



## Ocean Surge Flood Avoidable Susceptibility Index (FASI) of Victoria Island, Lagos, Nigeria

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### Abstract

Ocean surge causes flooding of coastal areas and creates conditions hazardous to people, properties and certain economic activities. The level of damage depends to a very large extent on the level and presence of infrastructures and people within the hazard prone zone. Some of these infrastructures and consequently human beings need not necessarily be located within the zone; hence some of the susceptibilities are avoidable. Victoria Island, Lagos, is a coastal city that has experienced some severe flooding from ocean surges. Ocean surge Flood Avoidable Susceptibility Index (FASI) of Victoria Island, was computed in this study. FASI is a modification of Tsunami Avoidable Susceptibility Index (TASI). The final FASI is a product of the maximum ocean surge wave height and the points assigned to each of the human use of the hazard zone based on their coastal dependency. The highest contributors of FASI in the area studied are offices, schools and hospitals. The result obtained from this study is useful for reasonable planning and use of similar hazard zone while still keeping the overall hazard within reasonable bounds. This is generally to avoid high casualty levels and high loss of properties, in a case of a serious ocean surge within the region.

**Keywords:** Ocean surge, Flood, Coastal Dependence, Avoidable Susceptibility

### 1.0 Introduction

Coastal flooding and erosion are serious problems along much of Nigeria's coasts, although the frequency and magnitude of flooding and the severity of the erosion vary considerably. This becomes hazardous when there is an interrelationship between the destructive natural event and human use of the environment. Coastal flooding may be difficult to control, but susceptibility to the natural hazard can be reduced by controlling and regulating human activities in the hazardous zones. Storm surges from the Atlantic Ocean have severally flooded streets in Victoria Island.

From observation by the Nigerian Institute for Oceanography and Marine Research, the months of April to June and August to October are known as the peak periods when ocean storm surges occur along Nigerian shoreline. Between three to four major storm surges are experienced annually during these months. Sometimes, the onset of storm surge is a month earlier and or a month later than expected while the cessation period could also be a month later. During such periods, there is a sudden rise in

sea level that result in high plunging waves which top the beach and spill ocean water on to the streets of Ahmadu Bello Way and beyond. Large volumes of water topped the beach and the Kuramo waters, a small lagoon, separated from the ocean by a narrow fifty meters wide strip of beach, was virtually joined to the Atlantic Ocean. Many of the streets and drainage channels were flooded resulting in an abrupt dislocation of socio-economic activities in Victoria and Ikoyi Islands for the period of the flood (Awosika, *et al.*, 2002).

The major function of Ocean surge Flood Avoidable Susceptibility Index (FASI) is to provide a rational for land use in areas that are subject to ocean surge flooding. This is aimed at reducing, as much as possible, all avoidable risks associated with ocean surge flooding.

### 1.1 Victoria Island

Victoria Island is a small island of about 14 square kilometres located in Lagos State of Nigeria. It was once a complete island bordered by the Atlantic Ocean on the south, the mouth of the Lagos Lagoon on the west, the Five Cowrie Creek to the north,

and swamps on the East (Figure 1). Victoria Island continued as a complete island until the swamp to the east of the island was reclaimed to create a land connecting it to Lekki Peninsula. Later, a highway linking the island to Epe was constructed. Although the area was originally designated as an upscale residential area, it is today one of Nigeria's busiest centres of banking and commerce, with most major Nigerian and international corporations headquarters located on the Island (Abomeh *et al.*, 2013).



Figure 1: Victoria Island, Lagos.

By virtue of its geographical location Victoria Island is highly susceptible to ocean storm surge from the Atlantic Ocean.

## 2.0 Study Method

The Tsunami Avoidable Susceptibility Index (TASI) of Morgan, (1984) was modified to determine the Coastal Flooding Avoidable Susceptibility Index of Victoria Island, Nigeria. The hazard from flood is computed based on two factors; (1) the highest wave height in feet that has been recorded in the area, and (2) the extent of human use of the same stretch of coast. A coastal Flooding Avoidable Susceptibility Index (FASI) was then computed by multiplying factor 1 by factor 2. Factor 2 is the sum of a number of sub factors, each related to human use of the hazard zone.

$$FASI = P(H) \quad \dots 1$$

where  $P$  is the physical component and  $H$  is the hu-

man use factor;  $H$  is equal to the sum of the various human uses of the coastal zone. The product of  $P$  and  $H$  determines the FASI and hence the degree of hazard.

### 2.1 The P-factor

Morgan, (1984) defined the P-factor as the height in feet of a tsunami expected to occur once every 100 years. He noted that where data are not sufficient to calculate the height of the 100 year tsunami the value of the highest run-up in the historical record shall be substituted. The height of the ocean surge wave rather than tsunami run-up was considered in this study. Data are not sufficient to calculate an average wave height over a statistically acceptable period. Mehrotra *et al.*, (2009) reported that between August 16 and 17, 1995, a series of violent swells in the form of surges were experienced on the whole of Victoria Island, Lagos. The most devastating of these swells occurred on August 17, 1995. The surge coincided with high tide thus producing waves over 13 ft high flooding large parts of Victoria Island. This is the known maximum wave height recorded in the area and is taken as the P-factor value.

Although inundation distance is affected by the geomorphology of the coastal area, gradient of coastline and nature of the coastal area, wave height remains a major factor that affects the inundation distance. The extent of inundation distance is directly proportional to the wave height and substantial inundation coupled with wave actions result in heavy devastation (Hafeez, 2008).

### 2.2 The H-factor

H-factor is the sum of a great many sub-factors, each of which must be analyzed for its contribution to the flooding hazard. Some activities must be carried out close to the water if they must be carried out at all. Nearness to water is only desirable but not essential for some activities. The location of some activities close to water is completely immaterial. Morgan (1984) put the coastal dependency into five categories from essential to immaterial and assigned values ranging from 5 to 25 for the level of dependency. The same categorization and dependency are used in this study. Five additional FASI contribution points were assigned to high po-

pulation density use and 5 less FASI contribution points were assigned for low density use. The coastal dependency of the sub-factors of H has been categorized and Morgan, (1984) numerical values assigned to them (Table 1). The greater the potential of the sub-factor for loss of life and property the greater the contribution to the FASI. High FASI values are undesirable while low FASI values which are consistent with the rational use of the resources of the coastal zone are desirable.

The major categories of human activities (sub-factors) present in Victoria Island are listed and described according to their coastal dependence. The coastal dependency is translated into a contribution of the activities to the maximum FASI score.

### *i. Offices*

Over five thousand companies are listed as having offices in Victoria Island by the Crested Directory, a directory of businesses in the island. Although many of the offices are housed in high rise buildings, the lower floors still present flooding hazards. The professional categories of these offices include Telecommunications, Oil and Gas, Consultancies, Legal, Construction, Architecture, Education, Security, Medical, Fashion, Media, Arts, Publishing, Accounting, Banking, Investment, Insurance, Religious, Catering, Entertainment, Engineering, Pharmacy, Event Management, Travel/Tourism, Non-Governmental Organization, and so on. Most of these office buildings can be located anywhere within a city and their coastal dependency is immaterial. Hence, it is considered "immaterial" and a H-factor value of 25 assigned to it. An additional

5 points was assigned due to the fact that most office complexes houses a high population of people.

### *ii. Hotels*

About eighty hotels are currently located in Victoria Island alone. In the coastal regions of Nigeria tourism is not the main source of revenue for the people and government and as such siting a hotel along the flood hazard areas is not essential. Hotels in Victoria Island were considered highly desirable because of the need to provide services to the concentration of offices in the area. Additional 5 FASI points have been assigned due to the large number of people that could be in one hotel at a time. The prominent hotels located in Victoria Island are shown in Table 2.

Case could be made for assignment of only a few points to hotels in a coastal area where they are few and less expensive. This cannot be the case in Victoria Island where the hotels are many in number and generally very expensive. The building of hotels in areas within the reach of ocean surges should be discouraged by assigning a high FASI point value.

### *iii. Residential Houses*

A lot of communities are located in coastal areas of Nigeria both in the rural and urban settings. Since houses are associated with people the hazard to human life is also increased. It is certainly not essential that houses be located near the water, but it is desirable in some cases. A view of the water increases the property value of houses. Locating houses in the Nigerian coastal region is considered "beneficial". The density of residential houses in Vic-

Table 1: FASIH Sub-factors of Victoria Island, Lagos

H-Factor	Coastal Dependency	Score*	Additional Contribution**	H-factor Contribution	P-factor	FASI = P(H)
Offices	Immaterial	25	+5	30	13	390
Hotels	Highly desirable	10	+5	15	13	195
Residential Houses	Beneficial	20	-	20	13	260
School	Immaterial	25	+5	30	13	390
Hospitals	Immaterial	25	+5	30	13	390
Total						1625

\*Essential =5, highly desirable =10, Desirable =15, Beneficial =20, Immaterial =25. \*\*Additional contribution: High density use = +5, Low density use = -5. No values are added or subtracted where the sub-factor is not particularly a high or low density use.

toria Island is not considered high and no additional FASI points were assigned.

Table 2: Selected Hotels Located in Victoria Island, Lagos.

S/N	Hotel	UTM (31N)	
		Easting	Northing
1	Eko Hotels and Suites	546461.4m	710862.7m
2	Moonway Hotels	538343.7m	730218.4m
3	Protea Hotel	546137.9m	711912.6m
4	Protea Hotel	545735.0m	714255.2m
5	Radisson Blu Anchorage Hotel	545908.9m	710495.7m
6	S & S Hotel and Suites	548486.3m	710842.1m
7	The Blowfish Hotel	545908.9m	710495.7m
8	The Federal Palace	546461.4m	710862.7m
9	Victoria Crown Plaza Hotel	546138.3m	711511.8m

**iv. Schools**

Schools should not be permitted in high flood risk zones and their location in such zones is considered “immaterial”. Schools are high population density use institutions and an additional 5 FASI points have been added based on this. There are more than twenty school in Victoria Island. Some highly populated schools located in Victoria Island are shown in Table 3.

**v. Hospital**

Hospitals are essential anywhere they are located but their use is not in any way coastal dependent. A lot of caution must be exercised in locating a hospital in a hazard prone area. There are some notable hospitals located in Victoria Island (Table 4). Evacuating patients from hazard scene requires some specialized procedure and skill and could be challenging. Additional 5 points have been added to account for the high density of hospitals.

**3.0 Results**

FASI values are not comparable to TASI value because the 100 year tsunami run-up (P-factor) is much greater than the ocean surge wave heights. A FASI value of 1625 contributed by only five H sub-factors reflects the presence in a coastal area of activities that have little or no coastal dependency. If these five H sub-factors were all essential to the coast, the maximum FASI value would have been

Table 3: Selected Schools in Victoria Island, Lagos

S/N	School	UTM (31N)	
		Easting	Northing
1	Air Force Primary School	545314.5m	711037.5m
2	America International School	548042.7m	711694.9m
3	Buttercups School	549442.5m	710960.8m
4	Corona School	545746.1m	711315.9m
5	Crescent School	547976.2m	711737.3m
6	Kuramo Primary School	547431.5m	710492.3
7	Pan-African University	547316.6m	711666.0m
8	The Nigerian Law School	547259.5m	711831.0m
9	Victoria Island Nursery and Primary School	548531.5m	711563.4m
10	Whiteoak Preparatory School	549328.9m	710611.8m

Table 4: Selected Hospitals in Victoria Island, Lagos

S/N	Hospital	UTM (31N)	
		Easting	Northing
1	Ave Maria Hospital	547597.0m	711152.4m
2	Kelu Specialist Hospital	548570.1m	710912.8m
3	Lagoon Hospital	545645.2m	710441.3m
4	Paelon Memorial	546102.2m	711137.0m
5	Reddington Hospital	546460.8m	711139.7m
6	Vantage Medical Centre	548498.5m	711365.3m

165. The additional 1460 FASI contribution is an indication of the amount of avoidable flooding risk that has been built into Victoria Island by improper land use. The primary virtue of the FASI is that it provides a logical methodology for rational planning of land use in areas that are subject to flooding. The use of FASI allows reasonable use of the hazard zone while still keeping the overall hazard within reasonable bounds. There is no single value of the FASI which must not be exceeded. Each governmental organization and country can set its own standards, but the flood prone areas must not become excessively hazardous by the addition of structures.

**4.0 Conclusion**

Victoria Island has a high FASI value which implies that any major flooding of the area will result in high level of avoidable losses. Further infrastructural development of Victoria Island should exclude infra-

structures that do not have coastal dependency. The Nigerian government can use the knowledge of FASI in planning and decision making in other coastal areas of the country. This is generally to avoid high casualty levels and high loss of properties, in a case of a flooding within the region.

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