

**The Global Land Project Nodal Office on Integration
and Modelling Workshop
Data and Model Integration for coupled Models of land
use Change**

**Integrating Urban Land use Dynamics and
Precipitation for Flood Analysis in Lagos
(Collecting Data for Modelling)**

By

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Holding From 17th to 19th July, 2008

At

The Burn House, Glenesk, Aberdeenshire,
Scotland.

Introduction

- **Land use:** The use to which the land has been put.
- It expresses man activities within an area, which are not directly visible on imagery but appreciate only through the physical artefacts of the use of the land
- **Land cover:** Refers to the concrete land attributes of an area that can be directly observed and identified on the imagery.
- The change in the land from one use or its cover to another use is refer to as land use land cover change.
- Information on land use and land cover forms the basis from which past and present human interaction and their impact on natural resources and the environment can be understood.
- Land use change data and models are needed for planning and decision making especially for areas under severe pressure from unplanned development, sprawl and others affected by environmental changes.

Sources of land use / Cover data for coupled models of land use change

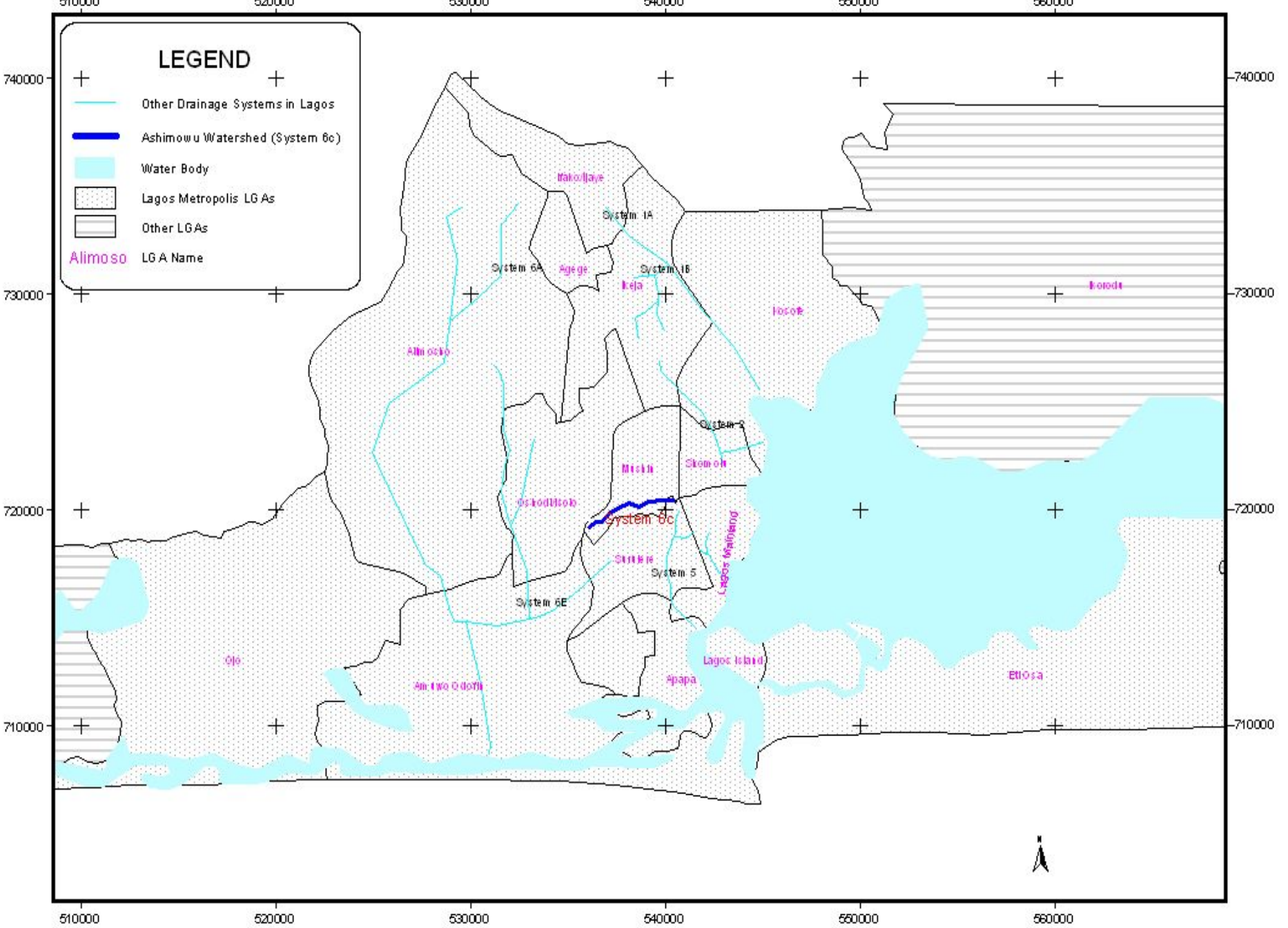
- **Satellite Imageries** (Characteristics: Spatial, Temporal and Spectral)
- **Aerial Photographs** (Characteristics known for existing aerial photos but could be re-acquire for specific large capital intensive projects, e.g, the on-going 7 modules GIS land use data acquisition using aerial photos by Lagos State Government in Nigeria)
- **Maps** (Known Characteristics).
- **Field Surveys** (for spatial and non spatial) and.
- **Others sources** e.g Library, Governmental organisations etc

Collecting data for coupled models of land use change (Key Issues)

- Purpose:
- Level of Analysis: (Micro, Meso and Macro),
- Scale: Consistence during extraction and MMUs capable of integrating and overlaying multi-scale and multi-sources data.
- Data Quality (spatial and non spatial).
- Data Characteristics: (spatial, spectral etc).
- Available resources (finance, time, manpower etc)

Data and Model Integration for coupled Models of land use Change for Urban Flood Analysis: The Lagos Experience

- In Lagos megacity, the need to meet infrastructural developments has resulted in policy change in land use.
- Violation of planning regulations.
- Indiscriminate use of wetland
- Encroachments into floodplain



Metropolitan Lagos

Purpose

- This research focused on modelling hydrological fluxes response to urban land use change in Lagos megacity.
- Two major drivers were investigated (The land use (urbanization) and precipitation drivers)

Collecting data for land use scenario

Table 1: Spatial Data Characteristics

Data Type	Date	Resolution (Meter)	Scale	Identification	Acquisition Source
Aerial Photograph	1965		1:40,000	CN70\RUN 3\71-76	Federal Survey
Aerial Photograph	1975		1:20,000	Line7\75288\206-209	Federal Survey Dept
Aerial Photograph	1987		1:4000	L31\87692\104-117 L32E\87701\39-50	Federal Survey Dept
Topographic Map	1985		1:25000	Ilaro Sheet 279 SE.3	Lagos State Survey Dept
Ikonos Imagery	2003	1 meter		Surulere / Mshin(Lagos)	Geo. Dept, UNILAG

Table 2: Hierarchical Urban hydrological land use classification scheme for flood simulation.

CODE	PRIMARY LEVEL	CODE	SECONDARY LEVEL
1	BUILT-UP AREA	11	Roof cover Land Spaces
2	TRANSPORTATION	21	Tarred road/ Car park
		22	Untarred road / Car park and Rail tract
3	AGRICULTURE	31	Croplands/Pasture/ Orchards, Nurseries, Vineyards and Horticulture.
4	VEGETATIVE LAND	41	Mixed vegetation
		42	Grassland/ Garden and Lawns
		43	Riparian forest
5	WATER BODY	51	Streams / Canals
		52	Open concretized drainage
		53	Closed concretized drainage
		54	Unconcretized drainage
		55	Lagoon, Lake, Creeks, and open seas.
6	OPEN / BARE SURFACES	61	Strip mines, Quarries, Gravels pits and Dump site
		62	Open sandy area
		63	Concretized open space
		64	Unconcretized open space
7	WETLAND	71	Swamp/ Mash Lands
		72	Open wetland

Land use scenario data extraction: Scale and Minimum Mapping Units MMUs

Scale:

- Constant scales of 1:5000, 1:5000, 1:2500 and 1:1500 were maintained during the mapping exercise for 1965, 1975, 1987 and 2003 scenarios respectively

MMUs

- 1965: 1mm x 1mm MMUs (representing 0.16 hectare on the ground)
- 1975: 2mm x 2mm MMUs (representing 0.16 hectare on the ground)
- 1987: 10mm x 10mm MMUs representing 0.16 hectare on the ground).
- 2003: 16mm x 16mm MMUs representing 0.16 hectare on the ground).



Key Issue in Classification, Scale and MMUs for this research is Capability to identify hydrological significant land uses within an urban setting

Ikonos Image showing continuous developments in Lagos Megacity.

Collecting data for precipitation drivers

- Rainfall Characteristics with special emphasis on intensity.
- Variability (spatio-temporal).
- Eleven storm rainfall events were monitored between August 2005 and November 2005.

Precipitation Water Inundation Model (PWIM)

- PWIM is land system model that synthesis hydrological processes on digitally generated urban surface characteristics.
- It has four major components which include: Rainfall-Runoff Model, Infiltration, Digital Surface and Stochastic.
- Simulation of runoff, peak flow and area inundated arising from the precipitation driver on Land use scenarios (1965, 1975, 1987 and 2003) was achieved using PWIM.
- Future runoff, peak flow and area inundated were generated for four climate scenario; low, medium-low, medium-high and high for 25 years, 50 years and 100 years scenario.

Table 3: The multiplying factor for precipitation driver

Scenario	Year					
	25		50		100	
	Amount	Intensity	Amount	Intensity	Amount	Intensity
High	5	10	7.5	15	10	20
Medium High	2.5	5	5	10	7.5	15
Medium Low	0	2.5	2.5	5	5	10
Low	0	0	0	2.5	2.5	5

Table 4: The multiplying factor for Urbanization driver:

Scenario	Year		
	25	50	100
High	0.01	0.05	0.1
Medium High	0.002	0.01	0.05
Medium Low	0.001	0.002	0.01
Low	0.0	0.001	0.002

Results & Discussion: Land use / Land cover Scenarios

Table 5: Static LU/LC distribution for 1965, 1975, 1987 and 2003.

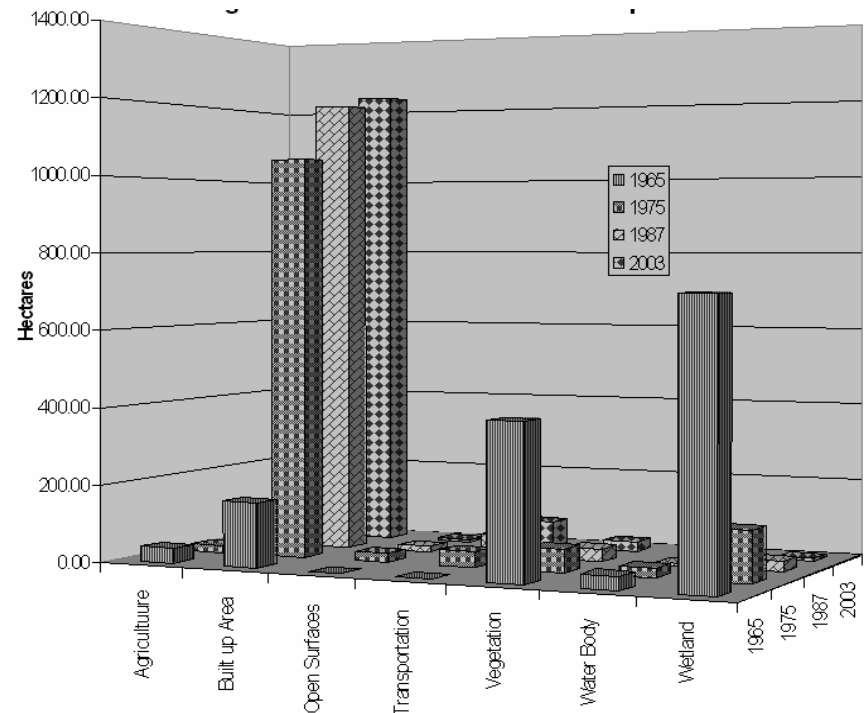
	1965		1975		1987		2003	
General Landuse	Area in Hectares	% of total	Area in Hectares	% of total	Area in Hectares	% of total	Area in Hectares	% of total
Agricultuure	38.09	2.83	18.57	1.38	10.90	0.81	3.86	0.29
Built up Area	166.88	12.40	1045.54	77.69	1195.99	88.87	1231.00	91.46
Open Surfaces			23.15	1.72	14.94	1.11	6.03	0.46
Transportation			40.78	3.03	55.04	4.09	66.70	4.96
Vegetation	396.60	29.47	60.02	4.46	33.24	2.47	24.93	1.85
Water Body	35.26	2.62	25.84	1.92	6.86	0.51	6.16	0.46
Wetland	708.96	52.68	131.89	9.80	28.80	2.14	7.10	0.53
Total	1345.78	100.00	1345.78	100.00	1345.78	100.00	1345.77	100.00

Table 6: Annual rate of Change (Hectare)

	1965-1975	1965-1987	1965-2003
Agricultuure	-1.951381	-1.23567073	-0.900673
Built up Area	87.8659762	46.77808936	28.003244
Open bare surfaces	2.3147416	0.679007182	0.1586842
Transportation	4.0777134	2.501927364	1.7552632
Vegetation	-33.6579578	-16.5163909	-9.780825
Water Body	-0.942046	-1.29072536	-0.765775
Wetland	-57.7070464	-30.9162369	-18.46992

■ The greatest loss was on the wetland between 1965 and 1975 with annual loss of 57.71 ha per annum.

■ The trend shows that while other major land use were recording negative indicating loss, built up area was recording positive indicating gain.



Results and Discussions

Date	Amount (mm)	Duration (Min)	Average Intensity/hr	PWIM Runoff (mm)	PWIM Peak Flow (m ³ s ⁻¹)	PWIM Area inundation (ha)
22/08/05	4.75	465	0.61	63.317	236.79	178.2426
28/08/05	9.75	120	2.6	34.658	129.58	185.526
1/9/2005	9.25	225	4.63	123.30	461.01	192.9558
7/9/2005	1.25	165	0.45	16.662	62.299	177.657
8/9/2005	2.25	15	9	29.992	112.14	208.95
20/09/05	6.5	30	13	86.645	323.96	223.59
24/09/05	4.75	150	1.9	63.317	236.74	182.964
27/09/05	7.5	180	2.5	99.975	373.80	185.16
4/10/2005	2.25	45	3	29.992	112.14	186.99
11/10/2005	1.8	75	1.8	23.994	89.711	182.598
3/11/2005	16.48	30	32.96	219.678	821.35	296.6436
Maximum	16.48	465	32.96	Table 7: PWIM simulated Runoff, Peak flow and Area inundation for 2003 base year		
Minimum	1.25	15	0.45			
Mean	6.05	136.36	6.59			
S/D	4.35	129.81	9.1			
CV(%)	71.9	96.20	138.09			

Table 8: Land use scenario and hydrological fluxes

Period	% increments in runoff and peak flow	% increase in Imperviousness (land use change)
1965-1975	87.47	68.32
1975-1987	10.19	10.24
1987-2003	3	5.46

$$r = 0.96, r^2 = 0.92$$

Table 9: PWIM simulated flood parameters for 25 years

Medium High Climate Change

Date	PWIM RUNOFF mm	PWIM PEAK m3/s	PWIM Area inundation (ha)
22/08/05	71.606	267.728	182.541
28/08/05	39.195	146.546	189.589
01/09/05	139.444	521.366	196.780
07/09/05	18.844	70.455	181.974
08/09/05	33.919	126.818	212.258
20/09/05	97.988	366.365	226.426
24/09/05	71.606	267.728	187.110
27/09/05	113.063	422.729	189.235
04/10/05	33.919	126.818	191.006
11/10/05	27.135	101.455	186.755
03/11/05	248.436	928.876	297.124

Runoff and peak flow increased by an average of 13.10% while area inundated increased by 1.80 %

Table 10: PWIM simulated flood parameters for 25 years
High Climate Change

Date	PWIM RUNOFF mm	PWIM PEAK m ³ /s	PWIM Area inundation (ha)
22/08/05	73.490	274.772	182.608
28/08/05	40.226	150.401	190.078
01/09/05	143.113	535.083	197.698
07/09/05	19.339	72.308	182.007
08/09/05	34.811	130.155	214.102
20/09/05	100.566	376.004	229.117
24/09/05	73.490	274.772	187.450
27/09/05	116.037	433.851	189.702
04/10/05	34.811	130.155	191.579
11/10/05	27.849	104.124	187.075
03/11/05	254.973	953.315	304.042

Average increment of 16.1% for runoff and peak flow while area inundation increased by 2.46%.

Table 11: PWIM simulated flood parameters for 50 years High Climate

Change

Date	PWIM RUNOFF mm	PWIM PEAK m ³ /s	PWIM Area inundation (ha)
22/08/05	75.803	283.419	191.519
28/08/05	41.492	155.135	199.355
01/09/05	147.616	551.922	207.348
07/09/05	19.948	74.584	190.889
08/09/05	35.907	134.251	224.555
20/09/05	103.730	387.837	240.306
24/09/05	75.803	283.419	196.598
27/09/05	119.689	447.504	198.961
04/10/05	35.907	134.251	200.930
11/10/05	28.725	107.401	196.205
03/11/05	262.997	983.316	318.900

Runoff and peak flow increased by an average of 19.72%. This reveals an additional marginal increment of 3.6% when compared with 25 years high climate change. PWIM area inundation increased by 7.46%.

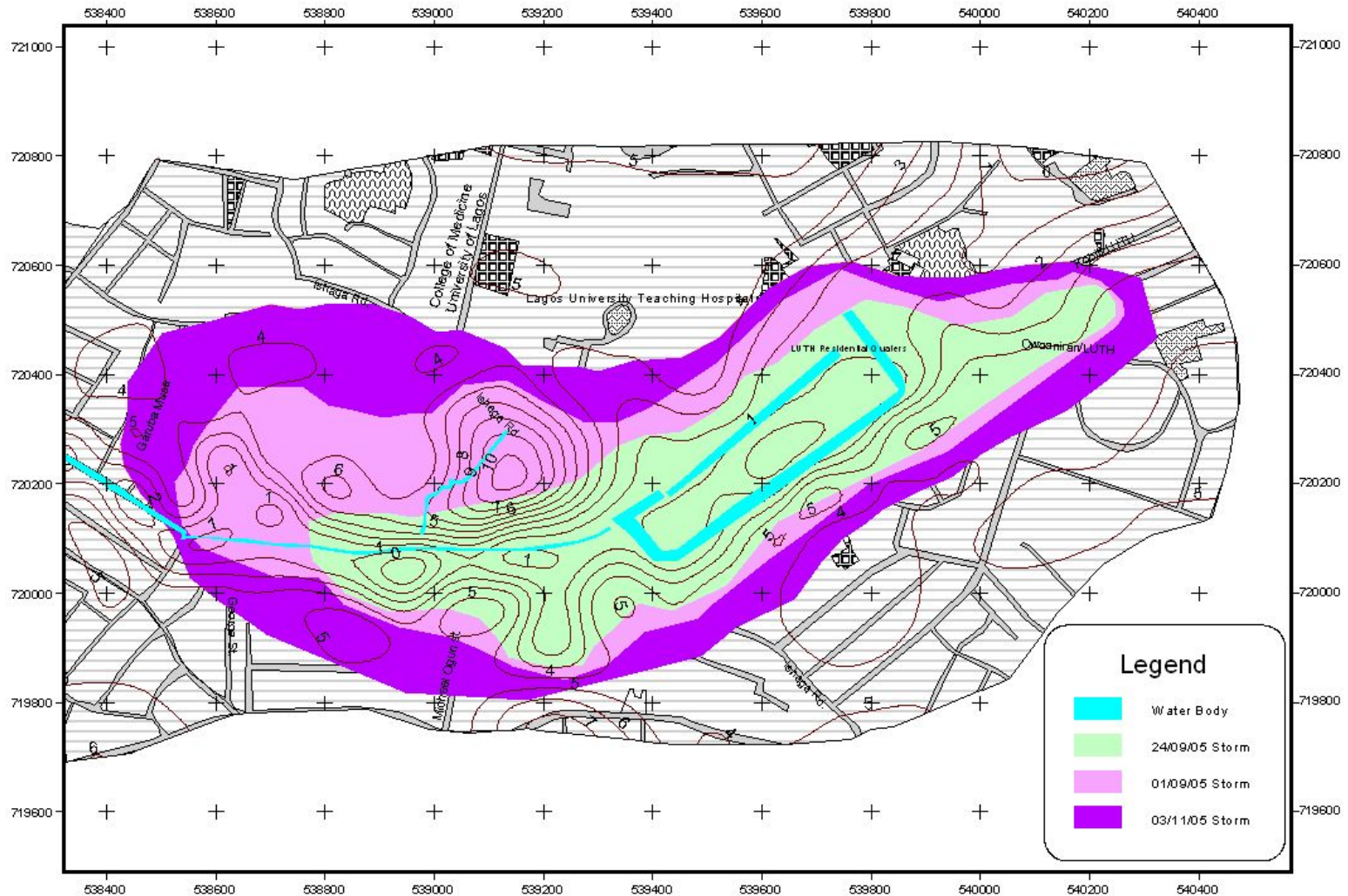
Table 12: PWIM simulated flood parameters for 100 years

High Climate Change

Date	PWIM RUNOFF mm	PWIM PEAK m ³ /s	PWIM Area inundation (ha)
22/08/05	78.344	292.918	195.972
28/08/05	42.883	160.334	203.989
01/09/05	152.564	570.419	212.168
07/09/05	20.617	77.083	195.327
08/09/05	37.110	138.750	229.773
20/09/05	107.207	400.835	245.888
24/09/05	78.344	292.918	201.169
27/09/05	123.700	462.502	203.586
04/10/05	37.110	138.750	205.601
11/10/05	29.688	111.000	200.766
03/11/05	271.811	1016.272	326.302

Runoff and peak flow increase by an average of 23.73% while area inundation increased by 9.96%. This reveals an additional marginal increment of 4% each in runoff and peak flow when compared with 50 years high climate change and 2.50% for PWIM area inundation.

Fig 2: PWIM 100 years projected high climate change area inundation of Ashimowu watershed for (3/11/05, 1/09/05 and 24/09/05) storms



Conclusion

- The modelling of the land use dynamic coupled with precipitation drivers reveal that urban flooding phenomenon in greater Lagos will be more severe and noticeable in the next 20 to 30 years.
- With respect to sustainability, the pressure on land is already threatening the right to adequate housing and good living conditions.

Recommendations

- Data issues for land use change couple modelling should be problem and project (PP) specific.
- GLP should encourage the use of integrated Models of land use Change amongst decision makers and for design purposes.
- Intervention strategies on global environmental change should always incorporate the issue of land use land cover change.

Acknowledgement

I express my profound appreciation to The Global land project Nodal Office on Integration and Modelling and the Macaulay Institute for the support provided, for me to be part of this workshop.

Thank you all