GEOSPATIAL ANALYSIS OF URBAN LAND USE PATTERN ANALYSIS FOR HEMORRHAGIC FEVER RISK – A REVIEW

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ABSTRACT:

Human modification of the natural environment continues to create habitats in which vectors of a wide variety of human and animal pathogens (such as Plasmodium, Aedes aegypti, Arenavirus etc.) thrive if unabated with an enormous potential to negatively affect public health. Typical examples of these modifications include impoundments, dams, irrigation systems, landfills and so on that provide enabled environment for the transmission of Hemorrhagic fever such as malaria, dengue, avian flu, Lassa fever etc. Furthermore, contemporary urban dwelling pattern appears to be associated with the prevalence of Hemorrhagic diseases in recent years. These observations are not peculiar to the developing world, as urban expansion also contributes significantly to mosquito and other vectors habitats. This habitats offer breeding ground to some vector virus populations. The key to disease control is developing an understanding of the contribution of human landscape modification to vector-borne pathogen transmission and how a balance may be achieved between human development, public health, and responsible urban land use. A comprehensive review of urban land use Pattern Analysis for Hemorrhagic fever risk has been conducted in this paper. The study found that most of the available literatures dwell more on the impact of urban land use on malaria and dengue fevers; however, studies are yet to be found discussing the implications of urban land use on the risk of Ebola, Lassa and other non-mosquito borne VHFs. A relational model for investigating the influence of urban land use change pattern on the risk of Hemorrhagic fever has been proposed in this study.

1. INTRODUCTION

Urban environment support high concentration of human, domestic pet, and introduced animals that create favourable conditions for the transmission of infectious parasite, such as the Hemorrhagic viruses. The rate of transmission of the parasite increases with the quest for speedy urbanization. Again, the actual process of rapid urbanization is associated with various ecological, social, and economic changes, in both the urban area, and the adjacent natural environment. Consequently, the continuous degradation of the ecosystem poses a threat to the present and future dwelling sustainability. Babanyara et al. (2010) observed that rapid population growth and urbanization were of great concern to the sustainability of cities; therefore, the more people on the earth, the greater the impact on the environment and the resources. Also, literature affirms that urbanization takes place in both developed and developing countries (Al-shalabi et al., 2013). However, speedy urbanization, especially the urban land expansion, and the associated problem of unemployment, poverty, poor sanitary condition and environment degradation pose a formidable challenge in some developing countries (Basnet, 2011; Hove et al., 2013; owoeye and ogundiran, 2014). Be that as it may, the developing countries lack adequate implementation policies to address dwelling and Hemorrhagic risks as a result of speedy urbanization. Nevertheless, adequate insight into the available dwelling patterns and their impact on the spread of Hemorrhagic diseases could fast-track decision making progress for sustainable urbanization.

Viral Hemorrhagic Fevers (VHFs) are found around the world, specific diseases are usually limited to areas where the animals that carry them live. For example, Lassa is limited to rural areas of West Africa where rats and mice carry the virus. Consequently, several literature (Stefani et al., 2013, Hahn et al., 2014, Li et al., 2016, Alimi et al., 2016, Ibekwe, 2012) have investigated land use/land cover classes and some Hemorrhagic diseases. Bulks of these studies were conducted in America, Asia and Australia with much emphasis on mosquito borne diseases such as dengue and malaria fevers. For instance, Messina et al. (2015) investigated the global distribution of Crimean-Congo Hemorrhagic fever (CCHF) using an exhaustive database of human CCHF occurrence records and a niche modeling framework. A greater proportion of shrub or grass land cover was found to be the most important contributor to their model, which predicts highest levels of risk around the Black Sea, Turkey, and some parts of central Asia. It was affirmed that Sub-Saharan Africa shows more localized areas of risk throughout the Sahel and the Cape region. However, studies on land use/land cover classification and other non-mosquito borne Hemorrhagic diseases such as Lassa fever, Ebola, Marburg etc. are yet to be common in current literature. It is therefore, essential to conduct a comprehensive review of the existing literature on urban dwelling pattern and the risks of Hemorrhagic diseases in order to establish the relationship that may exist between them as well as to benchmark the variations in literature on continental basis. This may be remarkable for predicting the spread of such diseases and providing decision support system for health management institutions. Therefore, this paper presents a review on urban dwelling pattern analysis for Hemorrhagic fever risks.

In what follows, the background of viral hemorrhagic fevers (VHFs) and urban dwelling pattern analysis is covered in Section 2, Section 3 details the types and source of materials utilized in this review while discussing the method adopted for the review. The results and findings of the paper are discussed in Section 4 while Section 5 wraps up the paper with conclusion.

2. THE BACKGROUND OF VIRAL HEMORRHAGIC FEVERS (VHFs) AND URBAN LAND USE PATTERN ANALYSIS

2.1 Viral Hemorrhagic Fevers (Vhfs)

Viral hemorrhagic fevers (VHFs) refer to a group of illnesses that are caused by several distinct families of viruses (Chollom et al.,2016). These include the Ebola , dengue fever, avian flu, malaria fever, Lassa fever, yellow fever viruses, Crimean–Congo hemorrhagic fever (CCHF), Rift Valley fever (RVF), Hantavirus diseases etc. In general, the term "viral hemorrhagic fever" is used to describe a severe multisystem syndrome (meaning that multiple organ systems in the body are affected). Characteristically, the overall vascular system is damaged, and the body's ability to regulate itself is impaired. These symptoms are often accompanied by hemorrhage (bleeding); however, the bleeding is itself rarely life-threatening. While some types of hemorrhagic fever viruses can cause relatively mild illnesses, many of these viruses like Ebola or Marburg cause severe, life-threatening disease and death (Ajayi et al., 2013).

2.1.1 Causes And Transmission of VHF

According to WHO, Viruses belong to several families; for instance, Ebola and Marburg belong to the Filoviridae family; Hantaviruses, CCHF and RVF belong to the Bunyaviridae family; Lassa belongs to the Arenaviridae family; stomatitis and rabies belong to Rhabdovaridae; while malaria, dengue and yellow fever belong to the Flaviviridae family. Viruses that cause hemorrhagic fevers are transmitted by mosquitoes (dengue, malaria, yellow fever, RVF), ticks (CCHF), rodents (Hantavirus), or bats (Ebola, Marburg). For Ebola and Marburg viruses, humans have been infected from contact with tissues of diseased non-human primates (monkeys and apes) and other mammals, but most human infections have resulted from direct contact with the body fluids or secretions of infected patients. Humans who develop CCHF usually become infected from a tick bite but can also acquire the virus from direct contact with blood or other infected tissues from livestock or from infected patients.

RVF can be acquired either by mosquito bite or by direct contact with blood or tissues of infected animals (mainly sheep), including consumption of unpasteurized milk. Lassa fever virus is carried by rodents and transmitted by excreta, either as aerosols or by direct contact. Some viral haemorrhagic fevers have been amplified in hospitals by nosocomial transmission resulting from unsafe procedures, use of contaminated medical devices (including needles and syringes) and unprotected exposure to contaminated body fluids (Kigozi et al., 2015; Asogun et al., 2012; Olugasa et al., 2015; Hahn et al., 2014; Judson et al., 2015; Fhogartaigh and Aarons, 2015; Messina et al., 2015; Bhatt et al., 2013; WHO, 2012; Adegboye and Kotze, 2014).

2.1.2 Nature And Distribution Of VHFs

The haemorrhagic fevers are severe acute viral infections, usually with sudden onset of fever, malaise, headache and myalgia followed by pharyngitis, vomiting, diarrhoea, skin rash and haemorrhagic manifestations. The outcome is fatal in a high proportion of cases sometimes more than 50%, (Dzotsi et al., 2012). Diseases in this group occur widely in tropical and subtropical regions. Ebola and malaria, dengue haemorrhagic fevers and Lassa fever occur in parts of sub-Saharan Africa. Crimean-congo haemorragic fever occurs in the steppe regions of central Asia and in central Europe, as well as in tropical and southern Africa (Lai et al., 2015; Kateera et al., 2015).

The distribution of VHF is determined by climate and other geographic factors that influence the development of the diseases' vectors and their parasites at a given time, which is also influenced by environmental changes over time. Ecosystem changes resulting from natural phenomena or human interventions, on a local or global scale, can alter the ecological balance and context in which vectors and their parasites develop and transmit the disease (Patz et al., 2000). According to Patz and Olson (2006), changes in temperature patterns, due to global climate change and in variation in local land use practices, may influence VHF risk.

2.2 Urban Land Use Pattern Analysis Using GIS And Remote Sensing

Changes in the uses of land occurring at various spatial levels and within various time periods are the material expressions, among others, of environmental and human dynamics and of their interactions which are mediated by land. Land use is characterised by the arrangements, activities and inputs people undertake in a certain land cover type to produce change or maintain it (FAO/UNEP, 1999).

For the consequences at local and regional levels, the spatial patterns of land use change are as relevant as the aggregate volume of change. Thus, analysis of urban land use/land cover (LU/LC) change is essential for social economic and regional development and environmental changes (Mirkatouli et al., 2015; Chen et al., 2013; Zhang et al., 2013; Barsimantov and Antezana, 2012).

According to Mirkatouli et al. (2015), development of urban region must be managed in such a manner that meet public needs and benefits current and future residents of cities and its surrounding areas, this requires utilisation of specialised tools and techniques such as remote sensing and GIS. Today, there are various approaches to urban studies such as ground survey, photogrammetry and remote sensing. Remote sensing as a major source of data, is used in the study of areas with urban or manmade characteristics, landscapes and natural environments (Peled and Gilichinsky, 2013; Ye and Fang, 2011; Pelorosso et al., 2009; Bhatta, 2009). However, the integration of remote sensing with GIS is now widely preferred for efficient and more accurate urban growth assessment (Hashim et al., 2011; Baja and Arif 2014; Arsanjani et al., 2015 ; Hove et al., 2013).

The definition given by Colwell (1997) to remote sensing as the art, science and technology of obtaining reliable information about physical objects and the environment, through a process of recording, measuring and interpreting imagery and digital representation of energy patterns derived from non-contact sensor systems" makes sense in the usage of its data for urban dwelling pattern assessment. Similarly, GIS as described by Malienea et al. (2011) and Nour (2011) to be a technology that makes possible the collection, compilation, analysis, as well as representation of very large amount of hypothetical/ real word data indicates its relevance for adoption in urban dwelling pattern studies.

In view of these, a number of studies (Nour, 2011; Hui-Hui et al., 2012) have been conducted on urban dwelling pattern analysis using remote sensing and GIS; these are found within a popular caption of land use/land cover pattern analysis. Land cover concerns the physical material observed at the earth surface (such as forests, water bodies and bare rock); Land use is related to the human use of the land and integrates socio-economic and cultural functions (such as agriculture and housing). Despite their differences, Land cover and Land use are often mapped together and often result from remotely sensed image classifications performed by RS experts. Such classification procedures range from totally unsupervised approach to a full visual interpretation of the images and highly depend on the availability of the remotely sensed data, the availability of experts of the application domain, the adequacy of the data for the question addressed and the competence of the technicians, engineers and/or researchers that perform the image processing. As a result, a wide variety of Land use/Land cover typologies and methodologies can be found in the literature.

Furthermore, in a bid to create comfortable dwelling for man, urban environment have been modified in various ways. These human modifications of the natural environment continues to provide habitats in which vectors of a wide variety of human and animal pathogens thrive with an enormous potential to negatively affect public health if left unchecked. This underscores the need for numerous studies on urban land use classification and diseases hazard risks found in current literature (see Table 1). Some authors have directly related environmental alteration to cases of VHF such as malaria and dengue.

3. MATERIALS AND METHODS

In conducting this review, five families of hemorrhagic fever namely; the Arenaviridae, the Bunyaviridae, the Filoviridae, the Flaviviridae, and the Rhabdoviridae were identified. Available literature discussing urban dwelling pattern and some of the VHFs in relation to the six continents of the world was utilized. The publications selected for the review include the original research articles using remotely sensed LU/LC information (i.e only focused on the explicit LU/LC types), with studies applied to various types of VHFs (considering vectors and parasites).

Referenced articles using a LU/LC characterization and urban land use pattern analysis for the study of hemorrhagic fever risk across the globe were isolated by performing queries in ISI Web of Knowledge databases: Web of Science, Medline, Journal Citation Reports, Google Scholar, PubMed and Current Contents Connect. The keywords and expressions chosen to construct database queries were: malaria, dengue, fever, Lassa, "urban land cover pattern" OR "urban land use pattern", "remote sensing", "GIS", "risk factor", "Asia", "South America", "Africa", "Europe", "North America". The queries were defined by the conjunction of two or more key words and/or expressions. A total of 15 recently published articles from 2011 to 2016 were identified on the subject matter. The identified articles were classified into two broad types: (i) urban land use pattern analysis (6 articles) and (ii) urban land use pattern analysis for VHFs (12 articles). These articles were isolated as the baseline articles for the review. Table 1a and 1b shows the summary of the articles in accordance to their classification.

Table 1a: Summary Of Literature For Urban Land Use Pattern Analysis

S/No	AUTHOR/YEAR	TITLE	METHODOLOGY	VAR.	FINDINGS AND RECO.	REMARK
1	Parvez, R, Madurapperuma, B, Ripplinger,D (2015)	Modelling land use pattern change analysis in northern great plains (NGP).	The study focuses on analysing causes of land use changes, such as GDP and population density. The concept of integrating econometric model and geospatial model was adopted to establish the relationship between economic activities and land use changes.	GDP per capital, GDP per capital square, POP Density. Dependent Variable, Agricultural land use, Forest Land use, Urban Land use e.g. y=a+ bx Y=Dependent X=Independent or explanatory variable.	The effect of income per capital varies for all three types of land use classes.	The estimated relationship between income per capital and change in land use area over the sixteen years is not very strong. This is because there is lack of reliable data and low number of observations in the NGP
2	Singh. P and Singhs. (2011)	Land use pattern analysis using remote sensing, A case study of Mau district India.	Geometric correction performed on the satellite image, The image was geocoded to UTM coordinate system using reference image 501 topo sheets and 25 regularly distributed ground control points. Quantification of land use parameters was done using Erdas imagine and Arc GIS software. The analysis clearly revealed changes especially, all round increasing trend noticed in categories such as land fallow, barren land, and mixed built up areas, while forest categories showed decreasing trend. An increasing in forest cover was seen from 1997 to 1999 due to extensive afforestation. Programme in the 1980s by government and the presence of extensive forest reserve hindering human access in the central part of the upper basin. On the contrary, severe degradation was noticed in the lower basin due to its low lying plain area providing access to human activities.		Land use classification in this study area was achieved and land use pattern map produced	The implication of such land use pattern was not identified. This could be of remarkable importance for studying the VHFs risks. Also the rate of change of pattern was not also addressed.

3	Sharma, P., Deka, D., and Saikia, R. (2011).	Analysis of changing land use pattern and its effect on Umtrew basin, north east India.	The method focuses on land use/land cover change in the river basin ecosystem of north east India. Maps and statistical data was used, for the success of land use land cover. The method adopted here was based on the comparison between the satellite imageries of different years. Satellite imageries of Landsat MSS and IRSICLISS III, were also used to access land use/ land cover change in the study area. Website and satellite imageries of other year were also produced from national remote sensing centre. The down loaded imagery was geometrically corrected using UTM/WGS 84 projection system, others was also corrected by taking Landsat image and topographic sheets as reference or a base for assessing the changes in land use pattern sub pixel image is to image registration accuracy through repeated attempt, subset operation of satellite imageries of all the years was carried out by creating an area of interest (AOI) layer from the vector layer of the basin boundaries, which was digitized from the survey of India topographical sheets at 1: 50,000 scale. After generating subset of all the imageries, supervised classification using parametric rule and maximum likelihood operation was used to access the land use/ land cover change in Umtrew river basin.		Remote sensing and GIS techniques are important tools for measuring land use / land cover.	The methodology is adequate and findings substantiated.

4	Mirkatouli et al. (2015)	Analysis of land use and land cover spatial pattern based on Markov chains modelling.	Proximity to and the amount of agricultural and forestland were used in the analysis and modelling of the land use changes. The probability of the conversion of agricultural and forestland to built-up areas use was modelled using the Markov chain.		The study found out that the employment of LULC change detection methods using satellite imagery and the analytical functions of distance and size in the GIS environment can help determine the process and pattern of significant changes in LULC.	Attention to planning for protective procedures was suggested to slow down the trend in transition of agricultural and forestland to built-up areas or else, it will have adverse effects on the regional environment..
5	Boysen et al (2014)	Global and regional effects of land-use change on climate in 21st century simulations with interactive carbon cycle	The impacts of LULC change on climate and land–atmosphere fluxes of carbon are examined by differencing model simulations with and without LULCC. To distinguish bio geophysical changes (BGP) and biogeochemical changes (BGC) effects, three simulation setups between the years 2006 and 2100 are used.		LULCC leads to carbon release from the land to the atmosphere. Accounting for gross LULCC transitions in both MPI and MIR results in stronger LULCC emissions than in the other two models.	Simple idealized experiments with clear protocols for implementing LULCC in ESMs are needed to increase the understanding of model responses and the statistical significance of results, especially when analysing the regional-scale impacts of LULCC.
6	Santiphop et al. (2012)	An analysis of factors affecting agricultural land use patterns and livelihood strategies of farm households in Kanchanaburi	A survey of 210 households in Kanchanaburi Province of Thailand was used. A stepwise multiple regression technique was used to analyse the factors influencing agricultural land use patterns and livelihoods.		A number of influencing factors of economic, demographic, and physical characteristics. Multiple regression	Further assessment in terms vector habitat could be a pointer to VHFs risks in the study area.

		Province, Thailand			analysis showed that there were three and six significant factors explaining the crop acreage change in upland and lowland households, respectively.	

Table 1b: Summary Of Literature For Urban Land Use Pattern Analysis For Viral Hemorrhagic Fevers

S/No	AUTHOR/YEAR	TITLE	METHODOLOGY	VAR.	FINDINGS AND REC.	REMARK
1	V alle, D, clark J. (2013)	Conservation efforts may increase malaria burden in Brazilian Amazon.	Large malaria data set was collected, satellite imagery, permutation tests, and hierarchical bayesia regression was carried out to show the relationship between malaria risks and land cover pattern.		It was showed that greater forest cover tends to be associated with higher malaria incidence.	The methodology is adequate and findings substantiated.
2	Ahmed, A. (2014)	GIS and remote sensing for malaria risk mapping, Ethiopia.	Malaria data was combined into a decision support system (DSS) using Geographic information system GIS and remote sensing tool, in order to prepare a malaria hazard, vulnerability and at risk map, which give the final output. Malaria risk map.		The resulting malaria hazard map depicts that 19.2%, 30.8%, 25.1%, 16.6% and 8.3% of the District were subjected to very high, high, moderate, low and very low malaria hazard areas respectively	
3	Mccann et al. (2014)	Modelling larval malaria vector habitat	Four landscape variables was used e .g topographic wetness index (TWI), soil		Larval habitats were more likely to be	

		locations using landscape features and cumulative precipitation measures.	type, land use land cover, and distance to stream, and accumulated precipitation to modellarval habitat location with two methods the logistic regression and random forest.		present in locations with a lower slope to contributing area ratio. The probability of larval habitat presenceincreased with increasing accumulated precipitation. The random forest models were more accurate than the logistic regression models, especially when accumulated precipitation was included to account for seasonaldifferences in precipitation.	
4	Tomitope et al. (2016).	A multi-criteria decision analysis approach to assessing malaria risk in Northern South America.	The risk of malaria transmission and vector exposure in north south America was assessed using multi –criteria decision analysis.		As this research will help to give information to public health and also help the decision makers or policy makers give attention to spatial planning of effective vector control measures.	The methodology is adequate and findings substantiated.
5	Dery et al. (2015).	Baseline malaria vector transmission dynamics in communities in Ahafo	Traps were hanged in rooms that were selected from a pool of 1, 100, randomly selected houses. Types of material used in construction of houses		This shows that transmission in Asutifi and tano is high even before the	The methodology is adequate.

		mining area in Ghana.	were recorded and mosquito prevention measures were assessed from occupants.		commencement of mining operation.	
6	Okebe et al. (2014).	A comparative case control study of the determinants of clinical malaria in the Gambia.	This method involves 150 children, with test confirmed malaria infection three health facilities, from outpatient clinics, also cases in Greater Banjul area, the Gambia. Also about one hundred and fifty controls negative for malaria were matched with age and residence. And information was also gotten from long lasting insecticidal nets, occupation, housing, structure, social demographic factor, and human population factor was also considered.		One's incomes play an important role in management of illnesses.	
7	Kudom malar (2015).	Larval ecology of Anopheles coluzzii in cape coast, Ghana: water quality, nature of habitat and implication for larval control.5	In this method larval survey and experimental analysis of the breeding habitats was used, using PCR assay.		Improving basic hygiene and sanitation in the city could make larval control intervention more practical and cost effective.	
8	Messisa et al. (2015).	Global distribution of Crimean congo hemorrhagic fever.	We used an exhaustive database of human CCHF occurrence records and a niche modeling framework to map the global distribution of risk for human CCHF occurrence.		While it is known that CCHFV transmission is limited to Africa, Asia and Europe, definitive global extents and risk patterns within these limits have not been well described.	

9	Kateera et al. (2015).	Malaria, anaemia and under-nutrition: three frequently co-existing conditions among preschool children in rural Rwanda.	A cross sectional house hold survey involving children between the ages of 6-59 months was showed. Data that involve malaria parasiaemia haemoglobin densities, anthropometre demographics, social economic status (SES) and malaria prevention knowledge and practices were collected.		In this study, it was found that malaria transmission prevents children from growing or developing properly.	
10	Wesolowski et al. (2014).	Impact of human mobility on the emergence of dengue epidemics in Pakistan.	Epidemiological model of dengue transmission in travelers, was shown based on mobility data from 40 million mobile phone subscribers and climatic information, was used to predict the geographic spread and timing of epidemics throughout the country.		The difficulty in capturing cross-border travels pattern.	
11	Qi et al. (2013).	The effect of social economic and environmental factors on the incidences of dengue fever in the pearl Rivers delta,china, 2013.	a spline-smooth technique was used and plotted the predicted against the observed co-variable value.		This work improves our understanding of the differences and effects of socioeconomic and environmental factors on DF and supports effectively targeted prevention and control measures.	
12	Kikiti et al. (2015).	Spatial distribution of dengue in a Brazilian urban slum setting: role of social economic gradient in	The association between CTs characteristics and spatial risk of both dengue and non-dengue AFI were associated by poisson log-normal and conditional auto-regressive model		Multivariable CAR regression analysis showed increased dengue risk in CTs with poorer inhabitants (RR:	

		discuss risk.	(CAR)		1.02 for each percent increase in the frequency of families earning_1 times the minimum wage; 95% CI: 1.01-1.04), and decreased risk in CTs located farther from the health unit (RR: 0.87 for each 100 meter increase; 95% CI: 0.80-0.94). The same CTs characteristics were also associated with non-dengue AFI risk.	

4. FINDINGS OF THE REVIEW AND DISCUSSION

The findings from this review are discussed based on the classifications as summarised in the table above. Variable studies exist for different hemorrhagic fevers in different part of the world. This could be attributed to the variations in government response to cases of endemic diseases, cultural differences and the nature of urban life style.

4.1 Urban Land Use Pattern Analysis And VHFs Risks

The use of remote sensing (RS) to provide new insights for epidemiological studies was identified very early (Hopley, 1978) as many diseases have been linked to environmental features. A literature review by Herbreteau et al. (2007) found that RS was often, and increasingly, used to study parasitic diseases (59% of studies) including malaria (16% of studies).

The challenge of studying VHFs is on identifying all the natural factors (such as seasonality, rainfall, temperature, humidity, surface water and vegetation) and anthropogenic elements (such as agriculture, irrigation, deforestation, urbanization and movements of populations) of the study area, and how to link them with either the incidence of disease or the presence of vectors whilst also integrating temporal and spatial variations. This will help to identify the risk factors from the set of possible environmental parameters. One approach is to link VHFs and land cover (LC) and/or land use (LU) characteristics (Curran et al., 2000). Within such a methodological framework, (Ostfeld et al., 2005) suggest that using more explicit landscape approaches to study ecoepidemiological systems could improve the understanding and prediction of the disease risk.

Landscape composition (the number and types of patches) and configuration (the spatial relationships among patches) must be considered alongside the set of highly localized biotic and abiotic features. Within the framework of the study of landscape ecological functions (also referred to as landscape ecology), there are many ways to characterize the landscape, around point samples or LU/LC patches. This raises questions of objectivity, relevance and adequacy when carrying out environmental characterization. Some studies have therefore tried to standardize and evaluate the effectiveness of the characterization methods (Tischendorf et al., 2003; Palaniyandi and Mariappan, 2012) or to objectify them (Stefani et al., 2011). Studies relating LU/LC with VHFs varies in terms of the VHF families and geographical regions.

4.1.1 Urban Land Use Pattern Analysis For Malaria

Several studies discussing urban land use pattern and the risks of malaria fever across the globe have become popular in recent literature. In South America for instance, Olson et al. (2010) studied malaria in Mâncio Lima County, Brazil, in 2006. Adjusting for population, access to care and district size, a 4.3% increase in deforestation between 1997 and 2000 was associated with a 48% increase in malaria risk. Vittor et al. (2006) and Vittor et al. (2009) suggested that deforestation and other human environmental alteration favour the presence of both Anopheles darlingi larvae and adults in the Peruvian Amazon. However, Conn et al. (2002) and Moreno et al. (2007) suggested that human intervention could increase the presence of Anopheles marajoara over Anopheles Darlingi, forest clearance and pollution may be reducing the availability of larval sites for Anopheles darlingi and increase habitats preferred by Anopheles marajoara.

Also, a study on mapping a Knowledge-Based Malaria Hazard Index Related to Landscape Using Remote Sensing has been conducted by Li et al. (2016) in the Cross-Border area between French Guiana and Brazil. A set of normalized landscape-based hazard indices was developed by computing and combining landscape metrics. Through empirical selection of the best index, the index that successfully represents the current knowledge about the role played by landscape patterns in malaria transmission within the study area was identified. In the northern South America, Alimi et al. (2016) and Piovezan et al. (2012) assessed the risk of malaria transmission and vector exposure using multi-criteria decision analysis, just as Piovezan et al. (2012) performed spatial evaluation of Culicidae (Diptera) larvae from different breeding sites in the São Paulo State municipality of Santa Bárbara d' Oeste.

Furthermore, a handful of literature on urban land use pattern analysis for malaria risk over Africa also exists. Kelly-Hope and McKenzie (2009) and Olson et al. (2010) conducted a review of entomological inoculation rate measurements and methods across sub-Saharan Africa; this was to examine the distribution of transmission intensity across the sub-region. Extensive geo-referenced database and geographical information systems was used to highlight transmission patterns, knowledge gaps, trends and changes in methodologies over time, and key differences between land use, population density, climate, and the main mosquito species. Dery et al. (2015) also conducted a baseline malaria vector transmission dynamics in Ghana for assessing impact of mining Land use in relation to future vector control interventions, the study identified areas where intensified vector control activities would be beneficial. Investigating the contribution of agricultural insecticide use to increasing insecticide resistance in African malaria vectors, Reid and McKenzie, (2016) found that higher resistance in mosquito populations across Africa was associated with agricultural insecticide use. This association appears to be affected by crop type, farm pest management strategy and urban development.

Nevertheless, similar efforts over Europe and Asia have revealed that there are relatively few studies (Al-Eryani et al., 2016; Palaniyandi, 2014; Palaniyandi et al., 2014) on urban land use pattern analysis for malaria risks in those regions. This may be due, in part to strong economic growth in many countries of Europe and Asia, and improved housing standards and control programs (Tapia-Conyer et al., 2012), which have reduced vector populations in those regions.

4.1.2 Urban Land Use Pattern Analysis For Dengue

A number of studies have also discussed urban land use pattern and dengue fever risks recently, significant proportion of these literature emerged from Asia and South America, however, few literature exist that cover other continents of the world.

Large volume of extensive literature on the risks, distribution and mapping of the spread of dengue fever in relation to urban land use pattern has been well reported over Asia than any continent of the world (Wesolowski et al., 2015; Qi et al., 2015; Palaniyandi, 2014b; Palaniyandi, 2014a; Koyadun et al., 2012; Dom et al., 2013; Cheah et al., 2014; Arima et al., 2013; Wongkoon et al., 2012). Also, Almeida et al. (2009) studied the spatial analysis of dengue and the socioeconomic context in South eastern Brazil, the study found that problems related to basic sanitation contribute decisively to increase in the risk of the disease. Furthermore, the spatial distribution of risks of dengue fever have been recently studied (Kikuti et al., 2015; Barbosa et al., 2014; Allicock et al., 2012), it was found that lower neighbourhood socioeconomic status was independently associated with increased risk of dengue which suggested that, in slum communities with high levels of absolute poverty, factors associated with the social gradient influence dengue transmission. While identifying poor geographic access to health services as a possible barrier to identifying both dengue and non-dengue cases, further spatial studies that could account for such potential source of bias have been recommended in these studies. Therefore, utilising urban land use metrics in addition to socioeconomics may be a pointer to the desired goal.

4.1.3 Urban Land Use Pattern Analysis For Non-Mosquito Borne VHFs

The non-mosquito borne VHFs include basically, the Arenaviridae (e.g. Lassa fever), Filoviridae (e.g. Ebola and Marburg) and some members of Rhabdovaridae (e.g. rabies) families. Unlike the mosquito-borne VHFs, less attention has been given to the study of non-mosquitoes borne VHFs risk and urban land use pattern analysis. This is evident by the virtually none existence of any specific article in the current literature discussing the land used pattern analysis for families of the non-mosquito borne Hemorrhagic fever risks. However, these families of VHFs present peculiar features as they can cause severe, life-threatening ailments (Ibekwe, 2012; Chowell and Nishiura, 2014; Ibekwe et al., 2011). Typical among them are Ebola and Lassa fevers whose recent outbreaks has posed serious health challenges in the world especially in sub-Sahara Africa. For instance, it has been reported in medical literature that rats are the key vectors of lassa virus (Yun and Walker, 2012). The short incubation period of these diseases, their high infectious characteristics and high mortality rate associated with the spread has led to their classification as high risk health issue (Ibekwe et al., 2011). The challenge therefore, is to determine the link between these diseases and urban land use pattern

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4.2 A Relational Framework for the Prediction of Non-Mosquito Borne VHFs Risks Using Urban Land Use Pattern Analysis

It is obvious that most of the vectors of the non-mosquito borne VHFs (e.g. rats, monkeys, bats etc.) cohabits with man in urban environments, such ecology may be influenced by certain human activities or natural events relating to urban land use. Therefore, the critical questions to be addressed in subsequent studies include:

(i) Is there any relationship between urban land use pattern and non-mosquito borne Hemorrhagic fevers?

(ii) How may this relationship (if it exists) provides leading information for the prediction of VHFs risks?

In order to address these issues and establish the desired relationship, there is the need to first, construct a relational framework. This will help in understanding the relationship between land use characteristics and the incidences of hemorrhagic fevers; Figure 1 depicts the relational framework.

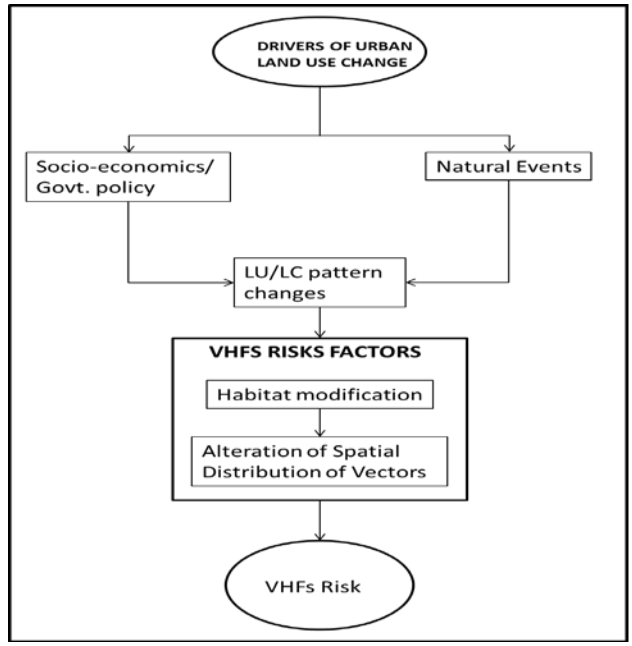

Figure 1: A relationship framework interfacing urban land use pattern changes with the VHFs riskS.

This relational framework as shown in Figure 1 indicates a possible relationship between hemorrhagic fevers and land use change pattern. Since the vectors for non-mosquito VHFs also thrive well in a favourable habitat, modification of such habitats occasioned by land use/land cover change pattern would equally influences the spatial distribution of the vectors. Hence analysis of the urban land use pattern could certainly give indication of the non-mosquito borne VHFs such as Lassa or Ebola fevers. This addresses the questions raised above. Thus, a GIS model can be utilised to analyse the land use change pattern metrics, such a system requires the remotely sensed data (satellite imageries) as input.

5. CONCLUSIONS

This paper has reviewed varieties of studies on urban land use pattern analysis for Hemorrhagic fevers as found in recent literature. Spatial variation of available literature on continental basis was investigated; findings from all the studies suggest that urban land use pattern analysis is crucial for the prediction of VHFs risks. Bulk of the literature dwell on land use pattern analysis for mosquito borne VHFs such as malaria and dengue fevers risks with little or no similar efforts found on non-mosquito borne Hemorrhagic fevers such as Lassa and Ebola fevers risks. Similarly, majority of the available literature on malaria emerged from the Caribbean (particularly, Brazil) followed by sub-Saharan Africa, while Asia has the most studies on dengue Hemorrhagic fevers. A relational framework for investigating the link between urban land use pattern and the non-mosquito borne VHFs has been designed in this paper, this will serve as a guide for the construction of a GIS based model for prediction of the non-mosquito borne VHFs risk factors. This framework can be said to have provided a preliminary answer to the questions raised in Section 4.2.

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