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**HYBRID APPROACH ON MULTI- SPATIOTEMPORAL DATA
FRAMEWORK TOWARDS ANALYSIS OF LONG-LEAD
UPSTREAM FLOOD: A CASE OF NIGER STATE, NIGERIA**



AHMED BABALAJI NDANUSA

UUM
Universiti Utara Malaysia

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Awang Had Salleh
Graduate School
of Arts And Sciences

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Prof. Dr. Huda Hj. Ibrahim

Tandatangan
(*Signature*)

Nama Penyelia/Penyelia-penyelia:
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Prof. Dr. Zulkhairi Md Dahalin

Tandatangan
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Dr. Azman Ta'a

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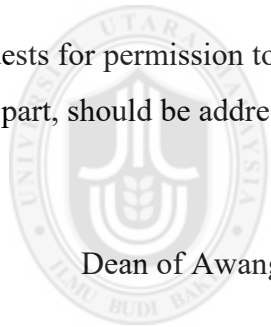
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Abstrak

Banjir telah menjadi kebimbangan yang serius di seluruh dunia kerana menyebabkan malapetaka kepada ekonomi dan ekologi. Oleh itu, strategi pengurangan risiko banjir digunakan untuk mengurangkan kesan yang berkaitan dengan banjir dengan mengenalpasti kejadiannya secara jangka panjang. Pelbagai faktor penyebab termasuk penggunaan kerangka data hibrid pelbagai ruang-masa dipertimbangkan dalam melaksanakan strategi tersebut. Selain faktor struktur atau bukan struktur homogen, penggunaan pelbagai alat berasaskan Sistem Maklumat juga diperlukan untuk menganalisis faktor penyebab semula jadi dengan tepat. Pada asasnya, strategi ini diperlukan untuk mengatasi pengelasan kerentanan banjir yang tidak tepat dan meramal kejadian banjir dalam jangka masa pendek. Oleh itu, kajian ini mencadangkan satu rangka kerja yang dinamakan: Rangka Kerja Data Hibrid Pelbagai Ruang-Masa Analisis Banjir Huluhan Jangka Panjang (HyM-SLUFA) untuk menyediakan dimensi baru mengenai kajian kerentanan banjir dengan mendedahkan pengaruh beberapa faktor yang diperolehi dari topografi, hidrologi, tumbuh-tumbuhan dan pemendakan terhadap pengelasan kelemahan banjir serantau dan analisis banjir jangka panjang. Dalam membangunkan cadangan rangka kerja, imej ruang diperbetulkan secara geometri dan radiometrik berbantuan Sistem Maklumat Geografi Kuantum (QGIS). Data temporal dibersihkan melalui kaedah *winsorization* dengan menggunakan perisian statistik STATA. Segmen rangka kerja hibrid mengklasifikasi kelemahan banjir dan membuat analisis jangka panjang. Pengelasan dan analisis dijalankan dengan menggunakan imej ruang yang diperbetulkan untuk memperolehi pemahaman yang lebih baik mengenai hubungan antara hujan dengan ciri yang diekstrak terhadap peningkatan kejadian banjir serta menghasilkan pelbagai kerentanan banjir serantau di kawasan kajian. Di samping itu, dengan bantuan teknik regresi, pemendakan dan paras air digunakan untuk membuat analisis banjir jangka panjang bagi mengenalpasti potensi kejadian banjir supaya langkah penyelesaian proaktif dapat diambil. Untuk memastikan kebolehpercayaan dan kesahan rangka kerja yang dicadangkan, satu penilaian ketepatan telah dijalankan ke atas hasil data. Kajian ini mendapati pengaruh Faktor Penyebab Banjir (FCFs) yang digunakan dalam rangka kerja HyM-SLUFA, dengan mendedahkan ketaksamaan jurang ruang menunjukkan bahawa cerun rantau mempengaruhi tahap kerentanan banjir adalah lebih tepat berbanding dengan FCF yang lain, yang secara umumnya menyebabkan banjir huluhan yang teruk apabila terdapat jumlah mendakan rendah di kawasan yang mempunyai tahap cerun yang rendah. Secara teorinya, HyM-SLUFA akan berfungsi sebagai panduan yang boleh digunakan atau disesuaikan untuk kajian yang serupa. Terutama, dengan mempertimbangkan gaya pemendakan dan klasifikasi kerentanan banjir yang ditentukan oleh pelbagai FCFs. Klasifikasi ini akan menentukan jenis polisi yang akan dilaksanakan dalam perancangan bandar, dan jumlah pengurangan kerentanan banjir dapat memberikan pandangan pada masa depan mengenai sebarang kejadian banjir agar tindakan penyelesaian proaktif yang praktikal dapat diambil oleh pihak berkuasa tempatan.

Kata kunci: Analitik data raya, Analisis alam sekitar, Kerentanan banjir, Sistem Maklumat Geografi (GIS), Sistem Maklumat.

Abstract

Floods have become a global concern because of the vast economic and ecological havoc that ensue. Thus, a flood risk mitigation strategy is used to reduce flood-related consequences by a long-lead identification of its occurrence. A wide range of causative factors, including the adoption of hybrid multi-spatiotemporal data framework is considered in implementing the strategy. Besides the structural or homogenous non-structural factors, the adoption of various Information Systems-based tools are also required to accurately analyse the multiple natural causative factors. Essentially, this was needed to address the inaccurate flood vulnerability classifications and short time of flood prediction. Thus, this study proposes a framework named: Hybrid Multi-spatiotemporal data Framework for Long-lead Upstream Flood Analysis (HyM-SLUFA) to provide a new dimension on flood vulnerability studies by uncovering the influence of multiple factors derived from topography, hydrology, vegetal and precipitation features towards regional flood vulnerability classification and long-lead analysis. In developing the proposed framework, the spatial images were geometrically and radiometrically corrected with the aid of Quantum Geographic Information System (QGIS). The temporal data were cleaned by means of winsorization methods using STATA statistical tool. The hybrid segment of the framework classifies flood vulnerability and performs long-lead analysis. The classification and analysis were conducted using the corrected spatial images to acquire better understanding on the interaction between the extracted features and rainfall in inducing flood as well as producing various regional flood vulnerabilities within the study area. Additionally, with the aid of regression technique, precipitation and water level data were used to perform long-lead flood analysis to provide a foresight of any potential flooding event in order to take proactive measures. As to confirm the reliability and validity of the proposed framework, an accuracy assessment was conducted on the outputs of the data. This study found the influence of various Flood Causative Factors (FCFs) used in the developed HyM-SLUFA framework, by revealing the spatial disparity indicating that the slope of a region shows a more accurate level of flood vulnerability compared to other FCFs, which generally causes severe upstream floods when there is low volume of precipitation within regions of low slope degree. Theoretically, the HyM-SLUFA will serve as a guide that can be adopted or adapted for similar studies. Especially, by considering the trend of precipitation and the pattern of flood vulnerability classifications depicted by various FCFs. These classifications will determine the kind(s) of policies that will be implemented in town planning, and the Flood Inducible Precipitation Volumes can provide a foresight of any potential flooding event in order to take practical proactive measures by the local authority.

Keywords: Big data analytics, Environmental analysis, Flood vulnerability, GIS, Information systems.

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List of Abbreviations

Acronyms	Abbreviations
AHP	Analytical Hierarchy Process
CAR	Centre for Atmospheric Research
CRED	Centre for Research on the Epidemiology of Disasters
CSTD	Centre For Satellite Technology Development
DEM	Digital Elevation Model
DMC.	Disaster Monitoring Constellation
DMSG	Disaster Management Support Group
DN	Digital Number
EKF	Extended Kalman Filter
EM-DAT	Emergency Events Database
EO	Earth Observation
EOSDIS	Earth Observing System Data and Information System
ESRI	Environmental Systems Research Institute
FCFs	Flood Causative Factors
FIPV	Flood Inducible Precipitation Volume
GIS	Geographical Information Systems
HyM- SLUFA	Hybrid Multi-spatiotemporal data framework for Long-lead Upstream Flood Analysis

ICT	Information and Communication Technology
LiDAR	Laser Detection and Range
MODIS	Moderate Resolution Imaging Spectroradiometer
NASA	National Aeronautics and Space Administration
NASRDA	National Space Research and Development Agency
NDVI	Normalized Difference Vegetation Index
NEMA	National Emergency Management Agency
NIHSA	Nigeria Hydrological Services Agency
NNARX	Neural Network Autoregressive Model with Exogenous
NSEMA	Niger State Emergency Management Agency
OGC	Open Geospatial Consortium
P.R.O	Public Relation Officer
QGIS	Quantum Geographic Information System
RS	Remote Sensing
SSTL	Surrey Satellite Technology Limited
SVMs	Support Vector Machine
TM	Thematic Mapper
TOA	Top of the Atmosphere
TRMM	Tropical Rainfall Measuring Mission
TWI	Topographic Wetness Index
UNISDR	United Nations International Strategy for Disaster Reduction (

CHAPTER ONE

INTRODUCTION

1.1 Introduction

This chapter presents an overview and synopsis of this research, starting with the background information and the motivation for conducting the research in section 1.2. Section 1.3 focuses on the problem statement which captures the challenges regarding flood mitigation strategies. Also, the chapter outlines the research questions and the corresponding objectives in sections 1.4 and 1.5 respectively. The scope of the research is highlighted in section 1.6, while section 1.7 concisely presents the significance of the research. The structure of the thesis is provided in section 1.8. This chapter concludes by presenting a chapter summary in section 1.9, while the frequently used terms are contextually defined in section 1.10.

1.2 Background and Motivation of the Study

Flooding has become a serious issue in several parts of the world and will relentlessly affect the way in which cities grow [1]. Adversely, the current climate change has triggered major changes in rainfall pattern which in turn, has increased flood vulnerability in several regions[2],[3]. As a result, flood-related disasters will correspondingly continue to occur in the future – one can never achieve complete safety [4]. Yet, flood vulnerability can be seriously alleviated if an appropriate means of mitigation or preparedness is developed [4].

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APPENDICES

Appendix A: Copyright Permission

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No problem to use some of our products based on EM-DAT until you put the full citation : "EM-DAT: The Emergency Events Database – Université catholique de Louvain (UCL) – CRED, D. Guha-Sapir – www.emdat.be, Brussels, Belgium” and the complete reference for the graph taken from ‘2015-Disasters in Numbers’ report.

Best regards,

Pascaline Wallemacq
Geographer at CRED – EMDAT
30, Clos Chapelle-aux-Champs - B.1.30.15
1200 Brussels - Belgium
Tel : +32-2-764-33-66

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Your consideration shall greatly be appreciated and acknowledged.

Best regards

Ahmed Ndanusa

Appendix B: Sample of Temporal Data

Date	Temperature	Precipitation	Water Level
1/1/2015	19.29	0	0.226
1/2/2015	18.91	0	0.280
1/3/2015	18.14	0	0.176
1/4/2015	17.67	0	0.144
1/5/2015	17.33	0	0.136
1/6/2015	17.83	0	0.175
1/7/2015	17.84	0	0.208
1/8/2015	18.47	0	0.196
1/9/2015	17.98	0	0.146
1/10/2015	17.4	0	0.180
1/11/2015	17.18	0	0.149
1/12/2015	16.91	0	0.129
1/13/2015	17.5	0	0.150
1/14/2015	18.77	0	0.148
1/15/2015	19.31	0	0.143
1/16/2015	19.95	0	0.139
1/17/2015	21.03	0	0.142
1/18/2015	21.1	0	0.157
1/19/2015	22.02	0	0.146
1/20/2015	21.07	0	0.275
1/21/2015	20.8	0	0.313
1/22/2015	21.08	0	0.258
1/23/2015	21.55	0	0.176
1/24/2015	21.49	0	0.160
1/25/2015	21.55	0	0.236
1/26/2015	21	0	0.327
1/27/2015	21.25	0	0.372
1/28/2015	21.1	0	0.250
1/29/2015	20.52	0	0.261
1/30/2015	20.93	0	0.421
1/31/2015	21.07	0	0.455
2/1/2015	21.57	0	0.337
2/2/2015	21.57	0	0.267
2/3/2015	21.57	0	0.264
2/4/2015	22.52	0	0.390
2/5/2015	23.09	0	0.327
2/6/2015	22.48	0	0.309

2/7/2015	23.21	0	0.321
2/8/2015	22.11	0	0.322
2/9/2015	22.71	0	0.271
2/10/2015	23.07	0	0.356
2/11/2015	21.69	0	0.463
2/12/2015	21.24	0	0.222
2/13/2015	21.3	0	0.318
2/14/2015	21.45	0	0.285
2/15/2015	22.7	0	0.315
2/16/2015	22.78	0	0.367
2/17/2015	22.86	0	0.351
2/18/2015	24.21	0	0.472
2/19/2015	21.31	0	0.448
2/20/2015	23.54	0	0.413
2/21/2015	23.04	0	0.367
2/22/2015	20.81	0.405	0.356
2/23/2015	20.59	0	0.202
2/24/2015	21.86	0	0.235
2/25/2015	22.26	0	0.314
2/26/2015	21.19	0	0.257
2/27/2015	20.59	0	0.226
2/28/2015	20.95	0	0.348
3/1/2015	21.47	0	0.477
3/2/2015	21.48	0	0.250
3/3/2015	20.95	0	0.226
3/4/2015	20.82	0	0.394
3/5/2015	21.33	0	0.236
3/6/2015	22.26	0	0.195
3/7/2015	22.17	0	0.249
3/8/2015	23.33	0	0.289
3/9/2015	22.78	0	0.350
3/10/2015	22.42	0	0.308
3/11/2015	23.65	0	0.347
3/12/2015	21.66	0	0.355
3/13/2015	21.86	0	0.317
3/14/2015	21.84	0	0.293
3/15/2015	22.39	0	0.328
3/16/2015	24.28	0	0.284
3/17/2015	21.74	0	0.283
3/18/2015	23.54	0	0.367
3/19/2015	24.78	0	0.353

3/20/2015	24.56	0	0.395
3/21/2015	23.57	0	0.402
3/22/2015	23.46	0	0.431
3/23/2015	26.19	0	0.388
3/24/2015	24.93	2.4075	0.946
3/25/2015	26.18	0.045	0.145
3/26/2015	29.8	0.0225	0.401
3/27/2015	33.63	0	0.096
3/28/2015	32.25	0	0.044
3/29/2015	34.73	0	0.057
3/30/2015	37.28	0	0.046
3/31/2015	30.34	0.0225	0.115
4/1/2015	38.46	0	1.230
4/2/2015	38.46	0	1.230
4/3/2015	22.39	0	0.555
4/4/2015	25.03	0	0.216
4/5/2015	23.43	0	0.400
4/6/2015	22.09	0	0.468
4/7/2015	23.17	0	0.404
4/8/2015	21.46	0	0.425
4/9/2015	25.13	0	0.450
4/10/2015	25.04	0	0.481
4/11/2015	22.28	0	0.475
4/12/2015	21.72	0	0.518
4/13/2015	22.03	0	0.592
4/14/2015	22.06	0	0.230
4/15/2015	21.5	0	0.179
4/16/2015	21.7	0	0.228
4/17/2015	21.45	0	0.320
4/18/2015	22.08	0	0.167
4/19/2015	22.1	0	0.260
4/20/2015	22.12	0	0.219
4/21/2015	22.65	0	0.293
4/22/2015	24.79	0	0.339
4/23/2015	24.31	0	0.518
4/24/2015	24.3	0	0.366
4/25/2015	22.89	0	0.393
4/26/2015	22.12	0	0.516
4/27/2015	24.21	0	0.460
4/28/2015	23.26	0	0.363
4/29/2015	23.62	0	0.340

4/30/2015	22.44	0	0.399
5/1/2015	23.32	0	0.393
5/2/2015	24.5	0	0.449
5/3/2015	23.74	0	0.439
5/4/2015	22.05	0	0.440
5/5/2015	23.66	0.765	0.658
5/6/2015	19.92	0.0675	0.707
5/7/2015	23.15	0	0.398
5/8/2015	22.78	0	0.457
5/9/2015	22.32	1.1925	0.510
5/10/2015	23.74	0.3825	0.521
5/11/2015	21.89	0.0225	0.556
5/12/2015	22.27	0	0.468
5/13/2015	23.2	0	0.522
5/14/2015	21.82	0	0.466
5/15/2015	17.63	2.475	0.656
5/16/2015	21.04	0.1575	0.594
5/17/2015	19.69	0	0.510
5/18/2015	21.98	0	0.715
5/19/2015	21.77	0	0.488
5/20/2015	22.71	0	0.523
5/21/2015	21.3	0	0.547
5/22/2015	21.97	0	0.474
5/23/2015	22.7	0	0.462
5/24/2015	21.85	0	0.554
5/25/2015	24.04	0	0.579
5/26/2015	22.59	0	0.661
5/27/2015	22.38	0	0.610
5/28/2015	22.13	0	0.623
5/29/2015	22.33	0	0.667
5/30/2015	21.9	0	0.583
5/31/2015	21.58	0	0.604
6/1/2015	22.33	0	1.081
6/2/2015	21.28	0	1.016
6/3/2015	23.96	9.31	0.769
6/4/2015	23.12	12.75	1.390
6/5/2015	16.87	34.3	4.014
6/6/2015	31.45	0	0.101
6/7/2015	23.45	10.02	1.026
6/8/2015	22.57	21.5	2.710
6/9/2015	22.9	20.95	2.504

6/10/2015	21.21	25.21	3.012
6/11/2015	18.04	30.75	3.333
6/12/2015	22.58	0	0.861
6/13/2015	21.03	0	0.823
6/14/2015	20.91	0	0.739
6/15/2015	21.01	0	0.814
6/16/2015	22.26	0.6075	0.749
6/17/2015	22.31	0.1125	0.751
6/18/2015	21.87	0.27	0.699
6/19/2015	21.11	0.6075	0.850
6/20/2015	23.01	0.0675	1.019
6/21/2015	20.81	1.665	1.226
6/22/2015	20.32	0	1.020
6/23/2015	20.83	0	0.931
6/24/2015	20.91	0	0.847
6/25/2015	20.57	0	0.795
6/26/2015	19.94	1.17	0.842
6/27/2015	20.68	0.225	0.883
6/28/2015	20.89	0	0.843
6/29/2015	20.49	0.09	0.781
6/30/2015	22.18	0	0.877
7/1/2015	23.28	0.945	0.762
7/2/2015	21.37	3.9375	0.928
7/3/2015	19.44	16.7625	0.859
7/4/2015	20.02	11.0925	0.876
7/5/2015	19.22	2.6325	0.887
7/6/2015	19.14	0	0.818
7/7/2015	20.2	0.0225	0.704
7/8/2015	20.59	0.1125	0.798
7/9/2015	19.96	18.81	0.686
7/10/2015	21.1	3.06	0.694
7/11/2015	18.9	6.4575	0.725
7/12/2015	20.95	6.4125	0.856
7/13/2015	19.86	0.6075	0.841
7/14/2015	20.58	0	0.708
7/15/2015	16.8	0.4725	0.728
7/16/2015	18.49	2.0925	0.791
7/17/2015	21.67	0.18	0.689
7/18/2015	22.3	0.09	0.758
7/19/2015	20.97	11.565	0.886
7/20/2015	14.33	119.7675	1.361

7/21/2015	17.09	0.7875	1.597
7/22/2015	18.32	0.0225	1.314
7/23/2015	20.25	1.8225	0.792
7/24/2015	18.22	0.99	0.682
7/25/2015	18.97	0.36	0.985
7/26/2015	17.21	33.57	1.097
7/27/2015	14.63	30.8925	0.961
7/28/2015	14.33	5.895	1.331
7/29/2015	17.31	0.6975	1.661
7/30/2015	16.42	2.61	1.134
7/31/2015	18.26	0.0225	1.345
8/1/2015	17.4	0.09	0.964
8/2/2015	14.98	12.375	1.427
8/3/2015	16.94	0.3375	1.304
8/4/2015	15.08	8.3025	1.700
8/5/2015	16.13	2.07	1.363
8/6/2015	17.22	3.2625	1.064
8/7/2015	15.19	2.115	1.457
8/8/2015	14.71	4.0725	1.303
8/9/2015	16.37	5.2425	1.740
8/10/2015	15.19	32.1525	1.678
8/11/2015	16.86	6.9525	1.343
8/12/2015	15.63	19.8	1.040
8/13/2015	17.19	0.675	1.704
8/14/2015	17.61	0.0225	1.176
8/15/2015	17.53	0	1.106
8/16/2015	19.09	0.135	1.071
8/17/2015	16.67	83.6325	0.981
8/18/2015	16.85	0.6525	1.555
8/19/2015	18.36	0.045	1.095
8/20/2015	18.12	11.4075	1.089
8/21/2015	15.57	19.2375	1.158
8/22/2015	17.36	0.045	1.512
8/23/2015	18.84	3.69	1.160
8/24/2015	17.59	4.005	1.348
8/25/2015	15.78	12.5775	1.194
8/26/2015	14.67	14.4675	1.354
8/27/2015	17.6	1.395	1.280
8/28/2015	16.84	5.6025	1.257
8/29/2015	13.56	43.11	1.595
8/30/2015	15.65	12.105	1.286

8/31/2015	16.95	9.495	1.220
9/1/2015	14.9	53.46	1.217
9/2/2015	17.28	4.8375	1.495
9/3/2015	13.97	32.13	1.535
9/4/2015	17.58	0.3375	1.555
9/5/2015	17.68	0	1.067
9/6/2015	16.93	7.5825	1.657
9/7/2015	17.57	0.09	1.319
9/8/2015	15.99	10.305	1.167
9/9/2015	16.91	2.52	1.754
9/10/2015	18.06	0	1.107
9/11/2015	18.66	0.1575	1.196
9/12/2015	17.41	0	1.412
9/13/2015	18.26	0.09	1.168
9/14/2015	18.62	0.675	1.049
9/15/2015	18.24	4.8825	1.122
9/16/2015	18.01	5.265	1.414
9/17/2015	13.75	121.8375	1.440
9/18/2015	15.6	4.1625	1.848
9/19/2015	17	0.5625	1.353
9/20/2015	17.77	4.9725	1.068
9/21/2015	17.55	0.045	1.329
9/22/2015	18.4	0	1.137
9/23/2015	18.85	0	1.028
9/24/2015	19.05	0	1.084
9/25/2015	17.69	0.45	1.136
9/26/2015	18.09	0	1.684
9/27/2015	18.78	0.18	1.110
9/28/2015	18.88	0.765	0.943
9/29/2015	17.9	0	1.076
9/30/2015	18.14	0	1.244
10/1/2015	18.58	0.09	1.000
10/2/2015	18.72	0	1.000
10/3/2015	18.25	0	1.038
10/4/2015	19.05	1.26	1.004
10/5/2015	18.12	5.7825	1.846
10/6/2015	19.1	0.945	1.035
10/7/2015	18.57	0	1.110
10/8/2015	18.32	0	0.985
10/9/2015	17.31	0.9225	1.217
10/10/2015	18.94	0.0225	1.142

10/11/2015	19.28	0.6525	0.835
10/12/2015	19.96	0.2925	0.955
10/13/2015	19.94	0	1.000
10/14/2015	19.28	0	0.926
10/15/2015	19.62	0	0.996
10/16/2015	20.51	0	0.915
10/17/2015	19.45	0	0.921
10/18/2015	19.46	0.0225	0.880
10/19/2015	19.54	0	1.000
10/20/2015	20.72	7.8525	0.824
10/21/2015	18.86	8.3475	0.860
10/22/2015	18.97	0	0.942
10/23/2015	19.8	0	0.904
10/24/2015	19.48	0	0.880
10/25/2015	20.7	0.3825	0.920
10/26/2015	20.8	0.2025	0.890
10/27/2015	19.41	0	0.901
10/28/2015	20.2	0	0.981
10/29/2015	20.09	0	1.080
10/30/2015	19.35	0	0.917
10/31/2015	19.5	0	0.819
11/1/2015	19.33	0	0.719
11/2/2015	19.12	0	0.681
11/3/2015	19.42	0	0.916
11/4/2015	19.49	0	0.630
11/5/2015	19.59	0	0.579
11/6/2015	19.1	0	0.674
11/7/2015	19.3	0	0.608
11/8/2015	19.2	0	0.560
11/9/2015	19.37	0	0.506
11/10/2015	18.68	0	0.501
11/11/2015	19.21	0	0.495
11/12/2015	19.51	0	0.441
11/13/2015	19.65	0	0.359
11/14/2015	19.62	0	0.355
11/15/2015	19.25	0	0.335
11/16/2015	19.17	0	0.470
11/17/2015	19.1	0	0.517
11/18/2015	19.64	0	0.473
11/19/2015	19.5	0	0.305
11/20/2015	19.42	0	0.349

11/21/2015	19.38	0	0.366
11/22/2015	20.17	0	0.378
11/23/2015	20.14	0	0.369
11/24/2015	20.19	0	0.335
11/25/2015	20.16	0	0.321
11/26/2015	20.78	0	0.304
11/27/2015	21.52	0	0.400
11/28/2015	20.65	0	0.488
11/29/2015	20.43	0	0.467
11/30/2015	19.91	0	0.413
12/1/2015	13.32	0	0.327



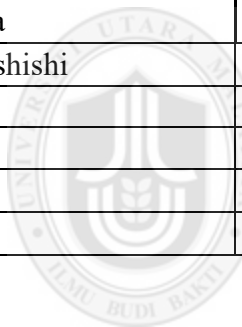
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Appendix C: Flood Inventory 2006-2017

Regions	Date of Flood
Agaie	27-Jul-12
	15-Aug-12
	9-Aug-14
	29-Sep-16
Agwara	9-Jul-12
	29-Jun-15
	11-Jun-16
Bida	17-May-06
	13-Aug-10
	20-Jul-12
	16-Jul-16
Borgu	17-May-06
	2-Jun-09
	23-Jul-12
	11-Jun-15
	26-Jul-16
	1-Oct-16
	29-Aug-16
Bosso	24-Aug-12
	11-Jun-12
	14-Aug-15
	27-Sep-15
	25-Aug-16
Chanchaga	28-Aug-17
	3-Jul-12
	1/9/2012
	28-Jul-16
Edati	1-Jul-12
	27-Jul-15

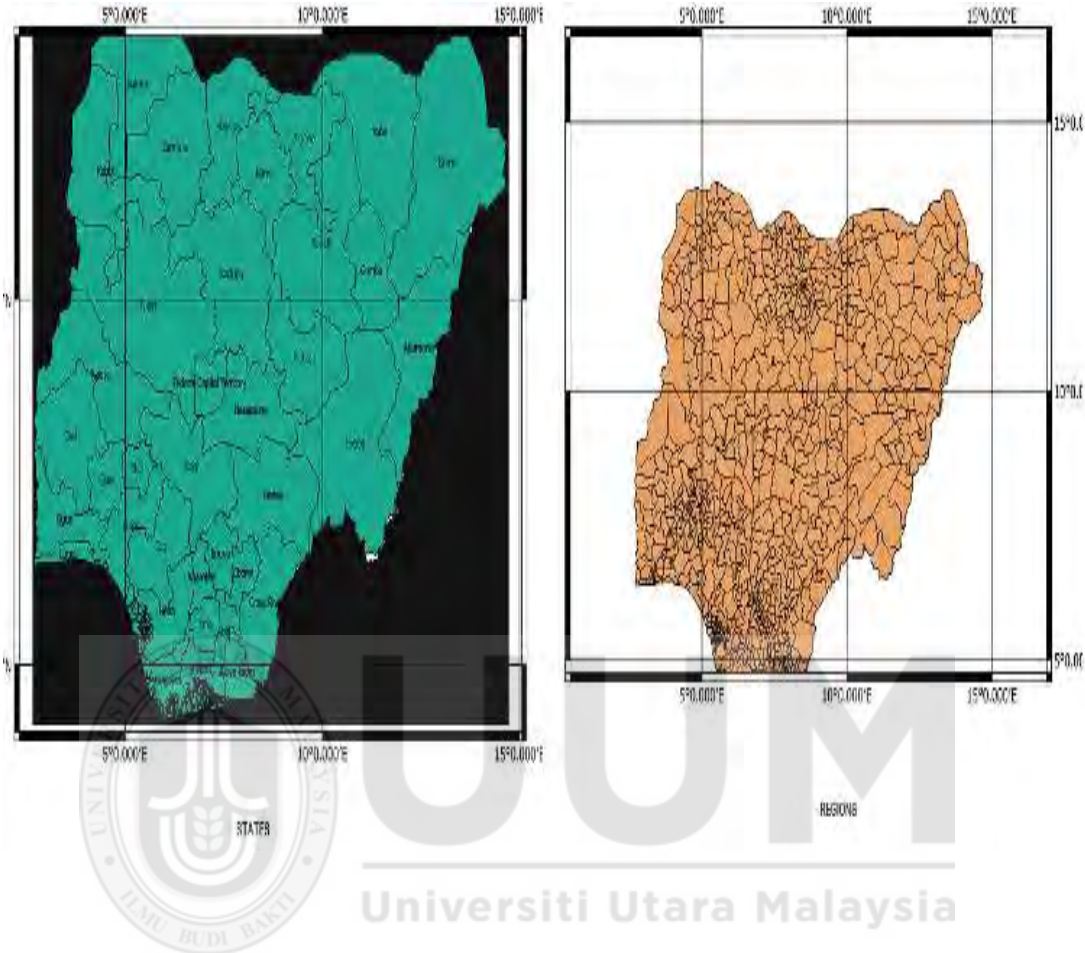
	16/08/2015
Gurara	10-Jul-12
Gbako	22-Aug-12
	9-Jul-15
Katcha	28-Aug-10
	4-Jul-12
	28-Aug-12
	13-Jul-15
	25-Jul-16
Kontagora	5-Jul-12
	13-Aug-16
	17-May-06
Lapai	24-Sep-15
	21-Jul-15
	8-Jul-09
	24/8/2016
	24-Aug-10
	3-Jul-12
	30-Jul-16
Lavun	25-Jul-09
	17-Jul-15
	29-Jul-16
	24-Sep-15
Magama	4-Oct-16
	15-Aug-12
Mariga	19-Jul-14
	22-Aug-12
Mashegu	8-Sep-16
Mokwa	23-Jun-09
	15-Aug-10
	2-Jul-10
	24-Aug-12
	24-Aug-12
	27-Jun-14
	28-Jun-14

	16-Aug-15
	7-Jul-15
	19-Sep-15
	29-Jul-16
Munya	15-Jun-12
	21-Jul-16
Paikoro	9-Aug-12
	27-Sep-15
Rafi	9-Jul-14
Rijau	17-Aug-12
Shiroro	24-Jul-09
	29-Jul-12
	15-Jul-12
	11-Aug-15
Suleja	26-Jul-16
Tafa	0
Wushishi	31-May-09
	17-Aug-10
	6-Jul-13
	21-Jul-15
	20-Jul-12

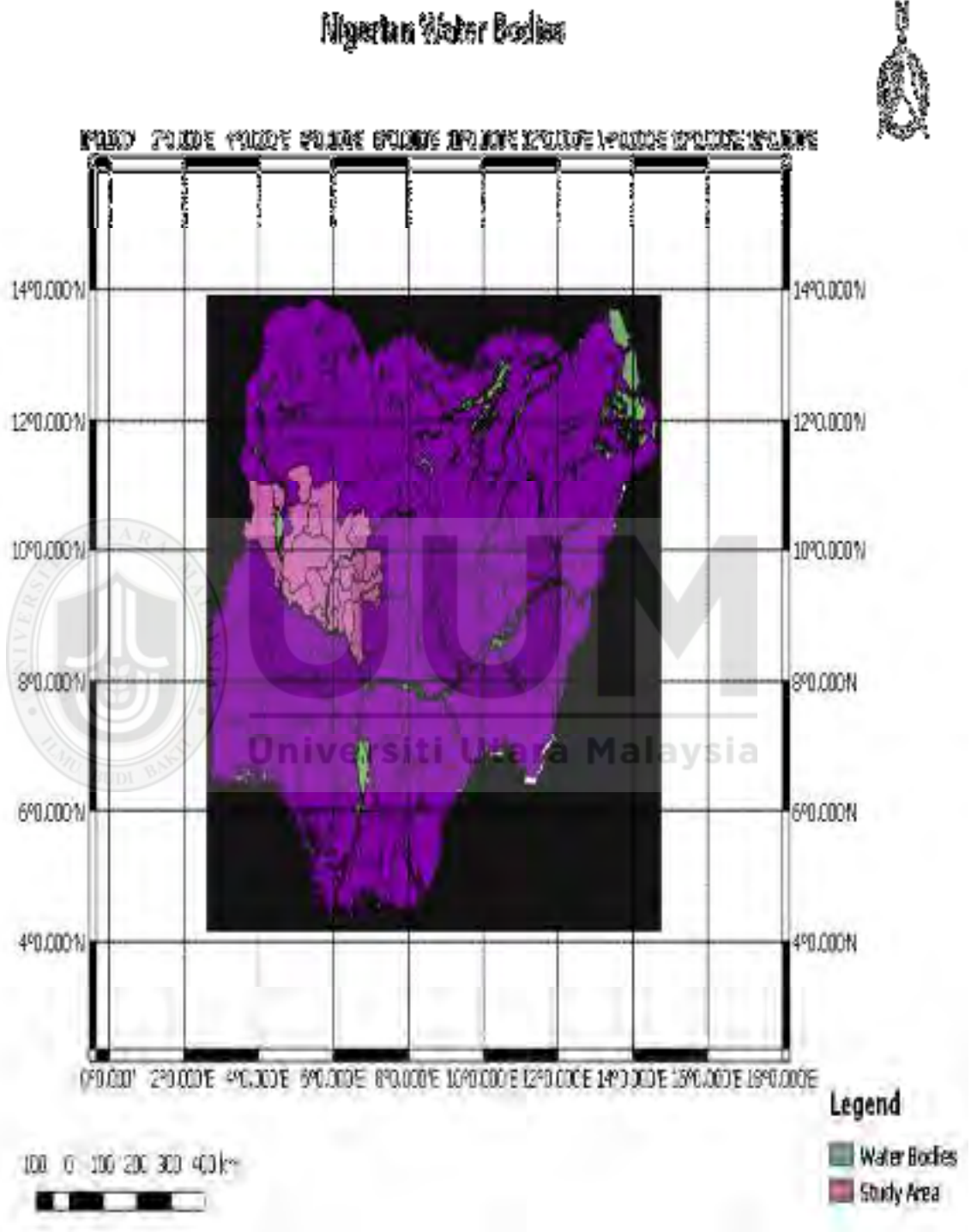


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Appendix D: Administrative Shapefile



Appendix E: Water bodies from Shapefile



Appendix F: Invitation to Participate in Framework Assessment



Dear Prof. / Dr. / Sir / Ma,

I am Ndanusa B. Ahmed who is currently pursuing his PhD study in Information Technology at Universiti Utara Malaysia. I am delighted to respectfully request for your ample time to participate in the review as well as validation of my proposed framework. You have been selected to participate for this research based on your expertise/experience in GIS and remote sensing data analysis.

The main aim of this review and validation is to examine the accuracy and applicability of the proposed framework within the domain of spatiotemporal data and flood analysis. Moreover, the validation is one of the objective of my PhD research. Therefore, upon agree to participate, the proposed framework and sets of generated outputs shall be sent to you for your perusal. Furthermore, once this is done, please you will provide feedback using a validation form that is attached with the documents of the proposed framework.

I assured you, the information given will be treated as confidential and will be used exclusively for the research purposes, which will be reported anonymously in academic publications.

Please feel free to contact me or my supervisors by email:

Thank you

Ndanusa B. Ahmed
elahmedn@gmail.com

Supervisors

Prof. Dr. Zulhairi Md. Dahalin
zul@uum.edu.my myazman@uum.edu.my

Dr. Azman Ta'a

Appendix G: Expert Review & Validation Form

Please validate and give comments on the below mentioned outputs on the proposed Multi-spatiotemporal approach for flood vulnerability classification and Long-Lead Upstream Flood Analysis for a Case of Niger state, Nigeria: Respondent: GIS Expert

Relevancy to the intended application	The proposed framework is useful to the long-lead flood analysis.	Agree Disagree Comments/ Suggestions: ----- ----- -----
Decision Support Satisfaction	The proposed framework provides appropriate results for valid decision-making.	Agree Disagree Comments/ Suggestions: ----- ----- -----
Comparison with existing usability evaluation method	The proposed framework is straight forward and easy to use compared to existing usability evaluation method	Agree Disagree Comments/ Suggestions: ----- ----- -----
Clarity	The flow of assessment process (items) is defined clearly	Agree Disagree Comments/ Suggestions: ----- ----- -----
Tasks appropriateness	The tasks in the proposed framework are appropriate and efficient	Agree Disagree Comments/ Suggestions: ----- ----- -----
Ease of use	The proposed framework can be implemented easily	Agree Disagree Comments/ Suggestions: ----- ----- -----

Internally consistent	The proposed framework is consistent, dependable and easy to apply	Agree Disagree Comments/ Suggestions: ----- -----
Well organised (organisation)	The proposed framework is organized and well-structured.	Agree Disagree Comments/ Suggestions: ----- -----
Presentation (readable and useful format)	The proposed framework is readable and can produce results in a useful format.	Agree Disagree Comments/ Suggestions: ----- -----
Ability to produce expected results	The proposed framework can produce usability problems for the intended flood analysis.	Agree Disagree Comments/ Suggestions: ----- -----
Ability to produce relevant and useful results	The proposed framework produces results that can be used for future improvement	Agree Disagree Comments/ Suggestions: ----- -----
Practicality (Ease of implementation)	The proposed framework is practical to be implemented in the real-world environment	Agree Disagree Comments/ Suggestions: ----- -----

Appendix H: Disaster Monitoring/Management Agency

Expert Review & Validation Form

Respondent: Disaster Monitoring/Management Agency Experts

Institution:

.....

.....

Phone:

Email:

Address of the Institution:

.....

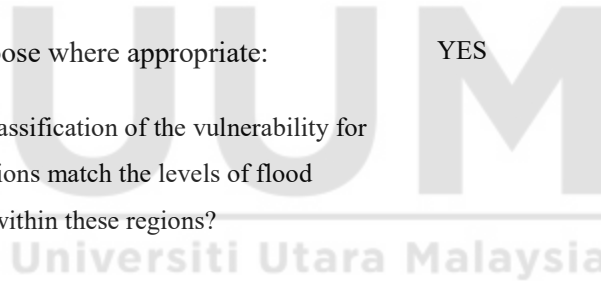
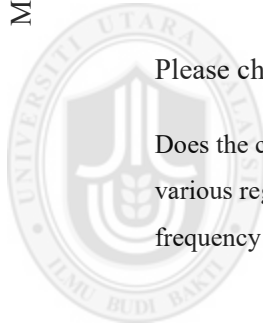
.....

Please choose where appropriate:

YES

NO

Does the classification of the vulnerability for various regions match the levels of flood frequency within these regions?



Accuracy on Vulnerability

Borgu region has been identified to be adjacent to a water body, does the discharge from the water body during a heavy rainfall contribute to flooding events?

Niger state is highly vulnerable to floods due to rainfall.

Are Tafa and Suleja regions the least vulnerable areas in Niger state as identified regions to flooding events?

		Are the regions identified with low or dense vegetation have the traits of such vegetations on the true-terrestrial features?				
	Land Cover Features	Are the water bodies identified in the output exist in the study area?				
		Identification of features images to the ground truth features				
		Are the regions correctly positioned on the maps?				
			NS:Not Satisfactory	NS	FS	S VS
			FS:Fairly Satisfactory			
			S:Satisfactory			
			VS: Very Satisfactory			
Visual Assessment	Vulnerability	Satisfaction with graphical presentation				
		Precision of the output formats				
Interpretability	Layouts/Presentation	Satisfaction with information representation				
		Satisfaction with legends representation				
		Satisfaction with classification				
		Satisfaction with coordinate representation				
		Satisfaction with scale and distance illustration				

Satisfaction with output display and format

Please validate and give assessment comments on the below mentioned vulnerability and geographical outputs on the proposed multi-spatiotemporal Data framework and flood vulnerability classification for Long-Lead Upstream Flood Analysis for a Case of Niger state, Nigeria.

Additional comments (if any):

.....
.....
.....
.....

.....Date.....

(Signature & Official Stamp)

Signed by(Name):

Thank you for your time and effort.



APPENDIX I: GIS Expert Review

Expert Review for Validation of Multi-spatiotemporal Data Framework Representing Niger State.

Respondent: **GIS (Satellite Imageries) & Geographical Experts**

Name: Prof./Dr./Mr./Mrs. (Other.....)

Years of Experience:

Place of work:

.....

.....

Position:.....

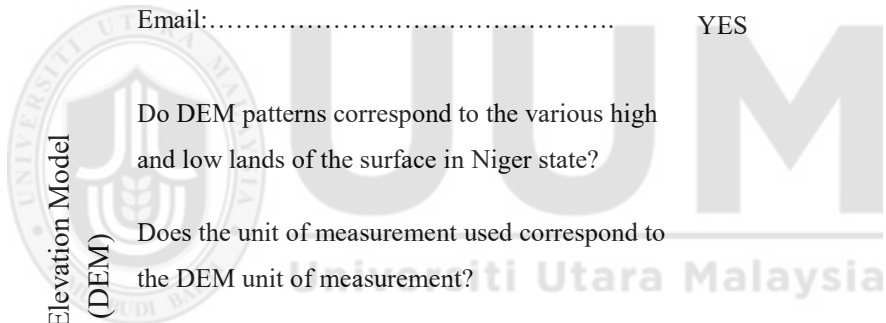
Phone:

Email:.....

YES

NO

Expert's Profile



Digital Elevation Model (DEM)

Do DEM patterns correspond to the various high and low lands of the surface in Niger state?

Does the unit of measurement used correspond to the DEM unit of measurement?

Does the classification method used in conformity with the various elevation patterns?

Terrain Feature

Are the patterns of the Slope in correspondence with the various high and low lands of the surface in Niger state.

Slope

Does the classification method used distiguish clearly between the various patterns of the slope?

Hydrological Features	Flow Accumulation	Do the identified features represent flow accumulation?				
		Is there any tendency of flow accumulation as identified in the feature?				
Land Cover Features	Flow Direction	Do the identified features represent flow direction?				
	(Vegetation)	Are the regions identified with low or dense vegetation have the traits of such vegetations on the true-terrestrial features?				
Accuracy	Water bodies	Are the water bodies identified in the output exist in the study area?				
		Identification of features images to the ground truth features				
		Are the regions correctly positioned on the maps?				
		<u>NS:Not Satisfactory</u>	NS	FS	S	VS
		<u>FS:Fairly Satisfactory</u>				
		<u>S:Satisfactory</u>				
		<u>VS: Very Satisfactory</u>				
		Satisfaction with graphical presentation				
		Precision of the output formats				

Satisfaction with outcome of the MCE using AHP

Satisfaction with information representation

Satisfaction with legends of representation

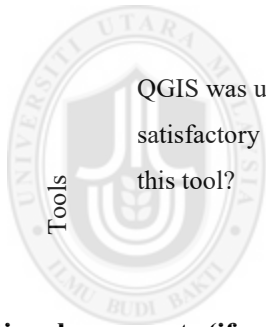
Satisfaction with classification of the patterns

Satisfaction with coordinate representation

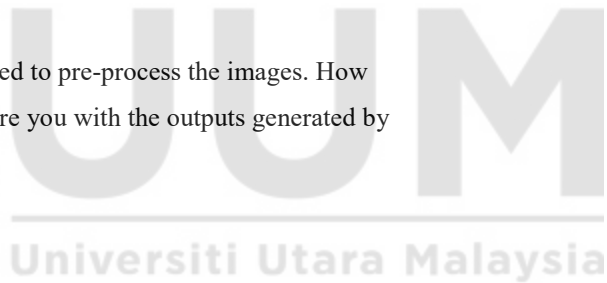
Satisfaction with scale and distance illustration

Satisfaction with output display and format

Interpretability
Layouts/Presentation



Tools
QGIS was used to pre-process the images. How satisfactory are you with the outputs generated by this tool?



Additional comments (if any):

.....
.....
.....
.....
.....

Thank you

.....

Date.....

(Signature & Official Stamp)

Appendix J: Regional FIPV

Locations	FIPV (mm)
Aga	190.32
Agw	301.08
Bid	208.540
Bor	164.79
Bos	213.44
Cha	181.44
Eda	361.64
Gur	247.52
Gba	295.8
Kat	215.89
Kon	317.81
Lap	287.05
Lav	170.27
Mag	199.23
Mar	281.60
Mas	485.90
Mok	386.41
Mun	218.88
Pai	203.66
Raf	235.74
Rij	243.85
Shi	292.11
Sul	579.92
Taf	N/A
Wus	351.81

Appendix K: A Sample of LandSand Imagery



Appendix L: Authorization for Data Usage

***** CAR Data Request Form *****

FOR THE ATTENTION OF:
Project Manager,
TRODAN, Centre for Atmospheric Research (CAR), NASRDA

Please print very clearly:

Your Name: Nolusa B. Alimic

Your Position: Senior Engineer /Ph.D. Research Student

Your Institute: National Space Research and Dev. Agency/University of Ilorin, Nigeria

Telephone/fax number: (include country code) +2348035329994

Email address: nib@nasrda.com

Purpose of Request of Data: Research in Troposphere

Please specify your request in this way:
station code (3 characters), and time period (yyyymmdd).

Eg. AYB, 20120101-20120331

Note: _____

Conditions of Use of TRODAN Data

The data made available by CAR are provided for research use and are not for commercial use or sale or distribution to third parties without the written permission of the Centre. Publications including those making use of the data should include an acknowledgment statement of the form given below. A citation reference should be sent to the TRODAN Project Manager (trodan@nasrda.com) for inclusion in a publications list on the TRODAN website.

Acknowledgement of data from TRODAN

The results presented in this paper rely on TRODAN data collected and managed by the Centre for Atmospheric Research, National Space Research and Development Agency, Federal Ministry of Science and Technology, Anyigba, Nigeria. We thank the Centre for Atmospheric Research and their partners for promoting high standards of atmospheric observatory practice as well as the Federal Government of Nigeria for continuous funding of the Nigerian Space programme (www.nasrda.com).

I agree to conform to all data usage rules of CAR.

Nolusa B. Alimic
Signature, Name and Date



Email completed form to: trodan@nasrda.com ; nalibgat@yahoo.com