IMPACT ASSESSMENT OF CLIMATE CHANGE ON HYDROLOGICAL RESPONSE AND URBAN FLOODING FOR ADAPTATION STRATEGIES (CASE OF LAI NULLAH, PAKISTAN)

By

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THESIS ACCEPTANCE CERTIFICATE

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DISCLAIMER

The views expressed in this work are those of the creators and do not necessarily represent those of the UK Government's Department for International Development, the International Development Research Centre, Canada or its Board of Governors.

DEDICATION

This work is dedicated to my beloved parents and family. It is their love and support that enabled me not only to complete this task but taught me to walk every step of life with confidence and commitment.

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ABSTRACT

Varying hydrological regimes caused due to intensive land use changes and high intensity rainfalls has significantly increased the frequency of extreme flood events in Lai Nullah, Pakistan. The current study involves application of a rainfall-runoff model through spatial modeling within GIS environment, frequency analysis for annual instantaneous peak flow and annual max daily rainfall series, estimation of Probable Maximum Precipitation (PMP) and Probable Maximum Flood (PMF), development of rainfall intensity duration frequency (IDF) and depth duration frequency (DDF) curves, application of a suitable hydraulic model for flood plain inundation mapping, analysis of future climate scenarios and identification of various adaptation strategies. Rainfall-runoff model was successfully calibrated and validated using 10 mins interval rainfall data against stream flow gauge data at Kattarian and Gawalmandi. PMF values for Kattarian and Gawalmandi suggests an annual return period of 500 years. IDF curves based on 3 hr interval rainfall data showed credible results for use in design purposes. DDF curves represent efficient operational forecast guide for different storm durations for various stakeholder and policy makers. Delta downscaling technique was applied for bias correction for conversion from grid rainfall GCM data to point rainfall data. Frequency analysis was also carried out for projected annual maximum rainfall data under ensembled model conditions. Results of calibrated and validated hydraulic model showed good consistency with observed stage values. The integrated approach encompassing hydrological and hydraulic modelling under changing climate scenarios was used and it was found that 100 year return period flood expected to increase by 11% with flood extent increase of 0.506 Km^2. Further, adaptation strategies like ponds, flow diversion and forestation were also explored to mitigate the flood hazards impacts. This study will facilitate various policy makers and stakeholders in deciding and formulating the mitigation and adaptation strategies to improve the existing flood risk management and relief plans.

TABLE OF CONTENTS

ACKNOWLEDGEMENTS v

ABSTRACT vi

LIST OF TABLES xii

LIST OF FIGURES xiii

LIST OF ABBREVIATIONS xvi

Chapter 1 1

INTRODUCTION 1

1.1 GENERAL 1

1.2 PROBLEM STATEMENT 1

1.3 RATIONALE OF THE STUDY 2

1.4 OBJECTIVES OF THE STUDY 3

1.5 SCOPE OF THE RESEARCH WORK 3

1.6 BENEFITS OF THE RESEARCH WORK 4

Chapter 2 5

LITERATURE REVIEW 5

2.1 GENERAL 5

2.2 PREVIOUS STUDIES ON LAI NULLAH 5

2.3 SIMILAR STUDIES ON LAI NULLAH 8

Chapter 3 11

MATERIALS AND METHODS 11

3.1 STUDY AREA 11

3.2 DATA 13

3.2.1 Precipitation Data 13

3.2.2 Stream Flow Data 14

3.2.3 Remote Sensing Data 14

3.2.4 Soil Data 14

3.2.5 Land Use Map & Urban Master Plan 14

3.2.6 Downscaled GCMs Dataset 14
3.2.7 Flood Plain Topography & Channel Geometry Data 14
3.3 METHODOLOGY 15
3.3.1 Hydrological Modelling 15
3.3.1.1 Terrain Processing in ArcGIS / HEC-GeoHMS 15
3.3.1.2 Land Use Analysis 16
3.3.1.3 Preparation of Soil Map and Curve Number Grid 17
3.3.1.4 Preparation of Spatial Precipitation Data 18
3.3.1.5 Hydrological Modeling System 18
3.3.1.6 HEC-HMS Model 18
3.3.1.6.1 Loss Methods 20
3.3.1.6.1.1 SCS Curve Number 20
3.3.1.6.1.2 Initial and Constant Rate 20
3.3.1.6.1.3 Green and Ampt 20
3.3.1.6.2 Transformation Methods 21
3.3.1.6.2.1 SCS Unit Hydrograph 21
3.3.1.6.2.2 Clark Unit Hydrograph 22
3.3.1.6.2.3 Snyder Unit Hydrograph 22
3.3.1.6.3 Routing Method 22
3.3.1.6.3.1 Muskingum Routing Method 22
3.3.1.6.3.2 Lag Routing Method 23
3.3.1.7 Model Calibration & Validation 23
3.3.1.8 Model Performance 24
3.3.2 Frequency Analysis 24
3.3.2.1 Annual Instantaneous Peak Flow Analysis 25
3.3.2.2 Annual Maximum Daily Rainfall Analysis 27
3.3.2.3 Comparison with JICA Study 29

3.3.3 Calculation of Probable Maximum Precipitation (PMP) 30
3.3.4 Calculation of Probable Maximum Flood (PMF) 31
3.3.5 Intensity Duration Frequency (IDF) & Depth Duration Frequency (DDF) Curves 31
3.3.6 Hydraulic Modelling 32
3.3.6.1 General 32
3.3.6.2 Full Saint Venant or Diffusion Wave Equations in 2D 33
3.3.6.3 Implicit Finite Volume Solution Algorithm 33
3.3.6.4 Unstructured or Structured Computational Meshes 34
3.3.6.5 Detailed Hydraulic Table Properties for Computational Cells and Cell Face 34
3.3.7 HEC-RAS Model 35
3.3.7.1 Terrain Processing 35
3.3.7.2 Addition of Structure Elevation Data 36
3.3.7.3 Generation of 2D Computational Mesh 37
3.3.7.4 Analysis in RAS Mapper 38
3.3.7.5 Model Calibration & Validation 39
3.3.7.6 Manning's n Roughness Coefficient 40
3.3.7.7 Simulation for Future Scenarios 41
3.3.8 Assessment of Climate Change Scenarios 41
3.3.9 Identification of Various Adaptation Strategies 43
Chapter 4 45
RESULTS AND DISCUSSIONS 45
4.1 LAND USE ANALYSIS 45
4.2 HYDROLOGICAL ANALYSIS 46
4.2.1 Model Calibration and Validation 46
4.3 FREQUENCY ANALYSIS 50
4.3.1 Annual Instantaneous Peak Flow (AIPF) 50
4.3.2 Annual Maximum Daily Rainfall (AMDR) 52
4.3.3 Comparison of Standard Flood Discharges 54
4.3.4 Probable Maximum Precipitation (PMP)/ Probable Maximum Flood (PMF) 55
4.3.5 Intensity Duration and Depth Duration Frequency Curves 56
4.4 HYDRAULIC MODELLING AND FLOOD EXTENTS 58

4.4.1 Model Calibration and Validation 58
4.4.2 Simulation for Various Return Periods 61
4.4.3 Climate Change Assessment 71
4.4.3.1 Bias Correction 71
4.4.3.2 Comparison of Top-30 AMDR Values 77
4.4.3.3 Frequency Analysis of Projected AMDR Data 79
4.4.3.4 Climate Models Efficiency Analysis 80
4.4.3.5 Simulation in HEC-HMS & HEC-RAS 81
4.4.4 Simulation for Various Adaptation Strategies 83
4.443.1 Formulation of Community Pond 83
4.4.4.2 Impact of Flood Mitigation Dam 83
4.4.4.3 Impact of Flow Diversion 85
4.4.4.4 Impact of Forestation 85
4.4.4.5 Combined Effect of Community Pond and Flood Mitigation Dam 88
4.4.4.6 Analysis of Various Adaptation Strategies 88
4.4.4.7 Other Possible Adaptation Measures 92
Chapter 5 93
CONCLUSIONS AND RECOMMENDATIONS 93
5.1 CONCLUSIONS 93
5.2 RECOMMENDATIONS 96
REFERENCES 99
APPENDICES 102
Appendix 1 102
Appendix 2 103
Appendix 3 104
Appendix 4 105
Appendix 5 106
Appendix 6 107
Appendix 7 108
Appendix 8 109
Appendix 9 110
Appendix 10 111

Appendix 11 113
Appendix 12 115
Appendix 13 116

LIST OF TABLES

Table - 3.1: Precipitation Data 13

Table - 3.2: Stream Flow Data 13

Table - 3.3: Flood Plain Topography & Channel Geometry Data 14

Table - 3.4: Methods used in HEC-HMS 23

Table - 3.5: Details of HI-AWARE GCMs 41

Table - 4.1: Land Use Classification – Lai Basin 45

Table - 4.2: Performance Evaluation – Calibration & Validation 50

Table - 4.3: Results - Goodness of Fit Tests 51

Table – 4.4: Standard Flood Discharges – AIPF 51

Table - 4.5: AMDR at Various Return Periods 53

Table - 4.6: Standard Flood Discharges – AMDR 54

Table - 4.7: Values of K_m Factor 55

Table - 4.8: 24-Hr PMP Values 55

Table - 4.9: Performance Evaluation – Calibration & Validation 60

Table - 4.10: Flood Inundated Areas 61

Table - 4.11: Frequency Analysis Projected AMDR Values – 100 Yr Return Period 80

Table - 4.12: Model Efficiency Analysis 81

Table - 4.13: Projected Flows – AMDR 81

Table - 4.14: Effects of Adaptation Strategies 88

LIST OF FIGURES

Fig - 3.1: Lai Nullah Basin 12

Fig - 3.2: Elevation Range – Lai Basin 12

Fig - 3.3: Conceptual Flow Chart 15

Fig - 3.4: Sub basins Delineation 16

Fig - 3.5: Land Use Classification 17

Fig - 3.6: Lai Soil Map 17

Fig - 3.7: Curve Number Grid 17

Fig - 3.8: Division of Basin through Thiessen Polygons 18

Fig - 3.9: Annual Instantaneous Peak Flows – (1986 - 2015) 26

Fig - 3.10: Annual Maximum Daily Rainfall Series 29

Fig - 3.11: Triangular Irregular Network (TIN) – Lai Basin 36

Fig - 3.12: Refined TIN – Lai Basin 37

Fig - 3.13: Generation of a 2D Computational Mesh 37

Fig - 3.14: Computational Grid Cells of 2D Mesh 38

Fig - 3.15: RAS Mapper Terrain 39

Fig - 3.16: Spatially Varying Manning Layer 40

Fig - 4.1: Comparison of Land Use Assessment 45

Fig - 4.2: Hydrological Model Calibration 48

Fig - 4.3: Hydrological Model Validation 49

Fig - 4.4: Best Fit Distributions 51

Fig - 4.5: Best Fit Distributions 53

Fig - 4.6: Comparison of Standard Flood Discharges 54

Fig - 4.7: Spatial Representation of PMP Values 56

Fig - 4.8: IDF Curves – 6 Stations 57

Fig - 4.9: DDF Curves 58

Fig - 4.10: Model Calibration – 2001 Event 59

Fig - 4.11: Model Validation Results 59

Fig - 4.12: Flood Extent Map 60

Fig - 4.13: Comparison of 2001 Flood Extent Map & JICA Map 61

Fig - 4.14: Flood Extent Map – 2 Year Return Period 62

Fig - 4.15: Flood Extent Map – 5 Year Return Period 63

Fig - 4.16: Flood Extent Map – 10 Year Return Period 64

Fig - 4.17: Flood Extent Map – 25 Year Return Period 65

Fig - 4.18: Flood Extent Map – 50 Year Return Period 66

Fig - 4.19: Flood Extent Map – 100 Year Return Period 67

Fig - 4.20: Flood Extent Map – 200 Year Return Period 68

Fig - 4.21: Flood Extent Map – 500 Year Return Period 69

Fig - 4.22: Flood Extent Map – 1000 Year Return Period 70

Fig - 4.23: Comparison of Observed Vs Baseline Data 71

Fig - 4.24: Bias Corrected Data – 2025s 72

Fig - 4.25: Bias Corrected Data – 2055s 73

Fig - 4.26: Bias Corrected Data – 2085s 74

Fig - 4.27: Bias Corrected Data (RCP - 4.5) 75

Fig - 4.28: Bias Corrected Data (RCP-8.5) 76

Fig - 4.29: Comparison Top 30 AMDR Values – Chaklala 77

Fig - 4.30: Comparison Top 30 AMDR Values – PMD 78

Fig - 4.31: Comparison Top 30 AMDR Values – RAMC 78

Fig - 4.32: Comparison Top 30 AMDR Values – Saidpur 79

Fig - 4.33: Impact of Climate Change – 100 Yrs Return Period 82

Fig - 4.34: Adaptation Strategies 84

Fig - 4.35: Impact of Community Pond 85

Fig - 4.36: Impact of Flood Mitigation Dam 87

Fig - 4.37: Impact of Flow Diversion 89

Fig - 4.38: Impact of Forestation 90

Fig - 4.39: Combined Effect of Community Pond & Flood Mitigation Dam 91

LIST OF ABBREVIATIONS

AD	Anderson-Darling
AIPF	Annual Instantaneous Peak Flow
AMDR	Annual Maximum Daily Rainfall
ASTER	Advance Spaceborne Thermal Emission and Reflection
AWCI	Asia Water Cycle Initiative
CF	Correction Factor
CI	Confidence Interval
CN	Curve Number
DDF	Depth Duration Frequency
DEM	Digital Elevation Model
DHM	Distributed Hydrological Model
D/S	Downstream
FAO	Food and Agricultural Organization of United Nations
GCM	General Circulation Model
GEOSS	Global Earth Observation System of Systems
GIS	Geographic Information System
HEC	Hydrologic Engineering Center
HI-AWARE	Himalayan Adaptation Water and Resilience Research
HKH	Himalaya Karakoram Hindukush
HMS	Hydrologic Modeling System
HR	Hour
HSPF	Hydrological Simulation Program - Fortran
IDF	Intensity Duration Frequency

IGIS	Institute of Geographical Information System
IWRM	Integrated Water Resource Management
JICA	Japan International Cooperation Agency
MAE	Mean Absolute Error
Max	Maximum
MODFLOW	Modular Finite Difference Flow Model
NCEP	National Centers for Environmental Prediction
NS	Nash-Sutcliffe Coefficient
KS	Kolmogorov-Smirnov
PARC	Pakistan Agricultural Research Council
PMD	Pakistan Meteorological Department
PMF	Probable Maximum Flood
PMP	Probable Maximum Precipitation
RAMC	Rawalpindi Agromet Centre
RAS	River Analysis System
RDA	Rawalpindi Development Authority
RMSE	Root Mean Square Error
RS	Remote Sensing
SCS	Soil Conservation Service
SDO	Small Dams Organization
SPI	Standardized Precipitation Index
SPOT	Satellite Pour l'Observation de la Terre, lit
SUPARCO	Space and Upper Atmosphere Research Commission
SWAT	Soil and Water Assessment Tool
TIN	Triangular Irregular Network

TMA	Tehsil Municipal Administration
UH	Unit Hydrograph
USGS	United States Geological Survey
U/S	Upstream
WAPDA	Water and Power Development Authority
WASA	Water And Sanitation Agency
WEB	Water and Energy Budget
WEST	Water Environmental Sedimentation Technology
WMO	World Meteorological Organization
WSE	Water Surface Elevation
WSM	Water Shed Management
YR	Year