to water systems as about 53.3% of households depend on wells.

Socially, the average age was 43 years with over 58% of households being females. Female households are more vulnerable to hazards as compared with households headed by male households. About 64% of the households' head were married with their spouses

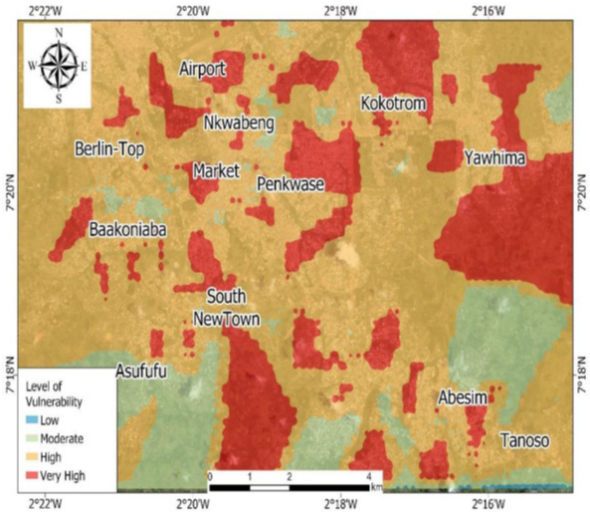

Figure 6: Social Vulnerability

living with them which will help reduce vulnerability levels as compared with a single parent. Knowledge about hazards and disasters was moderate with over 40%. Despite knowing the impact of hazards, they choose to live in hazard-prone area. Only 15% of the persons living in flood-prone areas has acknowledge that the houses are in flood area. Also, 30% of the people acknowledged that they knew their current place of residence was in a flood zone but still choose to settle there.

Economic vulnerability level for Urban Sunyani ranges from very low to high (Figure 7). Berlin Top, some parts of Airport and few patches along Kotokrom had a high vulnerability. These areas are high residential zones in Urban Sunyani. Households in these zones are more likely to have more equipment's and assets as compared with other areas.

Areas within the Market zone, Nkwabeng, Airport, New Town, Abesim and Tanoso had a moderate vulnerability.

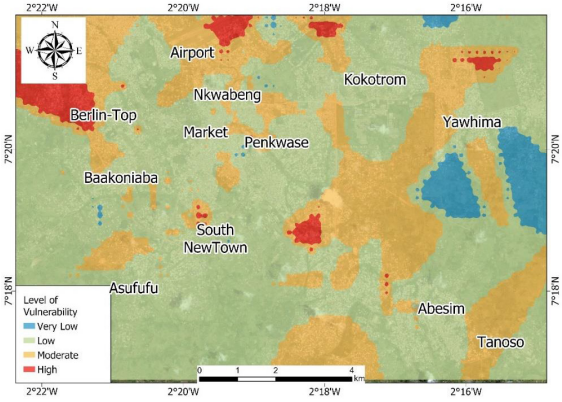

Figure 7: Economic Vulnerability

The total estimated economic impact of flood in Urban Sunyani is about 11,925,453 Ghana Cedis. With households living in the flood zone more than half do save with financial institutions but only 36% claimed their savings can help recover from hazardous events. In additions access to credit was very low as 27% were creditworthy. However, 40% attested to the fact that the credit amount

they can secure can help them recover from the impact of the disaster.

High Disaster Risk Areas

Combining the datasets of flood zone areas, elements at risk physical, social and economic vulnerability a disaster risk map was generated for Urban Sunyani. The main disaster risk zones were low, moderate and high areas (Figure 8). Majority of the areas in Urban Sunyani were within moderate disaster risk zone.

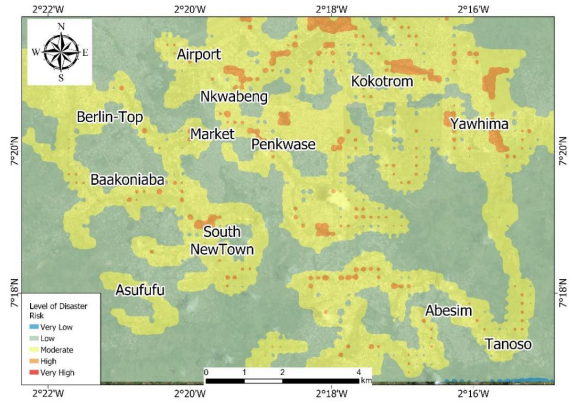

Figure 8: Disaster Risk Map

Patches of high-risk zones are located within moderate zones at South Newtown, Nkwabeng, Kotokrom, Yawhima and Airport (Figure 8). Moderate disaster risk zones within Urban Sunyani present a great opportunity for the Municipal Assembly to act. It also means that disaster situation is within manageable means and can easily be controlled with the right measures in place. This disaster risk output should be taken as static because day in day out the variables determining it is also changing. Flood zones within the Urban Sunyani will expand if developments along rivers bodies are not controlled. Also, the impact of climate will induce more rains which will exceed the river flow but this can be checked if physical developments are prevented around river course.

CONCLUSION

Disasters are events which will stay with urban cities with changing climate. Its impact can be reduced with a comprehensive disaster management plan. In developing disaster maps scientific and community science approach were used in gathering data about hazard areas, elements at risk, vulnerability levels of the elements at risk. It was released that the main hazard affecting the municipality was flooding. The causes of flooding ranges from the effect of climate, uncontrolled physical developments along river channels and destruction of vegetation along waterbodies. The main elements at risk were household items and appliances.

Social and economic vulnerability levels were significantly elevated. While physical vulnerability remained high for regions situated along river bodies, the majority of households had taken proactive measures by retrofitting plumbing systems and reinforcing their homes. The reinforcements can only help for some time but long-time risk associated with them to households is very high. Disaster map indicated most part of Urban Sunyani can be categorized as having moderate risk. The developed disaster risk map can help disaster managers in identifying areas to allocate resources and other helps during hazards.

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