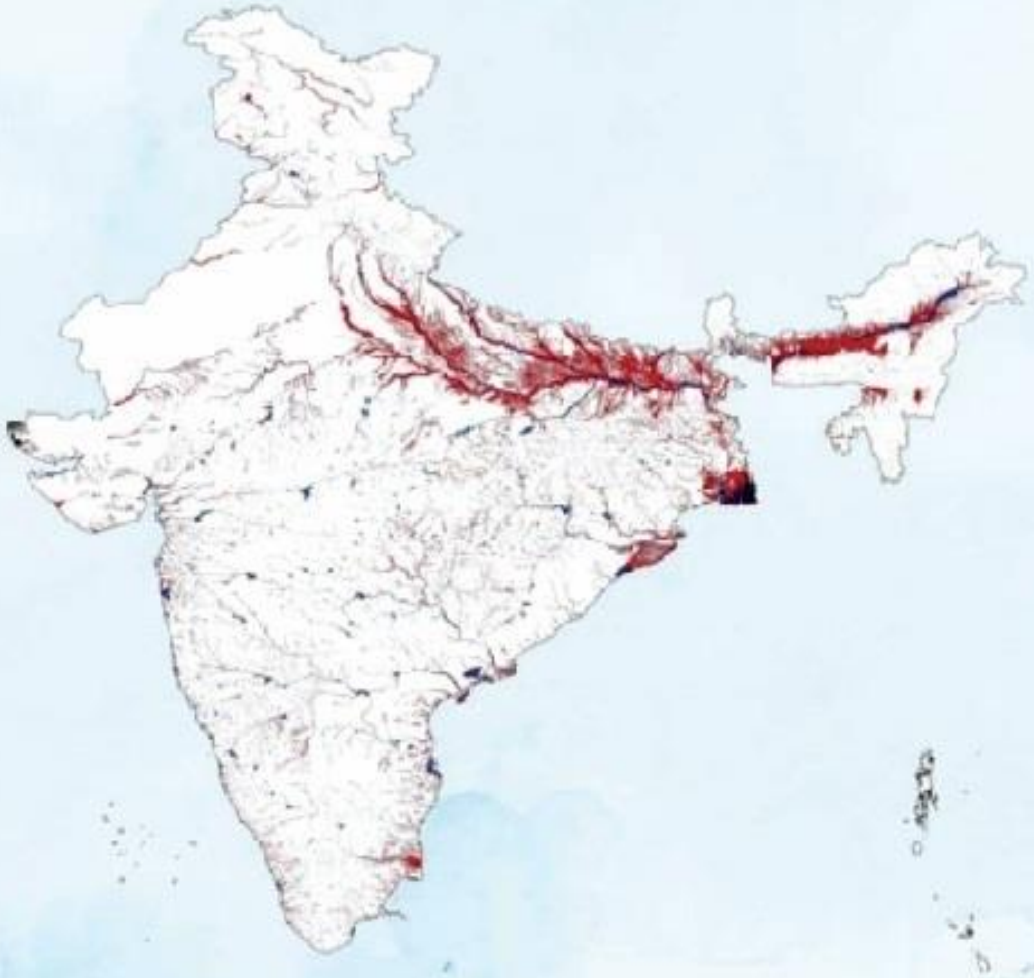
सत्यमेव जयते

Government of India
Ministry of Jal Shakti
Department of Water Resources,
River Development & Ganga Rejuvenation

Assessment of Area Affected Due to Floods in India



CENTRAL WATER COMMISSION
JUNE, 2021
NEW DELHI

Message

Shri C R Patil
Hon'ble Minister of Jal Shakti

"India experiences widely disparate climates in different parts of the country and rainfall also exhibits nonuniformity in terms of spatial and temporal distribution. Most of the rain occurs during monsoon season, Indo-Gangetic Plain, Brahmaputra and eastern coastal regions receive significantly more rainfall than rest of the areas in India. As a result, certain regions of India encounter flooding, while other regions simultaneously go through dry spells.

Floods are often caused by heavy rainfall, rapid snowmelt, storm surge, cyclone and typhoon etc. Flood management and flood-control measures are introduced in many places to prevent/mitigate the consequences of flood. The process of flood management is very complex as it involves several socio-hydro climatological factors. The fact that floods have occurred more frequently in recent decades indicates that climate change has potentially affected a number of factors that influence flood risk in the country.

The Government of India under the leadership of Hon'ble Prime Minister Shri Narendra Modi has taken up numerous measures to reduce the risks of flood occurrence and limit their potential consequences. The present study shall be very useful in prioritizing early warning system and structural measures to mitigate the effects of flood. I congratulate and compliment entire team of Central Water Commission (CWC) for doing commendable task in preparation of this publication."

Ms. Debashree Mukherjee
Secretary
Department of WR, RD, & GR
Ministry of Jal Shakti

Message

“India has vast geographical diversity comprising mountains, plateaus, plains, wet lands, coasts, forests and islands. Heavy rainfall and cloud burst events coupled with phenomenon like landslides, rock & debris fall etc. leads to flash floods in the mountainous regions. Rapid snowmelts in these regions accompanied by glacial lake outbursts and land slide lake outburst often leads to occurrence of floods in upper mountainous reaches.

Several factors like uneven rainfall pattern, reduced river channel carrying capacity for high flows, river bank erosion, siltation of channel beds, poor natural drainage in flood prone areas, encroachments in river’s right of way and several other meteorological factors have affected spatial and temporal distribution of floods. Additionally, in recent decades, rapid urbanization and rapid changes in the land use pattern have given rise to urban floods whereas, other parts of India suffer from drought due to the erratic nature of monsoon, being located on rain shadow area.

In order to mitigate the impacts of floods in India, the Ministry of Jal Shakti has launched various policies and programs to improve the water security and effective flood management. With this goal, the Central Water Commission (CWC) has been on constant strive to develop an integrated, dynamic and technology-driven approach to flood management with state-of-the-art technologies. This study has brought out Flood Affected Areas in India and shall be extremely useful for the States to take decisions regarding Flood Management Works. I compliment the entire team of CWC for their tremendous efforts in bringing out this publication.”

Foreword

Shri Kushvinder Vohra
Chairman
Central Water Commission
Department of WR, RD, & GR
Ministry of Jal Shakti

India is endowed with an abundance of fresh water resources and the monsoon season plays a pivotal role in recuperation of these resources. In the past decade, climatic changes, highly skewed water resource distributions and monsoon patterns resulted in seasonal abundance and devastating floods in some areas, while large tracts in other regions were chronically drought-affected.

The Government of India has set up various committees, task forces, and working groups and formulated policies that have provided guiding recommendations for water resource management, including flood management. Rashtriya Barh Ayog, Ganga Flood Control Commission, XII Plan Working Group and other Central/State agencies have attempted to address the issue of damages caused due to floods. However, these estimates of flood damages were State reported figures. A scientific approach to comprehend floods and designing essential measures to minimize losses is crucial.

Central Water Commission (CWC) is the apex organization in the country dealing with matters related to water resource development and management. CWC had carried out study to identify and delineate the region-specific maximum aggregated extent of inundated areas of entire country. All the flood events captured by the satellite imageries during the period 1986 – 2019 were incorporated for delineating the areas inundated due to floods and these layers/maps were ground verified by the States/UTs. In past few years recurrence of extreme flood events has been increased tremendously and the newer areas are also being flooded which were not considered flood prone. Observing this, the study was further refined and extended till 2022 to delineate the flood affected areas in India by using the satellite imageries of Landsat, Sentinel 1 & 2.

This study on ‘Assessment of Areas Affected due to Floods in India’ would be found extremely useful by all the offices of CWC, Central / State agencies / PSUs and other stakeholders, who are engaged in the planning and development of water resources in the country

Preface

Shri P. Manroi Scott

Member (RM)
Central Water Commission
Department of WR, RD, & GR
Ministry of Jal Shakti

I hope this study on 'Assessment of Areas Affected due to Floods in India' provide novel insights, making it valuable for decision making, raising awareness and implementing mitigation measures across the Country.

I would like to express deepest gratitude to Chairman, CWC who led these studies from the front. I also would like to express appreciation to Shri B.K.Karjee, Chief Engineer (Flood Management Organization), Shri Sharad Chandra, Shri Ritesh Khattar and Shri Ajay Kumar Sinha, Directors of CWC for their valuable insights, feedback and continuous guidance for completion of the study.

Special thanks goes to officials of CWC regional offices and States/UTs for their cooperation in completion of ground validation on the study of flood affected areas 2020.

I would also like to extend deepest gratitude to officers and officials of Flood Management Organization, CWC for their contributions and played a significant role in making this study comprehensive and informative.

I look forward to suggestions and feedback for improvement in content and quality of this publication

Steering Group

Shri Kushvinder Vohra	Chairman, CWC
Shri P M Scott	Member, RM
Shri B K Karjee	Chief Engineer, FMO
Shri Sharad Chandra	Director
Shri Ritesh Khattar	Director
Shri Ajay Kumar Sinha	Director

Core Team

Shri Rakesh Toteja	Director
Ms. Manjeet Kaur	Deputy Director
Shri Roopesh D	Deputy Director
Shri Pranav Shukla	Deputy Director
Smt. Suparna Sukumaran	Assistant Director

ABBREVIATIONS

CWC	Central Water Commission
BB	Brahmaputra Board
DEM	Digital Elevation Model
DoS	Department of Space
DoWR, RD &GR	Department of Water Resources, River Development & Ganga Rejuvenation
GFCC	Ganga Flood Control Commission
GIS	Geographic Information System
GLOF	Glacial Lake Outburst Flood
HH	Horizontal Horizontal
HV	Horizontal Vertical
ICID	International Commission on Irrigation and Drainage
IIT	India Institute of Technology
IMD	India Meteorological Department
Mha	Million hectare
MHA	Ministry of Home Affairs
MIR	Mid Infra-Red
MNDWI	Modified Normalized Water Difference Index
MoA&FW	Ministry of Agriculture and Farmer’s Welfare
MSI	Multispectral Instrument
NASA	National Aeronautics and Space Administration
NDMA	National Disaster Management Authority
NIH	National Institute of Hydrology
NIR	Near Infrared
NRSC	National Remote Sensing Centre
PSUs	Public Sector Undertakings
RBA	Rashtriya Barh Aayog
SAR	Synthetic Aperture Radius
SDMA	State Disaster Management Authority
SoI	Survey of India
SRTM	Shuttle Radar Topography Mission
SWIR	Short Wave Infra-Red
USGS	United States Geological Survey
UTs	Union Territories
VH	Vertical Horizontal
VV	Vertical Vertical

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EXECUTIVE SUMMARY

Flood studies involving technical analysis of historical flood data aids in flood risk reduction, early flood warning and planning of flood management measures proving extremely beneficial in minimizing impact and losses caused due to floods.

The Rashtriya Barh Ayog (RBA) - 1980, had defined the maximum area damaged in any one of the years is assumed to be the area liable to floods in the State and estimated the total area liable to floods in the country as 40 Mha (1953-1978). Ganga Flood Control Commission (GFCC) - 2006, in the context of granting aid to various States under “Flood Prone Area Development Programme” proposed by Govt. of India, identified 39 districts in India as flood prone by adopting a threshold value of average percentage area flooded more than 15% for identifying flood prone districts (1995-2004). Subsequently, the extent of maximum area affected by floods is updated by XII Plan Working Group (WG) on Flood Management and Region-Specific issues in 2011 as 49.815 Mha (1953-2010). National Remote Sensing Centre (NRSC) -2023, has prepared Flood Affected Area Atlas of India using flood event satellite imagery (1998-2022) and GIS technology and estimated it as 15.75 Mha.

In line with the suggestions of erstwhile Planning Commission, the then MoWR had constituted an Expert Committee for Scientific Assessment of Flood Prone Areas in India under the Chairmanship of Chairman, Central Water Commission (CWC) in July, 2012 and had representation from Ministry of Home Affairs (MHA), Niti Aayog, National Disaster Management Authority (NDMA), National Remote Sensing Centre (NRSC), Department of Space (DoS), Ministry of Agriculture and Farmers Welfare (MoA & FW), India Meteorological Department (IMD), Ganga Flood Control Commission (GFCC), Brahmaputra Board (BB), Survey of India (SoI), Department of Water Resources, River Development and Ganga Rejuvenation (DoWR, RD & GR), Professors from Indian Institutes of Technology (IIT) Roorkee & Guwahati and officials of CWC. Further, Regional Committees for each State / UT have been constituted having Principal Secretary (WRD) of Respective States / UTs as Chairman and representation from CWC, BB, GFCC, Engineer-in-Chief / Concerned Chief Engineer of State Govt., local unit of National Institute of Hydrology (NIH), regional office of SoI, regional office of NRSC, State Disaster Management Authority (SDMA) as per jurisdiction.

Central Water Commission had explored various available options for delineating the flood prone areas by implementing elaborate practices and criteria, for example: by mathematical modelling using MIKE-11, MIKE-GIS & Arc-GIS software and based on remote sensing technique by using satellite imageries on Google Earth Engine Application Program Interface and GIS technology. Subsequently, CWC had carried out a study to delineate aggregated extent of flood affected areas in India by analyzing the satellite imageries of Landsat (1986-2019) and Sentinel 1 & 2 (2015-2019). The layers were shared with the States / UTs for ground verification and validation. Ground verified and validated layers / maps of flood affected areas from the States / UTs have been obtained by CWC.

Further the same study was extended upto 2022 and the total inundated areas in India delineated from analyzing the optical and Multispectral data of Landsat & Sentinel- 2, Microwave data of Sentinel-1 is assessed as 21.213 Mha. The main objective of this study is to identify and delineate the region-specific maximum aggregated extent of inundated areas of entire India.

The maps aid to identify areas that are susceptible to flooding and raise the necessity for the development of early warning systems to mitigate the impacts of floods, advance development of flood management strategies, planning emergency response measures, infrastructure development to prevent damage caused by floods.

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Assessment of Areas Affected due to Floods in India

1.0 Introduction

As per International Commission on Irrigation and Drainage (ICID), Flood is defined as: A relatively high flow or stage in a river, markedly higher than the usual; also, the inundation of low land which may result therefrom. A body of water, rising swelling and over-flowing land not usually thus covered. Also deluge; a freshet.

Flood is the most prevalent and damaging natural disaster in the world which devastates both life and economy on large extent. It is a recurrent phenomenon in India and cause huge losses to lives, properties, livelihood systems, infrastructure and public utilities. Floods occur due to a variety of causes in almost all river basins. In India, as distribution of precipitation is not uniform, some areas receive heavy rainfall while some are at deficit. The disparity of rainfall also varies time to time; the areas which are not traditionally prone to floods also experience severe inundation due to landslides, downpour and cloud bursting. Urban flooding due to storm water drainage congestion (pluvial in nature) has also become common in towns / cities due to such extreme meteorological events, this point towards the need for the proper flood management system.

Causes / Situations of Flood: -

(i) Streams carrying flows in excess of the transporting capacity within their banks, thus overflowing adjoining land
(ii) Back water effect in the tributaries when they meet river to the extent that water spill beyond their banks
(iii) High rainfall corresponding to river spills
(iv) Heavy local rainfall
(v) Typhoons and cyclones
(vi) Drainage congestions
(vii) Blockade due to landslides causing the backwater to overflow river banks
(viii) Floods due to high tides etc.
(ix) Glacial Lake Outburst Flood (GLOF)
(x) Breach of embankments

Floods cannot be completely prevented; however, these can be managed effectively to minimize the damages / detrimental effects of flood waters.

Structural Measures / Control Protection Works

- Embankments and flood walls or dowel walls
- Reservoirs
- Natural detention basins
- Channel / drainage improvement
- Emergency flood ways
- River diversions
- Inter basin transfer
- Bank stabilization and anti-erosion measures
- Ring bunds
- Underground storage etc.

Non-Structural Measures / Modifying the susceptibility to flood damage

- Flood plain management
- Development and redevelopment policies
- Flood proofing
- Disaster preparedness and response planning.
- Flood forecasting and flood early warning etc.

The number of lives lost due to river floods has declined due to improved flood warning, protection measures and heightened hazard awareness. However, the damages due to river floods has risen. The increase in damages can be attributed to many reasons including a steep increase in population, rapid urbanization, growing developmental and economic activities in flood plains coupled with evidences of climate change.

The availability of information on the spatial extent of the flood affected areas is an important element in flood management for taking decisions and action. Proper assessment of flood affected areas helps the planner in prioritisation and deciding the specific measures required to be undertaken. Development of flood affected areas map or inundation maps form the base of flood risk management.

2.0 Past Efforts

The **Rashtriya Barh Ayog (RBA)** had defined the maximum area damaged in any one of the years is assumed to be the area liable to floods in the State. RBA had estimated in 1980, the figures of annual damage by floods and drainage congestion (1953 - 1978) reported to the Central Water Commission by the States and found that total area liable to floods in the country as **40 million hectares (Mha)**. RBA - State-wise summation of maxima of area affected in any year is given in **Table - 2.1**.

Table - 2.1: RBA – State-Wise Summation of Maxima of Area Affected

Sl. No	Details of area	Value
(i)	Sum of maxima of area affected in each State in any one of the years during the period 1953 to 1978 (33.516 Mha ~ 34 Mha)	34 Mha
(ii)	Area protected (9.7767 Mha ~ 10 Mha)	10 Mha
(iii)	During the years of high floods at least some protected areas also are affected due to failure of some protection works; the extent of such areas has not been reported by the States. Assuming such area accounted for in the 34 Mha, to be about 4 Mha	4 Mha
Total	**Area liable to floods = (i) + (ii) – (iii)**	**40 Mha**

Source: Rashtriya Barh Ayog Report, Volume -I, March 1980

In 2006, the Committee headed by Chairman, **Ganga Flood Control Commission (GFCC)**, Patna for identification and categorization of flood prone districts in the whole country in the context of granting aid to various States under “Flood Prone Area Development Programme” proposed by Govt. of India, had identified **39 districts** in India as flood prone. The Committee adopted a threshold value of average percentage area flooded more than 15% for identifying flood prone districts, which was purely an arbitrary figure. The same was tentatively accepted by erstwhile Planning Commission in 2011 till a better methodology emerges. The

maximum flooded area in a year during the period 1995 - 2004 was worked out for each State, which was treated as flood prone area.

Subsequently, the extent of maximum area affected by floods has been updated by **XII Plan Working Group** (WG 2011) on Flood Management and Region-Specific Issues constituted by the erstwhile Planning Commission as **49.815 Mha** based upon the data (1953-2010) reported by the State Revenue Authorities and Ministry of Home Affairs (MHA).

In 2023, **National Remote Sensing Centre (NRSC)** has prepared Flood Affected Area Atlas of India using satellite imagery and GIS technology. NRSC has estimated **15.75 Mha** as the aggregated flood affected area based on the digital archival of spatial flood data that were generated during the flood events from 1998 to 2022. However, some of the major floods were experienced in the period prior to that which were not captured in this study and therefore aggregated flood affected area indicated in the study is on lower side.

3.0 Present Study by Central Water Commission

This study is carried out to identify and delineate the region-specific maximum aggregated extent of inundated areas of entire country. All the flood events captured by the satellite imageries during the period 1986 – 2022 were incorporated for delineating the areas inundated due to floods. A flood affected area is an area of land adjoining a stream/ watercourse / river which is susceptible to being inundated due to floods in any given year, obtained by aggregating each pixel wetted at least once in a year in any satellite source. In the absence of detailed hydrologic and hydraulic calculations for large areal extents, identification of flood affected areas has been done based on information about historical flooding extent.

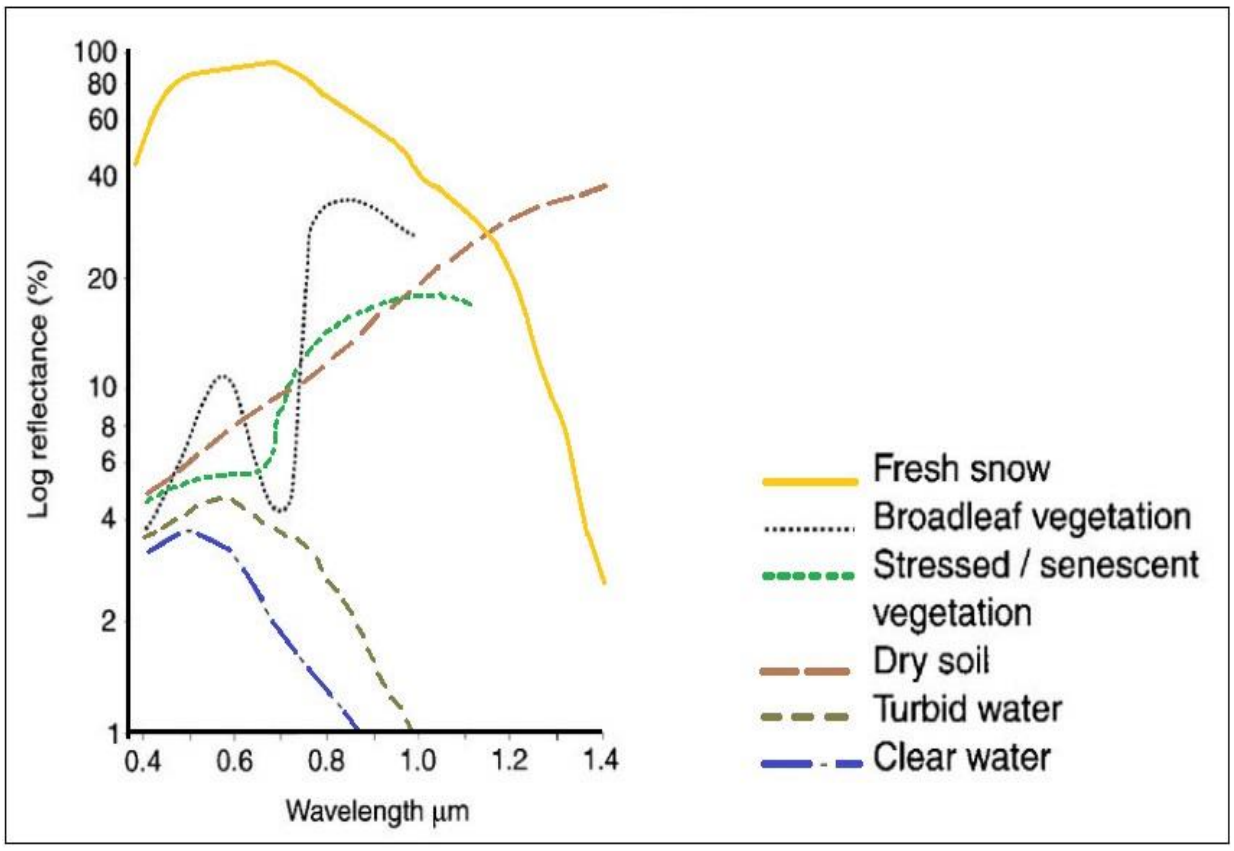
3.1 Remote Sensing Techniques

Remote sensing is used for detecting and monitoring myriad physical characteristics of a location / area / object by measuring the reflected and emitted radiation at a distance utilizing the aircraft or satellite or Lidar etc. There are two types of remote sensing namely Passive and Active.

Passive systems operate in the visible, infrared- thermal infrared, and microwave portions of the electromagnetic spectrum. These sensors measure land and sea surface temperature, vegetation properties, cloud and aerosol properties, and other physical attributes. The electromagnetic spectrum is composed of a range of different wavelengths or colours of light energy. A multispectral remote sensing instrument collects light energy within specific regions of the electromagnetic spectrum.

Active remote sensing - A form of remote sensing where the remote sensor provides its own source of electromagnetic radiation. Radiation also differs by wavelengths that fall into short (visible, NIR, MIR) and long (microwave). Each active sensor in remote sensing directs its signal to the object and then checks the response. The majority of devices employ microwaves since they are relatively immune to weather conditions.

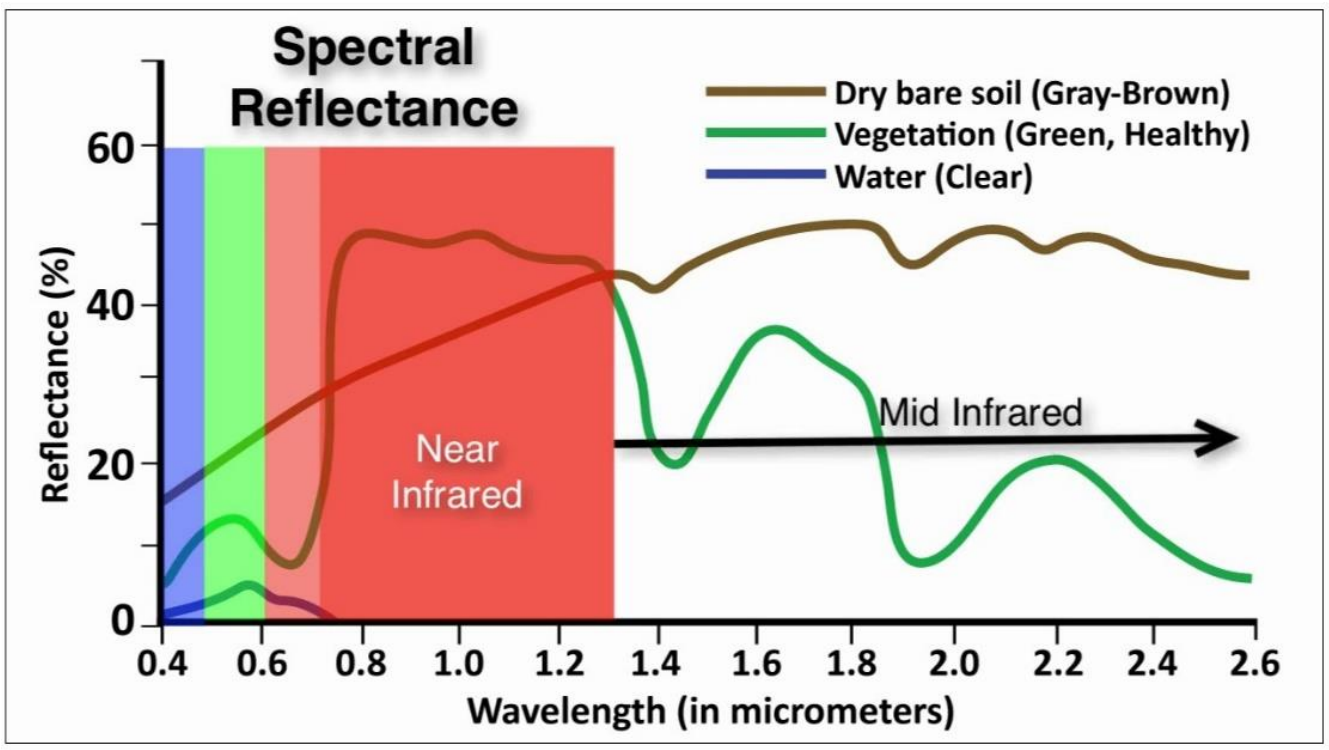
Reflectance of water ranges from 5 to 70%. Reflectance of the water is low at lower incidence angle and increases for higher incidence angles. Spectral reflectance curves (Spectral Signatures) for different natural surfaces in Visible and NIR wavelengths is given in **Figure - 3.1.1.**



Source: D Nagesh Kumar (2022)

Figure - 3.1.1: Spectral Reflectance Curves (Spectral Signatures) for different Natural Surfaces in Visible and NIR Wavelengths

Water in its different states exhibits varied spectral reflectance. Visible region of the electromagnetic radiation is between 0.4µm and 0.7µm, and around 0.6µm water in the liquid form shows high reflectance. Wavelengths beyond 0.7µm are completely absorbed (no curve formed beyond 0.7µm). Clear water appears in darker tone in the Near Infrared (NIR) image. Spectral reflectance curve for vegetation, soil and water is given in **Figure - 3.1.2.**



Source: T M Lillesand & Kiefer (2003)

Figure - 3.1.2: Spectral Reflectance Curves for Vegetation, Soil and Water

Based on the remote sensing approach, CWC has carried out a study for the assessment of areas affected due to floods in India using the freely available historical data with Google Earth Engine data repository (Satellite imageries captured by Landsat, Sentinel 1 & 2) and GIS technology. Google Earth Engine combines a multi-petabyte catalogue of satellite imagery and geospatial datasets with planetary-scale analysis capabilities and is available for scientists, researchers, and developers to detect changes, map trends, and quantify differences on the Earth's surface.

Details of Remote Sensing datasets used for extraction of flood affected areas is given in **Table - 3.1.1.**

Table- 3.1.1: Details of Remote Sensing Datasets

Sl. No.	Product	Spatial Resolution and Bands	Temporal Resolution
1	Landsat-4 (1982-1993)	30 m SWIR: 'B5', NIR: 'B4', Red: 'B3', Green: 'B2', Blue: 'B1'	16 days
2	Landsat-5 (1984-2012)	30 m SWIR: 'B5', NIR: 'B4', Red: 'B3', Green: 'B2', Blue: 'B1'	16 days
3	Landsat-7 (1999-2021)	30 m SWIR: 'B5', NIR: 'B4', Red: 'B3', Green: 'B2', Blue: 'B1'	16 days
4	Landsat-8 (2013-Present)	30 m SWIR: 'B6', NIR: 'B5', Red: 'B4', Green: 'B3', Blue: 'B2'	16 days
5	Sentinel-1 (2014-Present)	10 m HH, HV, VV, VH	6 days
6	Sentinel-2 (2015-Present)	10 m SWIR: 'B11', NIR: 'B8', Red: 'B4', Green: 'B3', Blue: 'B2'	5 days

3.1.1 Landsat Program

Landsat, a joint program of the USGS and NASA, has been observing the Earth continuously from 1972 through the present day. Today the Landsat satellites image the entire Earth's surface at a 30-meter resolution about once every two weeks, including multispectral and thermal data. The Landsat scene size is 185-km-cross-track-by-180-km-along-track

Landsat program is archive of Earth images

a. Landsat - 4 & 5 (LT04 & LT05): Multi Spectral Scanner - 60m resolution (0.5 - 1.1 wavelength - micrometer) and Thematic Mapper - 30m resolution (0.45 - 2.35 wavelength)

b. Landsat - 7 (LE07): Enhanced Thematic Mapper Plus - 30 m resolution and 15m -resolution panchromatic band (0.45 - 2.35 wavelength)

c. Landsat - 8 (LC08): Operational Land Imager - 30m resolution (0.435 - 2.294 wavelength) and Thermal Infrared Sensor (10.4 - 12.5)

3.1.2 Sentinel - 1 Imageries

The Sentinels are a constellation of satellites developed by European Space Agency (ESA) to operationalize the Copernicus program, which include all-weather radar images from Sentinel-1A and 1B, high-resolution optical images from Sentinel-2A and 2B.

The Sentinel-1 mission provides data from a dual-polarization C-band Synthetic Aperture Radar (SAR) instrument at 5.405GHz (C band). This collection includes the S1 Ground Range Detected (GRD) scenes, processed using the Sentinel-1 Toolbox to generate a calibrated, ortho-corrected product. The collection is updated daily, new assets are ingested within two days after they become available. Each scene has one of 3 resolutions (10, 25 or 40 meters), 4 band combinations (corresponding to scene polarization) and 3 instrument modes. Use of the collection in a mosaic context will likely require filtering down to a homogeneous set of bands and parameters. Each scene contains either 1 or 2 out of 4 possible polarization bands, depending on the instrument's polarization settings.

The possible combinations are single band VV or HH, and dual band VV+VH and HH+HV:

1. VV: single co-polarization, vertical transmit / vertical receive
2. HH: single co-polarization, horizontal transmit / horizontal receive
3. VV + VH: dual-band cross-polarization, vertical transmit / horizontal receive
4. HH + HV: dual-band cross-polarization, horizontal transmit / vertical receive

Each scene also includes an additional 'angle' band that contains the approximate incidence angle from ellipsoid in degrees at every point. This band is generated by interpolating the 'incidence Angle' property of the 'geolocation Grid Point' gridded field provided with each asset.

Each scene was pre-processed with Sentinel-1 Toolbox using the following steps:

1. Thermal noise removal
2. Radiometric calibration
3. Terrain correction using Shuttle Radar Topography Mission (SRTM) 30 or ASTER Digital Elevation Model (DEM) for areas greater than 60 degrees latitude, where SRTM is not available. The final terrain-corrected values are converted to decibels via log scaling (10*log10(x)).

SAR instruments are capable of acquiring meaningful data in all weather conditions during daytime and nighttime. The mission is composed of a constellation of two satellites, Sentinel-1A and Sentinel-1B, sharing the same orbital plane. Sentinel-1 has the interferometric wide swath of 250 km with 29 - 46 incidence angle and 5 x 20 m spatial resolution. Sentinel - 1A & 1B has 12-day repeat cycle at Equator with one satellite and 175 orbits per cycle for a single satellite, share the same orbit plane with a 180° orbital phasing difference. The two-satellite constellation offers a 6-day exact repeat cycle. The constellation will have a repeat frequency (ascending / descending) of 3 days at the equator.

The microwave portion of the spectrum covers the range from approximately 1cm to 1m in wavelength. Longer wavelength microwave radiation can penetrate through cloud cover, haze, dust, and all but the heaviest rainfall as the longer wavelengths is not susceptible to atmospheric scattering which affects shorter optical wavelengths. This property allows detection of microwave energy under almost all weather and environmental conditions so that data can be collected at any time.

3.1.3 Sentinel - 2 Imageries

The Copernicus Sentinel-2 mission comprises a constellation of two polar-orbiting satellites placed in the same sun-synchronous orbit, phased at 180° to each other. The Sentinel-2 mission collects high-resolution multispectral imagery. It aims at monitoring variability in land surface conditions, and its wide swath width (290 km) and high revisit time (10 days at the equator with one satellite, and 5 days with 2 satellites under cloud-free conditions which results in 2-3 days at mid-latitudes) will support monitoring of Earth's surface changes. The S2 Multispectral Instrument (MSI) samples 13 spectral bands: visible and Near-Infra Red (NIR) at 10 meters, red edge and Short Wave Infra-Red (SWIR) at 20 meters, and atmospheric bands at 60 meters spatial resolution. It provides data suitable for assessing state and change of vegetation, soil, and water cover as well as observation of inland waterways and coastal areas.

3.2 Methodology of the Study

The steps adopted for delineating aggregated extent of flood affected areas in India are as follows:

i. To delineate the areas affected due to floods in India based on the remote sensing technique using Satellite Imageries for all the States / UTs with the freely available data viz. Optical and Multispectral of Landsat & Sentinel- 2, Microwave of Sentinel-1 pertaining to India are sorted out in Google Earth Engine data repository.

ii. For detection of inundated areas in the satellite dataset, image collected in the repository are from 1st June to 31st October and for States / UTs with retreating monsoon the dataset was extended till 31st December.

iii. For the necessary location-based output w.r.t the State / UT, satellite dataset is filtered corresponding to the area of the respective State / UT. The data is further analyzed for discarding the pixels with cloud cover. Optical dataset is filtered to remove pixels with cloud cover greater than 20%.

iv. The satellite data of Google Earth Engine repository is interpreted for the signature of water. For detection of water in the pixels of Optical dataset, Modified Normalized Water Difference Index (MNDWI) is computed and for detection of water in the pixels of microwave dataset, reflectance of water is computed using the threshold values.

v. A lean season run for filtering the pre-monsoon pixels from the flood inundation is analyzed for the month of May. These pixels are further filtered to avoid the locations with higher altitude State / UT - wise.

vi. Inundated areas are obtained by aggregating the pixels of satellite dataset which were analyzed as above. Year-wise accumulation for each pixel wetted at least once in a year in any satellite source is incorporated.

vii. Final product / layer derived from Google Earth Engine Application Program Interface is further processed in Arc-GIS. Arc-GIS offers unique capabilities for applying location-based analytics and gain greater insights using contextual tools to visualize and analyse the data. Using Arc-GIS software, which offers location-based analysis for inundation mapping, all the layers viz. river network, State boundary etc. is used in Projected Coordinate System.

viii. Areas with the higher Normalized Difference Vegetation Index (NDVI) were discarded from the Modified Normalized Difference Water Index (MNDWI) pixels. Noises in the inundation maps were removed manually.

ix. These maps were further processed using Height Above the Nearest Drainage (HAND) tool by filling the pixels with the modified kern. The HAND model fills the pixels which were drained out before the satellite passes over the region. The HAND model normalizes topography according to the local relative heights found along the drainage network, and in this way, presents the topology of the relative local draining potentials. HAND tool utilizes the DEM for processing, in this study SRTM DEM is used.

x. Aggregated extent of flood affected areas is delineated State-wise and the corresponding areas is evaluated. Layer is used on projected coordinate system, and a map is delineated corresponding to State / UT.

xi. Rivers, water-logged areas and water bodies from these maps are removed using pre-monsoon inundation maps and using the existing shape file of river, water-logged areas and water bodies.

xii. Aggregated extent of flood map is further incorporated with the river network for identification of the locality and modality of the map.

xiii. The flowchart of methodology adopted for Satellite Data Analysis is presented in **Figure - 3.2.1**

xiv. The flowchart of methodology adopted in Arc-GIS Data Analysis is presented in **Figure - 3.2.2.**

xv. CWC had carried out a study based on the above methodology and delineated aggregated extent of flood affected areas in India by analysing the satellite imageries of Landsat (1986-2019) and Sentinel 1 & 2 (2015-2019). The layers were shared with the States / UTs for ground verification and validation. CWC has demonstrated a detailed procedure on ground verification using the google earth to all the States / UTs. The main steps involved in ground verification are as follows;

a) Removal of polygons which are not part of the flood affected areas
b) Merging of the isolated polygons into one single polygon based on the elevation in the google earth
c) Addition of the flood affected areas polygon which may be left out in the study
d) Addition of the polyline for embankments built for protection of the low-lying areas / areas getting inundated due to floods
e) Demarcating the areas protected by embankments which are part of flood affected areas

xvi. Ground verified and validated layers / maps of flood affected areas from the States / UTs have been submitted to CWC.

xvii. Study is further refined / updated till December - 2022

Flowchart for Satellite Data Analysis

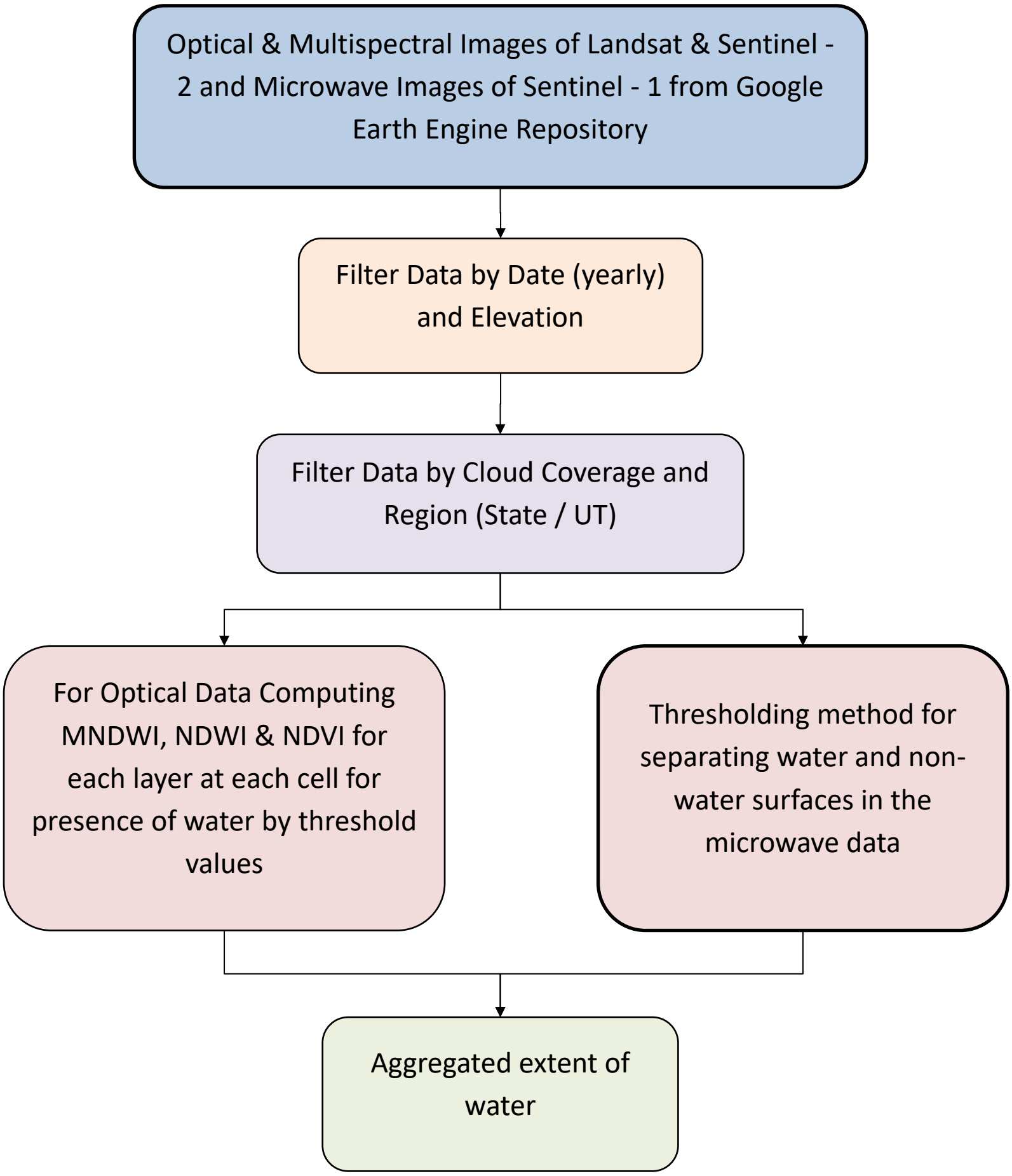


Figure - 3.2.1: Flowchart for Satellite Data Analysis

Flowchart for Arc-GIS Data Analysis

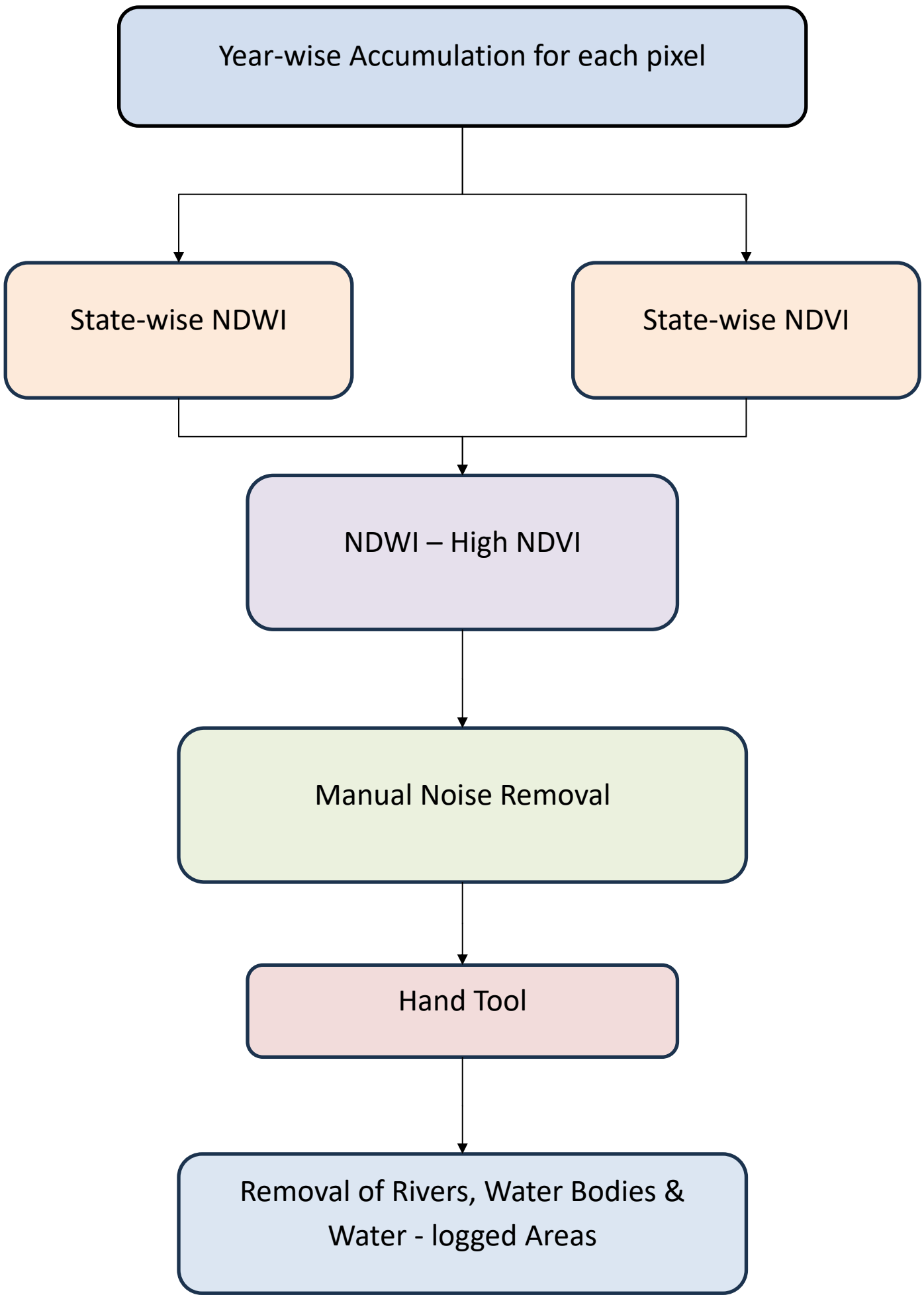


Figure - 3.2.2: Flowchart for Arc-GIS Data Analysis

4.0 Outcomes of the Study

The study focuses on analysis of long-term flood inundation maps and preparation of areas affected due to floods at country level which represents the overall scenario and identifications of flood damaged regions. Findings of aggregated extent of flood affected areas in India derived from satellite dataset (Landsat & Sentinel 1986 - 2022) is shown in the **Figure - 4.1.** States / UTs -wise aggregated extent of flood affected areas is tabulated in **Table - 4.1**.

Further, areas liable to floods as assessed by RBA (1980) along with the area protected till 1978 and State-wise flood affected areas assessed from CWC's study (2023) and the area protected upto 2017 is given in the aforesaid table.

Total flood affected areas in India delineated from analyzing the freely available Landsat and Sentinel-1 & 2 data on Google Earth Engine Application Program Interface and GIS technology during the period 1986 - 2022 is assessed as **21.213 Mha**. Maps showing States / UTs -wise aggregated extent of flood affected areas is given at **Annexure-I**.

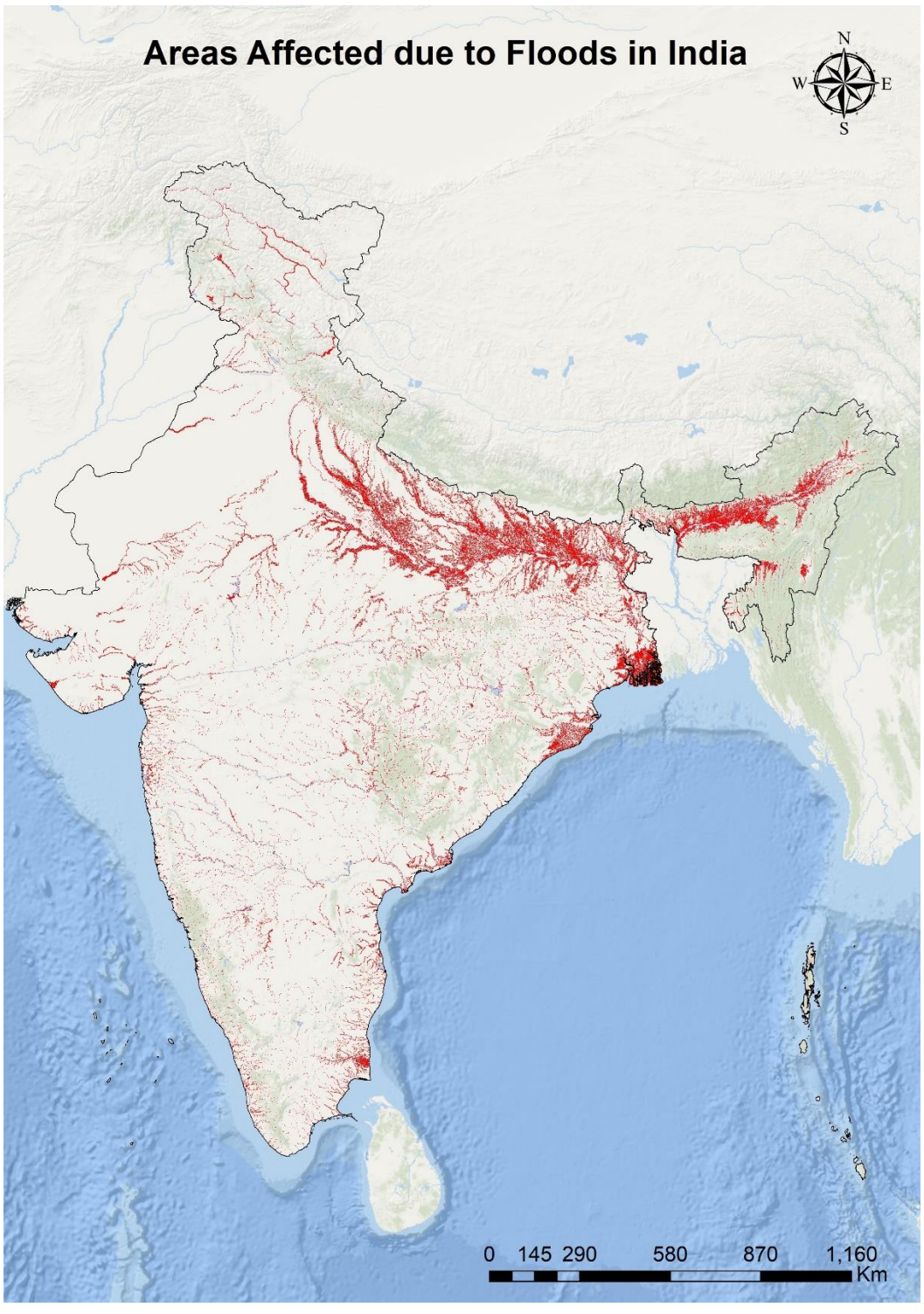


Figure - 4.1: Aggregated Extent of Flood Affected Areas in India (1986 - 2022)

Table - 4.1: States / UTs - wise Aggregated Extent of Flood Affected Areas

Sl. No.	State / UT	RBA - 1980 (1953 - 1978)		Total in Mha (c) = (a) + (b)	CWC - 2023 (1986 - 2022)		Total in Mha (r) = (p) + (q)
		Area Affected in Mha (a)	Area Protected in Mha (b)		Area Affected in Mha (p)	Area Protected in Mha (q)	
1	Andhra Pradesh	1.390	0.700	2.090	0.699	1.310	2.009
2	Arunachal Pradesh	-	-	-	0.106	0.100	0.206
3	Assam	3.150	1.305	4.455	2.477	2.110	4.587
4	Bihar	4.260	1.566	5.826	2.914	3.692	6.606
5	Chhattisgarh	-	-	-	0.447	0.000	0.447
6	Goa	-	-	-	0.024	0.003	0.027
7	Gujarat	1.390	0.362	1.752	0.588	0.483	1.071
8	Haryana	2.350	1.095	3.445	0.130	2.000	2.130
9	Himachal Pradesh	0.230	-	0.230	0.172	0.018	0.190
10	Jharkhand	-	-	-	0.413	0.001	0.414
11	Karnataka	0.020	0.001	0.021	0.536	0.005	0.541
12	Kerala	0.870	0.011	0.881	0.253	0.346	0.599
13	Madhya Pradesh	0.260	-	0.260	0.982	0.004	0.986
14	Maharashtra	0.230	0.001	0.231	0.888	0.001	0.889
15	Manipur	0.080	0.073	0.153	0.083	0.132	0.215
16	Meghalaya	0.020	0.075	0.095	0.050	0.015	0.065
17	Mizoram	-	-	-	0.026	0.000	0.026
18	Nagaland	-	-	-	0.016	0.632	0.648
19	Odisha	1.400	0.351	1.751	1.024	0.630	1.654
20	Punjab	3.700	2.407	6.107	0.121	3.190	3.311
21	Rajasthan	3.260	0.016	3.276	0.712	0.082	0.794
22	Sikkim	-	-	-	0.005	0.041	0.046
23	Tamil Nadu	0.450	0.030	0.480	0.665	0.122	0.787
24	Telangana	-	-	-	0.216	-	0.221
25	Tripura	0.330	0.009	0.339	0.062	0.033	0.095
26	Uttar Pradesh	7.336	0.739	8.075	5.174	1.703	6.877

Sl. No.	State / UT	RBA - 1980 (1953 - 1978)		Total in Mha (c) = (a) + (b)	CWC - 2023 (1986 - 2022)		Total in Mha (r) = (p) + (q)
		Area Affected in Mha (a)	Area Protected in Mha (b)		Area Affected in Mha (p)	Area Protected in Mha (q)	
27	Uttarakhand	-	-	-	0.114	0.002	0.116
28	West Bengal	2.650	1.001	3.651	1.840	3.584	5.424
29	A & N	-	-	-	0.020	-	0.019
30	Chandigarh	-	-	-	0.000	-	0.000
31	Daman, Diu and Dadar & Nagar Haveli	-	-	-	0.002	-	0.002
32	Delhi	0.050	0.023	0.073	0.010	0.078	0.088
33	Jammu & Kashmir	0.080	0.012	0.092	0.166	0.217	0.383
34	Ladakh	-	-	-	0.270	-	0.270
35	Lakshadweep	-	-	-	0.000	-	0.000
36	Puducherry	0.010	0.000	0.010	0.008	0.004	0.012
	TOTAL	**33.516**	**9.777**	**43.293**	**21.213**	**20.538**	**41.755**
(i)	Total Area Affected	34			21.213		
(ii)	Area Protected	10			20.538		
(iii)	Some protected areas affected due to failure of protection work, already accounted for under (i)	4			-		
	Area liable to floods = (i) + (ii) – (iii)	**40**			**41.751***		

***** *Since there is no specific criteria / study carried out for identification of areas inundated due to failure of some protection works, no deduction has been considered in this study as assumed by RBA-1980. Also, during the intervening period more protection works may have improved and more protection works have been carried out at local levels which may not have been reported.*

Flood Affected Areas during the period 1986-2022 and the area protected till 2017 is shown in **Figure- 4.2**.

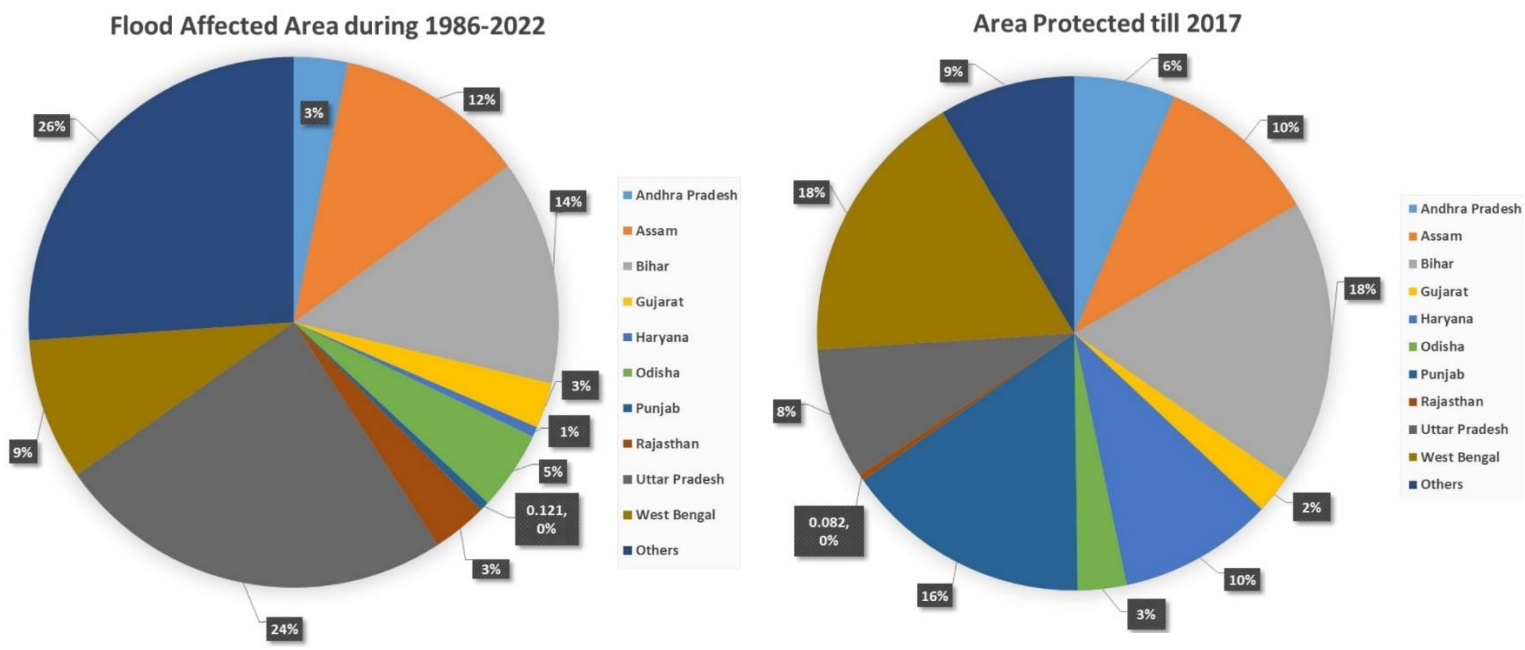


Figure - 4.2: Flood Affected Areas during the period 1986-2022 & Area Protected till 2017

4.1 Basin-wise Flood Affected Areas in India

Damages due to floods in the Ganga and Brahmaputra basin States / UTs account for about 70-75 percent of the total in country. In the North-East region, the major rivers are the Brahmaputra and Barak & their tributaries. The catchments of these rivers receive very heavy rainfall ranging from 1100 mm to 6350 mm in a year which occurs mostly during the months of May / June to September. As a result, floods in this region are severe and quite frequent.

Ganga has a large number of tributaries, the major ones being the Yamuna, Sone, Ghaghara, Gandak, Kosi and Mahananda. The normal annual rainfall of this region varies from about 600 mm in the western part to about 1900 mm in the eastern, of which more than 80% occurs during the south west monsoon. The rainfall increases from west to east and from south to north. The flood problem is mostly confined to the areas on the northern bank of the river Ganga. The damage is caused by the northern tributaries of the Ganga by spilling over their banks and changing their courses.

In Western India, Central India and Deccan Region the important rivers are Narmada, Tapi, Mahanadi, Godavari, Krishna and Cauvery. These rivers have mostly well-defined stable courses. They have adequate capacities within the natural banks to carry the flood discharge except in the delta area. The annual rainfall over the Western Ghats can be as high as 5000 mm; in the remaining areas it varies from about 750 mm to 1250 mm.

Basin-wise flood affected areas estimated in India based on the study adopted by CWC shows that about 10 - 15% of the total flood affected areas in the country is susceptible to flooding by the Brahmaputra River and about 55 - 60% of the total flood affected areas in the country is susceptible to flooding by the Ganga River. About 30 - 35% of the total flood affected areas in the country is susceptible to flooding by the rest of the rivers.

Basin-wise flood affected areas in India is tabulated in **Table - 4.1.1** and the basin-wise percentage of flood affected areas is shown in the **Figure - 4.1.1**.

Table - 4.1.1: Basin-wise Flood Affected Areas in India

Sl. No.	Basin	River Basin Area in Mha	Flood Affected Areas in Mha	% of Areas Affected due to Floods
1	Indus (Up to border)	31.754	0.727	2.29
2	Godavari	30.206	0.956	3.17
3	Krishna	25.393	0.723	2.85
4	Cauvery	8.558	0.364	4.26
5	Subarnarekha	2.571	0.127	4.94
6	Brahmani and Baitarani	5.190	0.294	5.66
7	Mahanadi	13.966	0.937	6.71
8	Pennar	5.429	0.130	2.40
9	Mahi	3.815	0.091	2.38
10	Sabarmati	3.086	0.084	2.71
11	Narmada	9.355	0.237	2.53
12	Tapi	6.347	0.107	1.69
13	West flowing rivers from Tapi to Tadri	5.678	0.332	5.86
14	West flowing rivers from Tadri to Kanyakumari	5.513	0.311	5.64
15	East flowing rivers between Mahanadi and Pennar	8.086	0.294	3.64
16	East flowing rivers between Pennar and Kanyakumari	10.251	0.477	4.65
17	West flowing rivers of Kutch and Saurashtra including Luni	18.628	0.572	3.07
18	Area of Inland drainage in Rajasthan	13.677	0.000	0.00
19	Minor rivers draining into Myanmar and Bangladesh	3.010	0.093	3.07
20	Area of North Ladakh not draining into Indus Basin	2.963	0.003	0.09
21	Drainage Area of Andaman and Nicobar Islands Basin	0.758	0.019	2.54
22	Drainage Area of Lakshadweep Islands Basin	0.067	0.000	0.00
23	Ganga	80.861	11.409	14.11
24	Brahmaputra	18.643	2.648	14.20
25	Barak and others	4.551	0.278	6.12

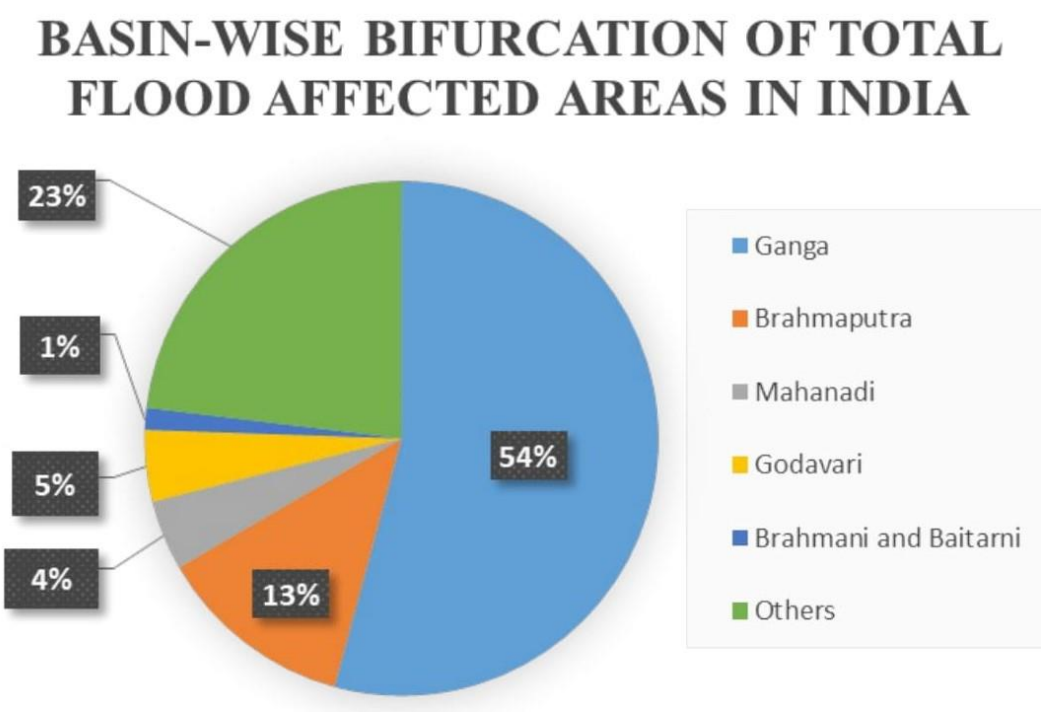


Figure - 4.1.1: Basin-wise bifurcation of total flood affected areas in India

5.0 Application of the study

Flood affected areas in India maps / layers delineated by CWC based on the Satellite Imageries aid to identify areas that are susceptible to flooding, development of early warning systems to mitigate the impacts of floods, advance development of flood management strategies, planning the emergency response measures, infrastructure development to prevent damage caused by floods. These maps can be used for further analysis at Sub-District, District and Regional levels.

Outcome of the study can be used for following purposes:

- General planning of flood management activities;
- Disaster management activities;
- Allocation of resources in flood management activities;
- For community awareness.

Limitations in the study

- The dataset used for delineating inundation maps are Optical from 1986 – 2014 which is not cloud free. Freely available microwave data is from 2015 onwards.
- Flood inundation area below the canopy cannot be detected by the satellite imageries.

ANNEXURE -I

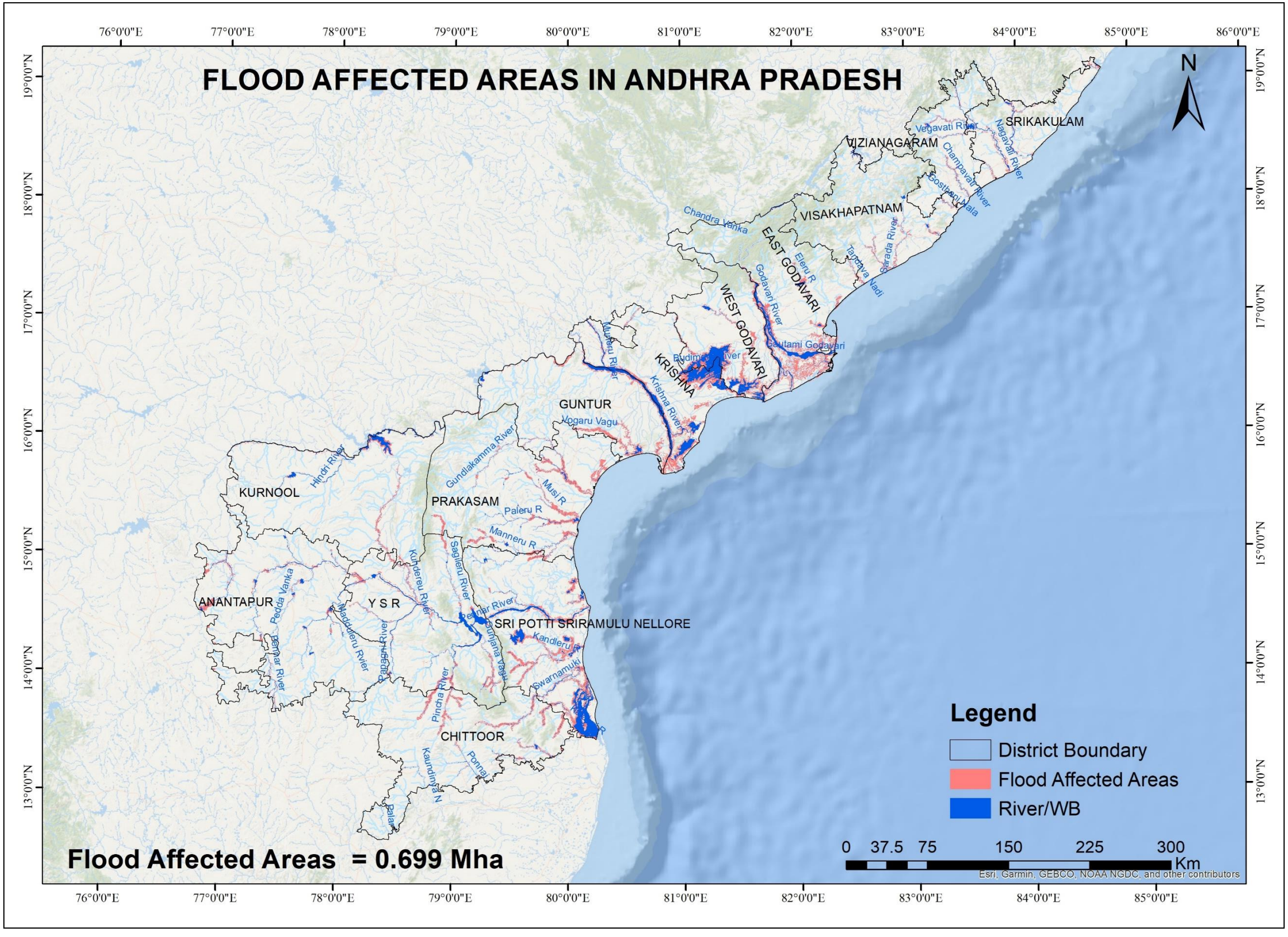
MAPS SHOWING

STATES / UTS –WISE AGGREGATED EXTENT OF FLOOD AFFECTED AREAS

&

ANALYSIS OF DISTRICT-WISE FLOOD AFFECTED AREAS

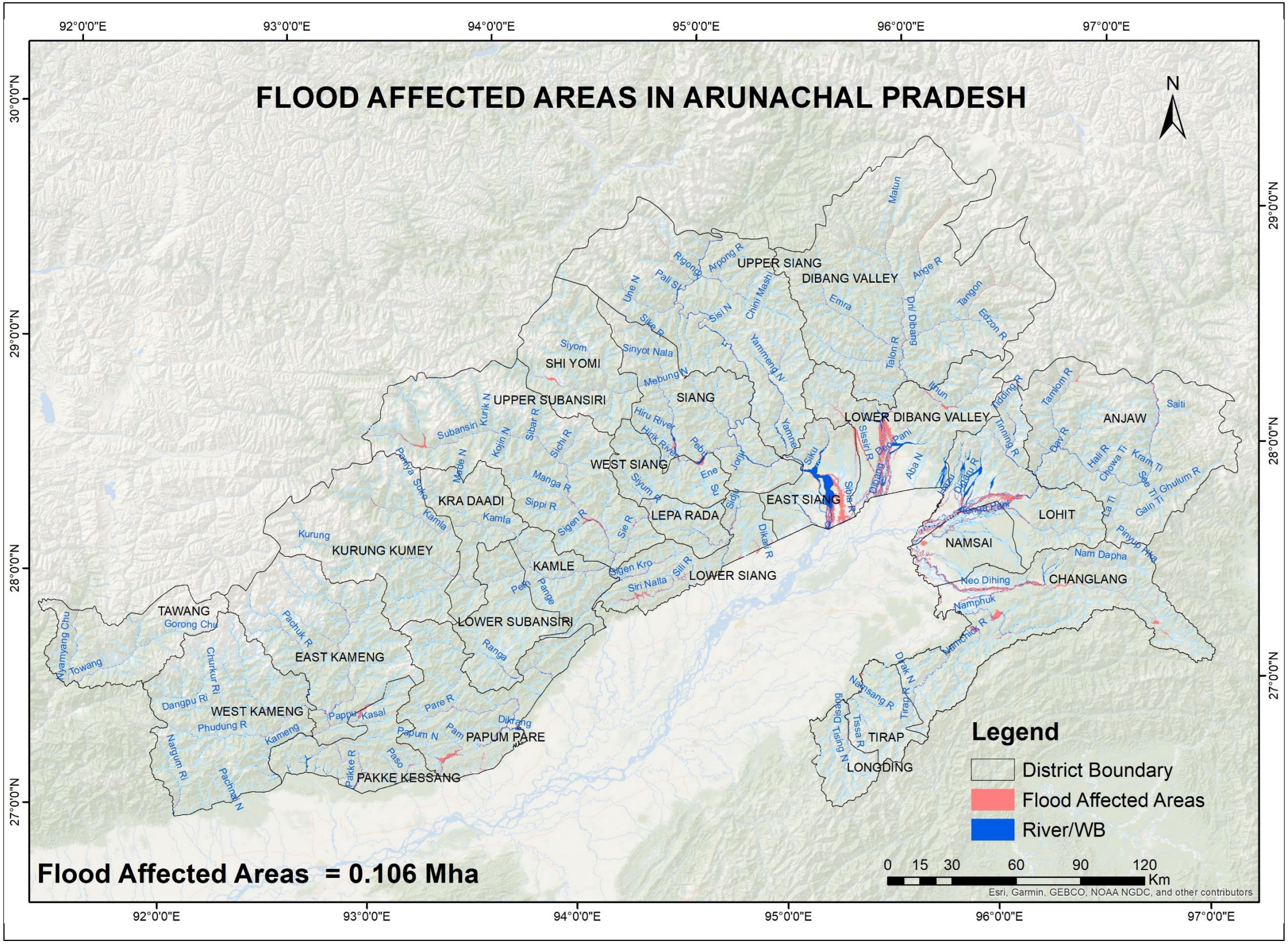
MAPS


FLOOD AFFECTED AREAS IN ANDHRA PRADESH
N
SRIKAKULAM
VIZIANAGARAM
VISAKHAPATNAM
EAST GODAVARI
WEST GODAVARI
KRISHNA
GUNTUR
PRAKASAM
SRI POTTI SRIRAMULU NELLORE
KURNOOL
ANANTAPUR
Y S R
CHITTOOR
Vegavati River
Nagavali River
Champavati River
Gosthani Vala
Chandra Vanka
Sarada River
Tarpuva Vadi
Eleru R
Godavari River
Gautami Godavari
Budameru River
Krishna River
Vogaru Vagu
Gundlakamma River
Musi R
Paleru R
Manneru R
Hindri River
Kunderu River
Sagileru River
Penner River
Kandleru R
Swarnamuki
Pincha River
Pedda Vanka
Maddileru River
Kaundinya N
Ponnai
Palar
Legend
District Boundary
Flood Affected Areas
River/WB
0 37.5 75 150 225 300
Km
Esri, Garmin, GEBCO, NOAA NGDC, and other contributors
Flood Affected Areas = 0.699 Mha
76°0'0"E
77°0'0"E
78°0'0"E
79°0'0"E
80°0'0"E
81°0'0"E
82°0'0"E
83°0'0"E
84°0'0"E
85°0'0"E
19°0'0"N
18°0'0"N
17°0'0"N
16°0'0"N
15°0'0"N
14°0'0"N
13°0'0"N

Flood Affected Areas in Andhra Pradesh

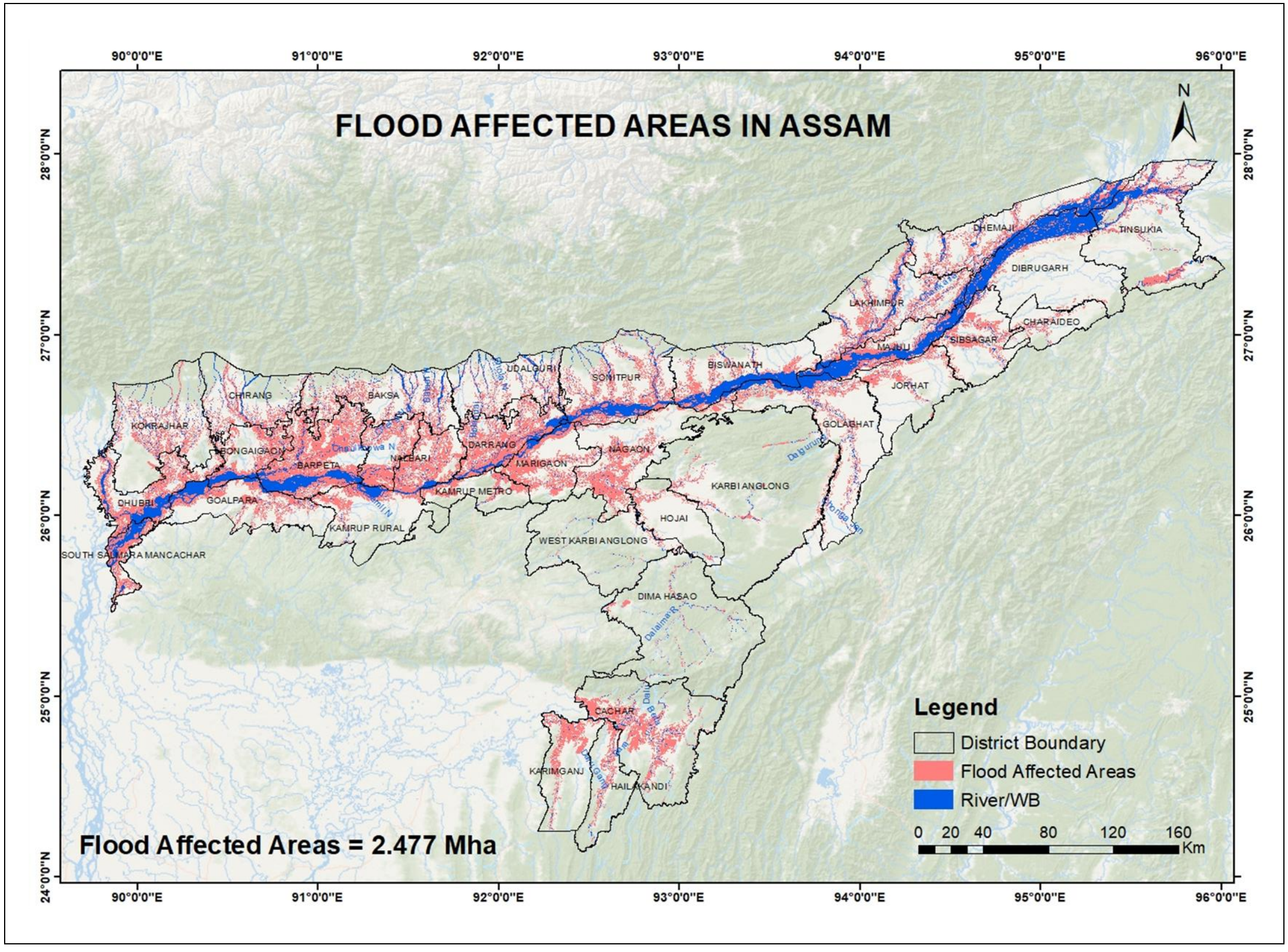
Sl. No.	Name of the District	Flood Affected Areas in ha
1	ANANTAPUR	38,337.40
2	CHITTOOR	48,759.95
3	EAST GODAVARI	94,333.35
4	GUNTUR	50,049.00
5	KRISHNA	78,578.23
6	KURNOOL	27,537.72
7	PRAKASAM	1,13,373.04
8	SRI POTTI SRIRAMULU NELLORE	82,706.97
9	SRIKAKULAM	18,685.99
10	VISAKHAPATNAM	18,937.13
11	VIZIANAGARAM	11,897.35
12	WEST GODAVARI	63,113.82
13	YSR	52,216.43
	Total	**6,98,526.40**

FLOOD AFFECTED AREAS IN ARUNACHAL PRADESH



Flood Affected Areas in Arunachal Pradesh

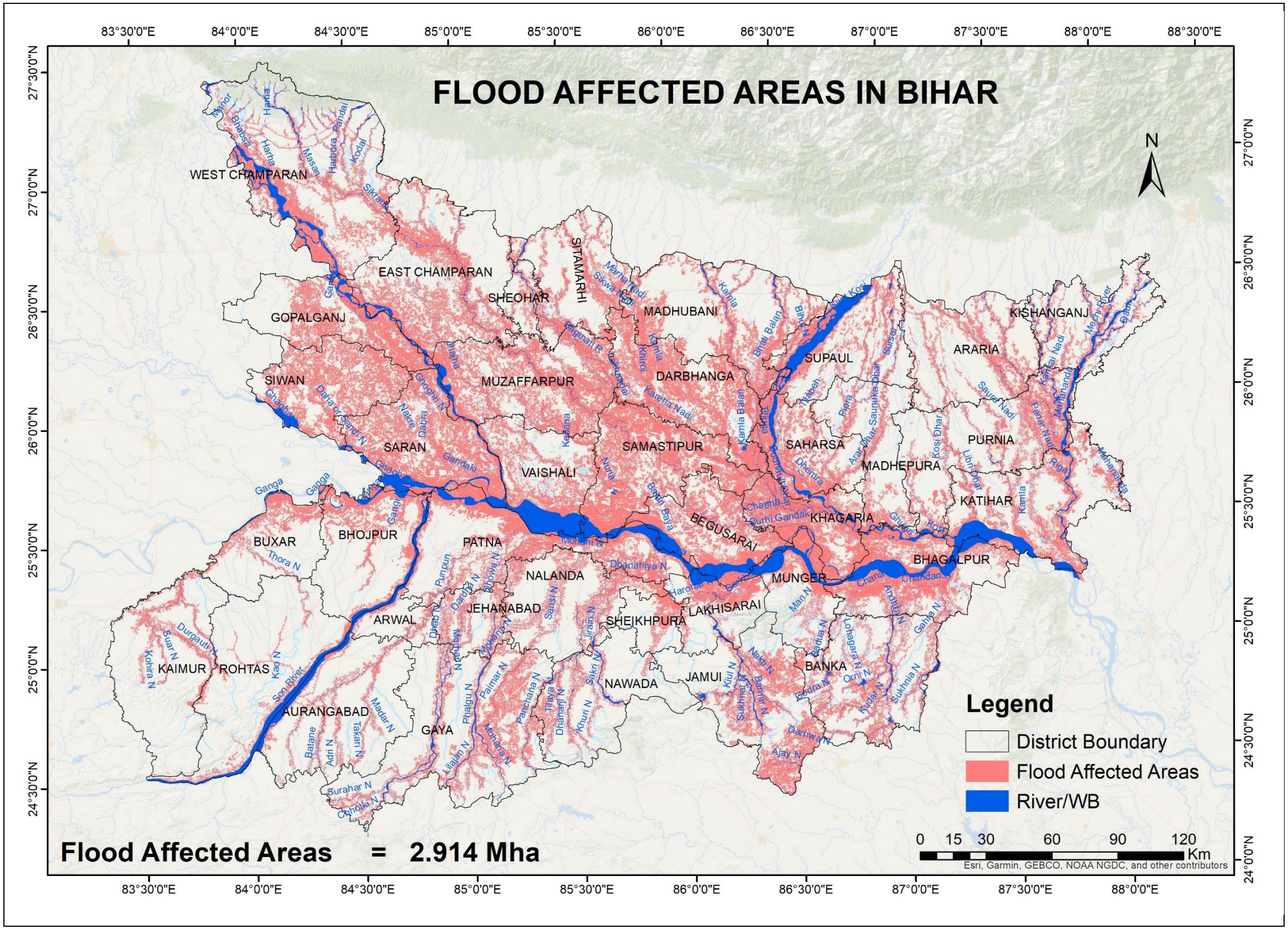
Sl. No.	Name of the District	Flood Affected Areas in ha
1	ANJAW	4,403.83
2	CHANGLANG	11,707.09
3	DIBANG VALLEY	6,377.56
4	EAST KAMENG	2,644.49
5	EAST SIANG	11,019.51
6	KAMLE	1,170.93
7	KRA DAADI	557.86
8	KURUNG KUMEY	1,262.78
9	LEPA RADA	615.18
10	LOHIT	11,562.04
11	LONGDING	438.03
12	LOWER DIBANG VALLEY	17,859.44
13	LOWER SIANG	4,116.16
14	LOWER SUBANSIRI	383.15
15	NAMSAI	6,098.00
16	PAKKE KESSANG	3,006.79
17	PAPUM PARE	4,930.60
18	SHI YOMI	1,940.71
19	SIANG	3,389.12
20	TAWANG	899.52
21	TIRAP	647.54
22	UPPER SIANG	3,995.46
23	UPPER SUBANSIRI	5,061.22
24	WEST KAMENG	1,162.50
25	WEST SIANG	750.35
	Total	**1,05,999.85**


FLOOD AFFECTED AREAS IN ASSAM
N
90°0'0"E
91°0'0"E
92°0'0"E
93°0'0"E
94°0'0"E
95°0'0"E
96°0'0"E
28°0'0"N
27°0'0"N
26°0'0"N
25°0'0"N
24°0'0"N
DHEMAJI
TINSUKIA
DIBRUGARH
LAKHIMPUR
CHARAIDEO
SIBSAGAR
MAJULI
JORHAT
BISWANATH
SONITPUR
UDALGURI
CHIRANG
BAKSA
KOKRAJHAR
BONGAIGAON
BARPETA
NALBARI
DARRANG
MARIGAON
NAGAON
GOLAGHAT
KARBI ANGLONG
DHUBRI
GOALPARA
KAMRUP METRO
KAMRUP RURAL
HOJAI
WEST KARBI ANGLONG
SOUTH SALMARA MANCACHAR
DIMA HASAO
CACHAR
KARIMGANJ
HAILAKANDI
Legend
District Boundary
Flood Affected Areas
River/WB
0 20 40 80 120 160
Km
Flood Affected Areas = 2.477 Mha

Flood Affected Areas in Assam

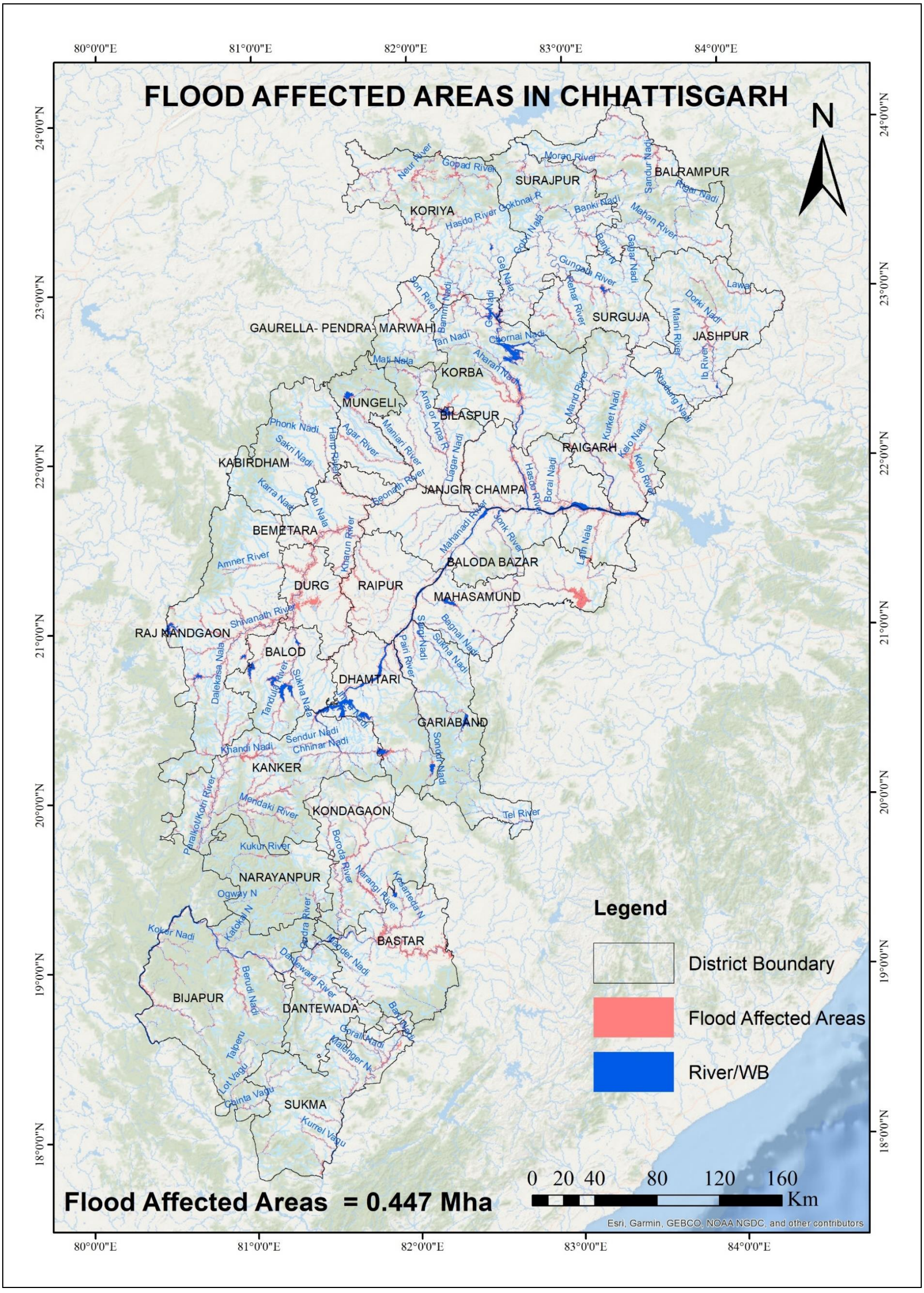
Sl. No.	Name of the District	Flood Affected Areas in ha
1	BAKSA	92,456.33
2	BARPETA	1,56,516.20
3	BISWANATH	69,381.06
4	BONGAIGAON	60,063.82
5	CACHAR	89,789.41
6	CHARAIDEO	21,546.43
7	CHIRANG	54,337.85
8	DARRANG	1,09,579.84
9	DHEMAJI	72,284.97
10	DHUBRI	1,05,107.33
11	DIBRUGARH	67,878.68
12	DIMA HASAO	11,493.62
13	GOALPARA	81,962.77
14	GOLAGHAT	1,07,467.48
15	HAILAKANDI	25,746.29
16	HOJAI	51,802.01
17	JORHAT	68,849.57
18	KAMRUP METROPOLITAN	28,798.89
19	KAMRUP RURAL	1,39,992.44
20	KARBI ANGLONG	43,473.00
21	KARIMGANJ	49,751.54
22	KOKRAJHAR	92,976.93
23	LAKHIMPUR	1,30,068.77
24	MAJULI	51,542.45
25	MORIGAON	97,745.89
26	NAGAON	1,39,263.92
27	NALBARI	75,372.63
28	SIVASAGAR	69,174.99
29	SONITPUR	1,17,248.80
30	SOUTH SALMARA MANKACHAR	34,485.75
31	TINSUKIA	63,734.28
32	UDALGURI	79,696.27
33	WEST KARBI ANGLONG	17,306.22
	Total	**24,76,896.41**

FLOOD AFFECTED AREAS IN BIHAR



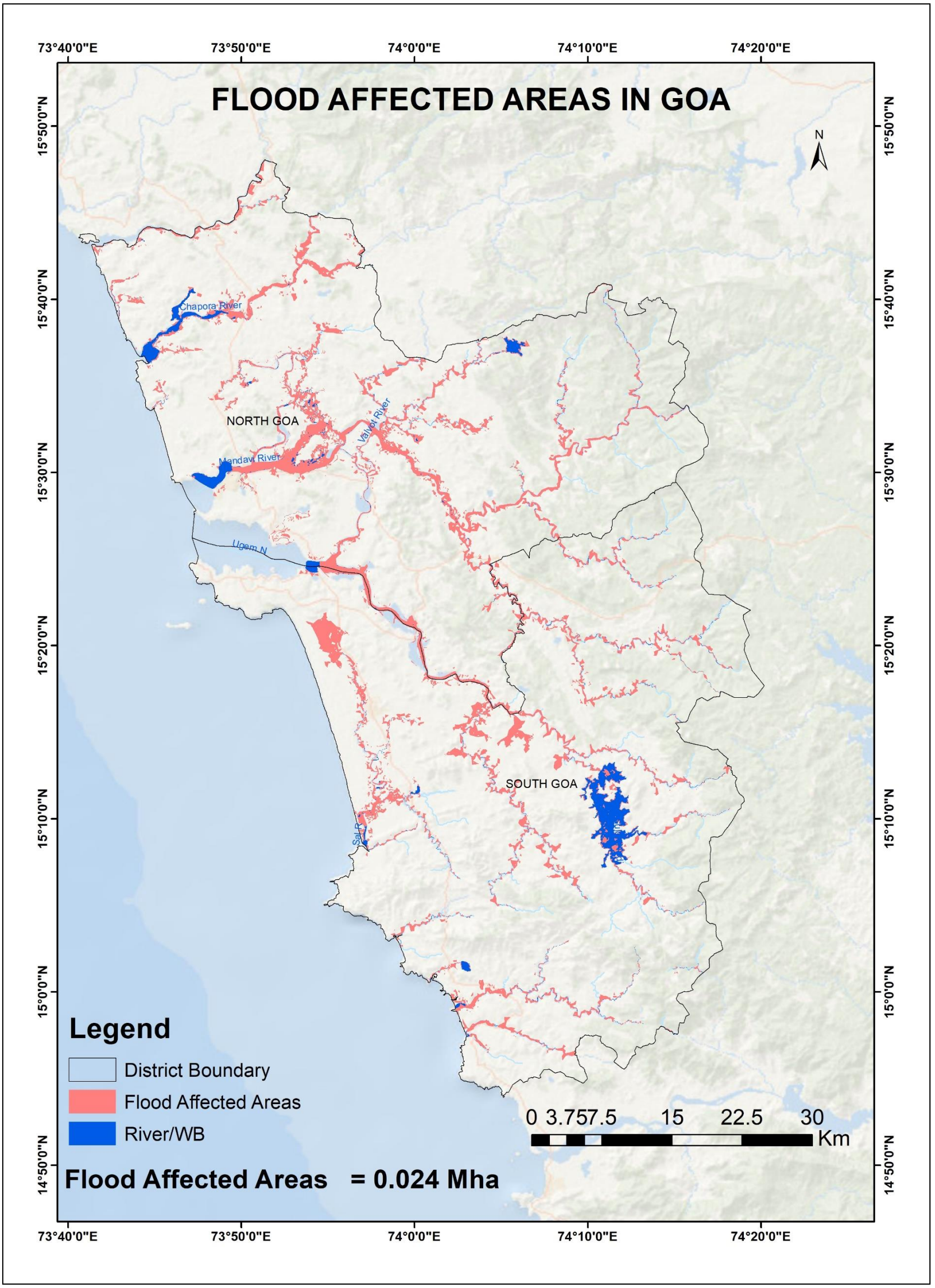
Flood Affected Areas in Bihar

Sl. No.	Name of the District	Flood Affected Areas in ha
1	ARARIA	59,410.13
2	ARWAL	10,048.61
3	AURANGABAD	39,388.70
4	BANKA	82,605.28
5	BEGUSARAI	91,562.72
6	BHAGALPUR	1,13,488.00
7	BHOJPUR	53,478.37
8	BUXAR	34,286.02
9	DARBHANGA	1,43,009.80
10	GAYA	1,16,627.40
11	GOPALGANJ	83,279.60
12	JAHANABAD	30,582.00
13	JAMUI	1,00,980.20
14	KAIMUR	33,244.31
15	KATIHAR	90,581.26
16	KHAGARIA	97,271.17
17	KISHANGANJ	38,068.48
18	LAKHISARAI	35,307.20
19	MADHEPURA	39,751.23
20	MADHUBANI	98,398.91
21	MUNGER	42,986.87
22	MUZAFFARPUR	1,63,641.10
23	NALANDA	63,608.00
24	NAWADA	36,502.16
25	PASHCHIMI CHAMPARAN	1,33,748.60
26	PATNA	1,21,166.90
27	PURBI CHAMPARAN	1,29,195.90
28	PURNIA	89,755.45
29	ROHTAS	25,788.18
30	SAHARSA	77,049.67
31	SAMASTIPUR	1,63,013.80
32	SARAN	1,44,966.90
33	SHEIKHPURA	14,719.85
34	SHEOHAR	12,159.83
35	SITAMARHI	61,547.09
36	SIWAN	1,09,021.20
37	SUPAUL	70,222.13
38	VAISHALI	63,257.61
	Total	**29,13,720.63**


FLOOD AFFECTED AREAS IN CHHATTISGARH
N
80°0'0"E
81°0'0"E
82°0'0"E
83°0'0"E
84°0'0"E
24°0'0"N
23°0'0"N
22°0'0"N
21°0'0"N
20°0'0"N
19°0'0"N
18°0'0"N
SURAJPUR
BALRAMPUR
KORIYA
SURGUJA
JASHPUR
GAURELLA- PENDRA- MARWAHI
KORBA
MUNGELI
BILASPUR
RAIGARH
KABIRDHAM
JANJGIR CHAMPA
BEMETARA
BALODA BAZAR
DURG
RAIPUR
MAHASAMUND
RAJ NANDGAON
BALOD
DHAMTARI
GARIABAND
KANKER
KONDAGAON
NARAYANPUR
BASTAR
BIJAPUR
DANTEWADA
SUKMA
Neur River
Gopad River
Moran River
Sandur Nadi
Hasdo River
Gokbnai R
Gokri Nala
Banki Nadi
Mahan River
Gel Nala
Son River
Bamni Nadi
Gungau River
Gagar Nadi
Lawar
Rehar River
Dorki Nadi
Tan Nadi
Chornai Nadi
Maini River
Ib River
Mati Nala
Aharan Nadi
Mand River
Kurket Nadi
Kharang Nadi
Phonk Nadi
Sakri Nadi
Hamp River
Agar River
Maniari River
Arna or Arpa R
Liagar Nadi
Kelo Nadi
Kelo River
Karra Nadi
Dolu Nala
Seonath River
Hasdo River
Borai Nadi
Mahanadi River
Sonk River
Amner River
Kharun River
Lath Nala
Shivnath River
Pari River
Sukha Nadi
Bagnai Nadi
Daleksa Nala
Tandula River
Jonk Nadi
Sendur Nadi
Chhinar Nadi
Khandi Nadi
Sondur Nadi
Tel River
Mendaki River
Pralkot/Kotri River
Kukur River
Boroda River
Narangi River
Kotarteda N
Ogway N
Kakoki N
Koker Nadi
Gadra River
Mander Nadi
Dankewara River
Berudi Nadi
Baghnai
Talperu
Gorali Nadi
Malanger N
Lor Vagu
Gointa Vagu
Kurrel Vagu
Legend
District Boundary
Flood Affected Areas
River/WB
0 20 40 80 120 160
Km
Flood Affected Areas = 0.447 Mha
Esri, Garmin, GEBCO, NOAA NGDC, and other contributors

Flood Affected Areas in Chhattisgarh

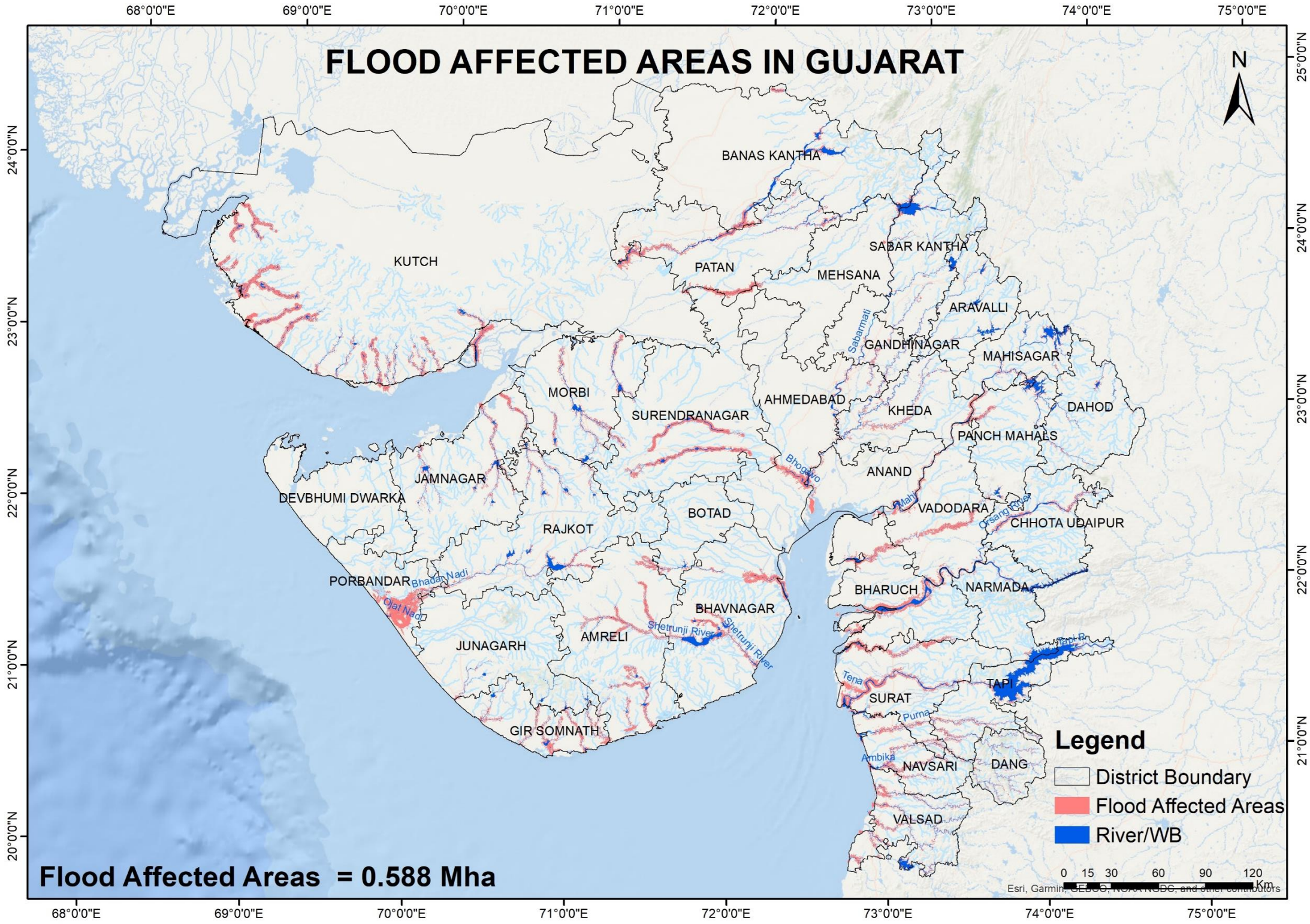
Sl. No.	Name of the District	Flood Affected Areas in ha
1	BALOD	11,164.17
2	BALODA BAZAR	11,019.38
3	BALRAMPUR	19,711.50
4	BASTAR	20,163.89
5	BEMETARA	12,000.67
6	BIJAPUR	27,198.99
7	BILASPUR	12,141.66
8	DAKSHIN BASTAR DANTEWADA	6,217.96
9	DHAMTARI	11,980.86
10	DURG	14,166.61
11	GARIABAND	11,224.07
12	GAURELLA - PENDRA - MARWAHI	5,080.26
13	JANJGIR CHAMPA	16,198.61
14	JASHPUR	13,596.56
15	KABIRDHAM	3,936.39
16	KONDAGAON	19,332.27
17	KORBA	24,112.46
18	KORIYA	31,801.66
19	MAHASAMUND	19,799.23
20	MUNGELI	8,076.08
21	NARAYANPUR	6,286.26
22	RAIGARH	21,502.89
23	RAIPUR	10,044.75
24	RAJNANDGAON	29,423.94
25	SUKMA	16,385.85
26	SURAJPUR	15,444.03
27	SURGUJA	12,195.88
28	UTTAR BASTAR KANKER	36,632.55
	Total	**4,46,839.43**


FLOOD AFFECTED AREAS IN GOA
73°40'0"E
73°50'0"E
74°0'0"E
74°10'0"E
74°20'0"E
15°50'0"N
15°40'0"N
15°30'0"N
15°20'0"N
15°10'0"N
15°0'0"N
14°50'0"N
N
Chapora River
NORTH GOA
Mandavi River
Valvoi River
Ugem N
SOUTH GOA
Sal R
Legend
District Boundary
Flood Affected Areas
River/WB
0 3.757.5 15 22.5 30
Km
Flood Affected Areas = 0.024 Mha

Flood Affected Areas in Goa

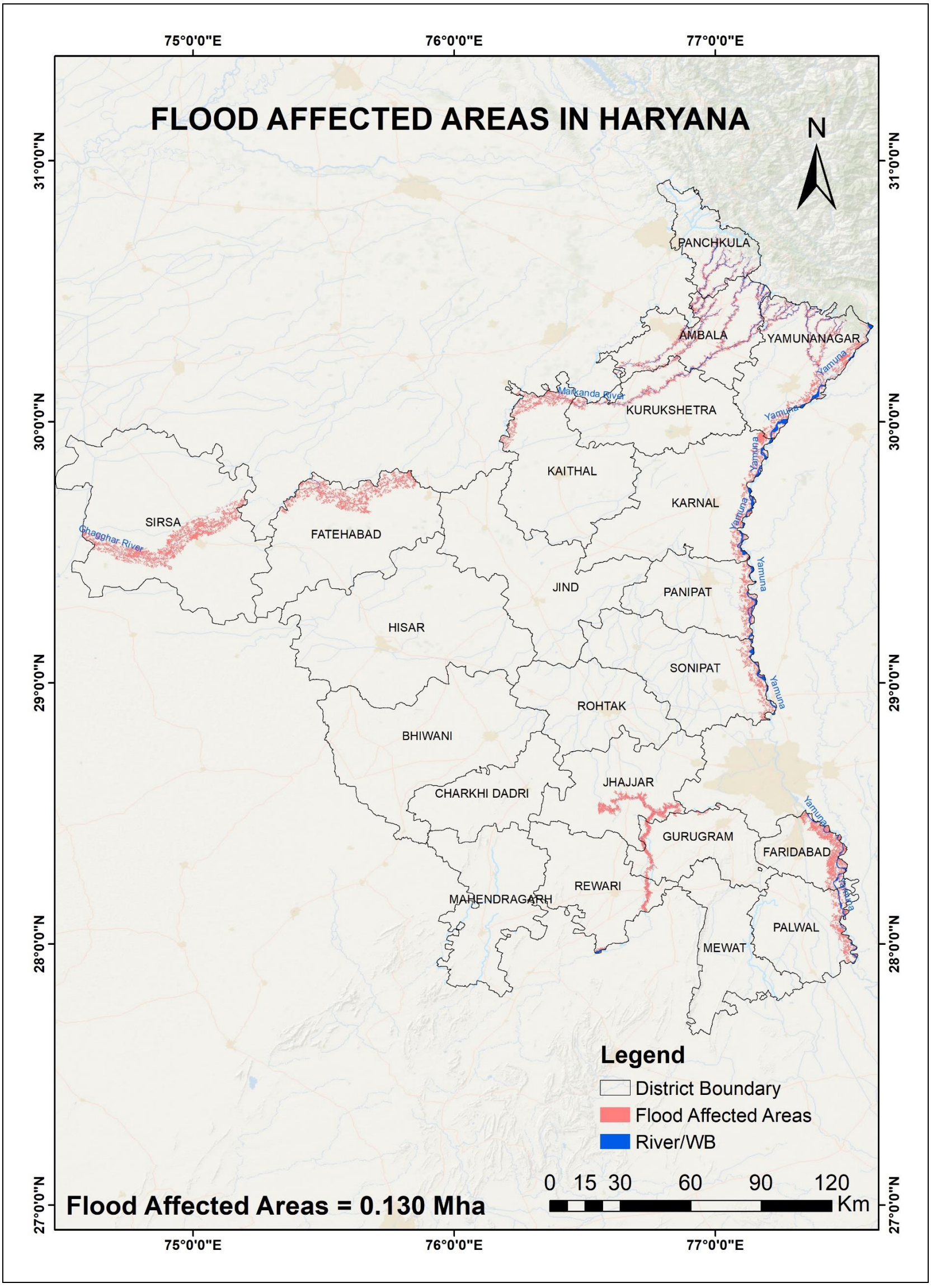
Sl. No.	Name of the District	Flood Affected Areas in ha
1	NORTH GOA	13,043.89
2	SOUTH GOA	10,688.06
	Total	**23,731.95**

FLOOD AFFECTED AREAS IN GUJARAT



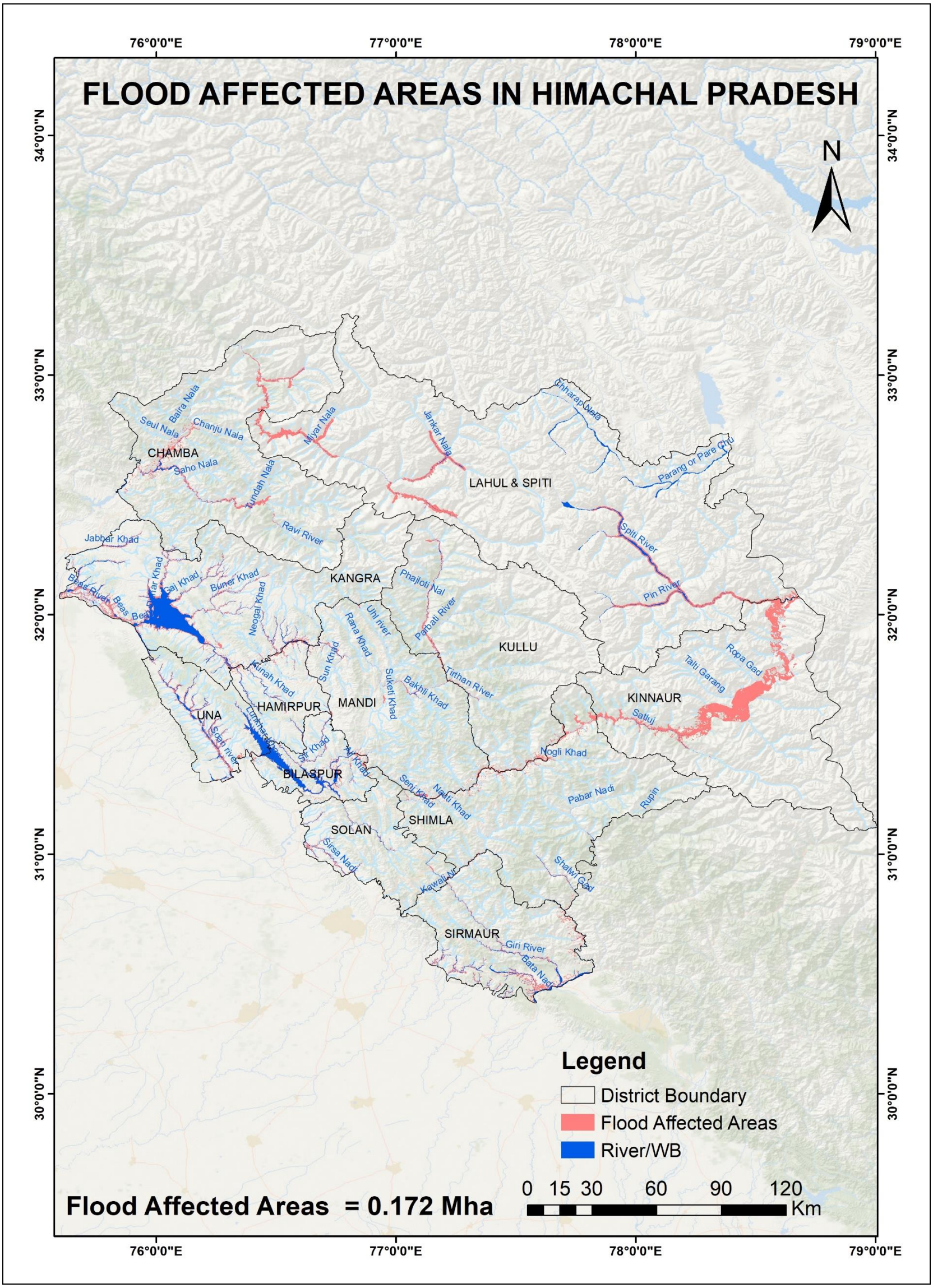
Flood Affected Areas in Gujarat

Sl. No.	Name of the District	Flood Affected Areas in ha
1	AHMEDABAD	15,150.45
2	AMRELI	37,045.76
3	ANAND	8,390.94
4	ARAVALLI	3,955.84
5	BANAS KANTHA	13,336.29
6	BHARUCH	29,775.34
7	BHAVNAGAR	26,977.59
8	BOTAD	2,037.34
9	CHHOTA UDAIPUR	9,277.62
10	DAHOD	4,157.96
11	DANG	8,659.19
12	DEVBHUMI DWARKA	0.00
13	GANDHINAGAR	4,336.75
14	GIR SOMNATH	21,513.63
15	JAMNAGAR	18,206.83
16	JUNAGARH	4,061.58
17	KHEDA	14,383.84
18	KUTCH	86,182.87
19	MAHISAGAR	7,100.63
20	MEHSANA	2,553.30
21	MORBI	16,562.40
22	NARMADA	3,827.63
23	NAVSARI	17,507.45
24	PANCHMAHAL	8,874.74
25	PATAN	25,460.25
26	PORBANDAR	33,773.18
27	RAJKOT	16,858.18
28	SABAR KANTHA	8,234.10
29	SURAT	38,654.20
30	SURENDRANAGAR	37,896.16
31	TAPI	17,482.91
32	VADODARA	21,220.71
33	VALSAD	23,606.73
	Total	**5,87,062.39**


FLOOD AFFECTED AREAS IN HARYANA
N
75°0'0"E
76°0'0"E
77°0'0"E
31°0'0"N
30°0'0"N
29°0'0"N
28°0'0"N
27°0'0"N
PANCHKULA
AMBALA
YAMUNANAGAR
KURUKSHETRA
KAITHAL
KARNAL
SIRSA
FATEHABAD
JIND
PANIPAT
HISAR
SONIPAT
ROHTAK
BHIWANI
JHAJJAR
CHARKHI DADRI
GURUGRAM
FARIDABAD
REWARI
MAHENDRAGARH
PALWAL
MEWAT
Markanda River
Chagghar River
Yamuna
Legend
District Boundary
Flood Affected Areas
River/WB
0 15 30 60 90 120
Km
Flood Affected Areas = 0.130 Mha

Flood Affected Areas in Haryana

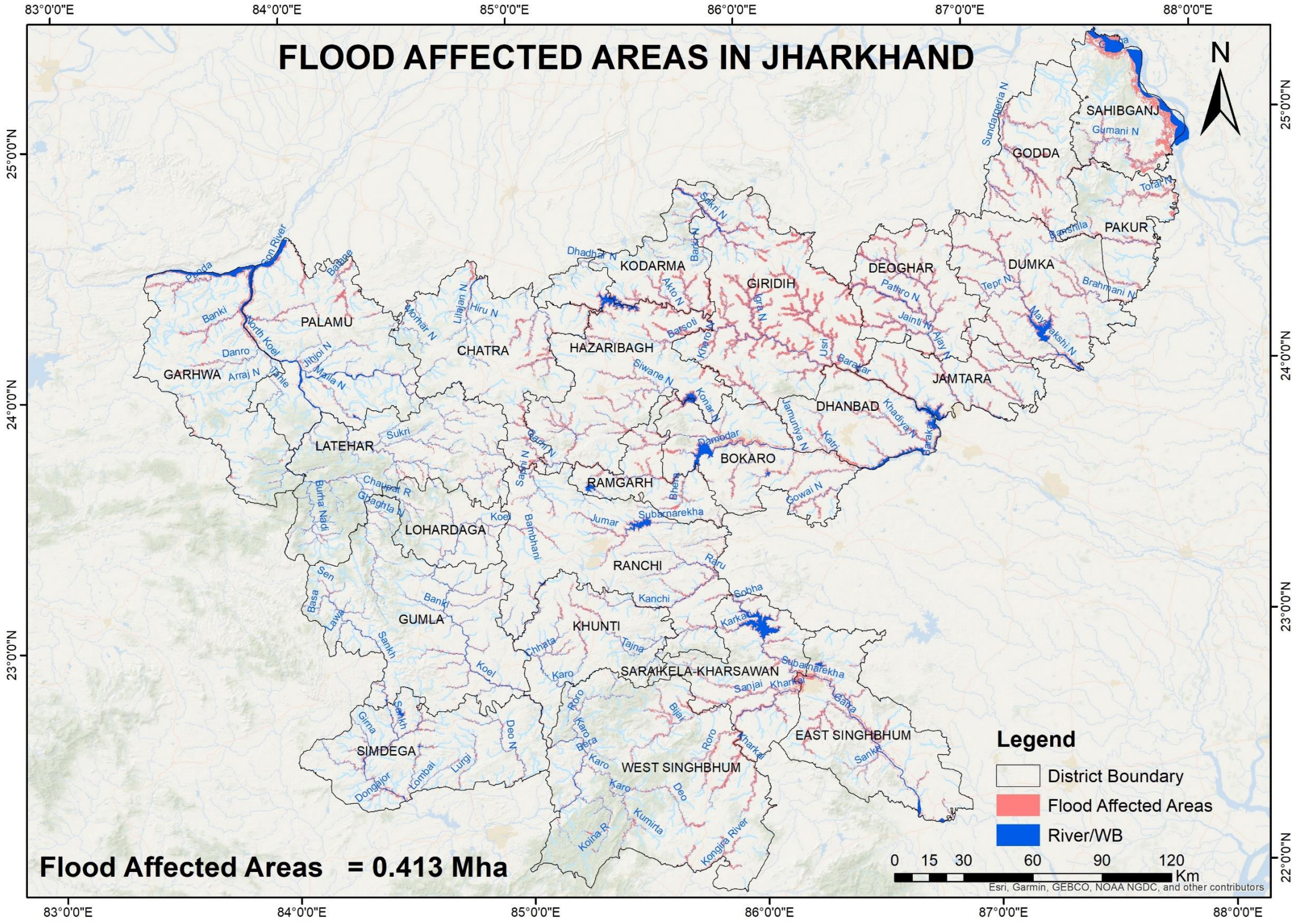
Sl. No.	Name of the District	Flood Affected Areas in ha
1	AMBALA	13,540.36
2	BHIWANI	0.00
3	CHARKHI DADRI	0.00
4	FARIDABAD	10,750.93
5	FATEHABAD	14,319.87
6	GURUGRAM	3,468.90
7	HISAR	0.00
8	JHAJJAR	8,165.23
9	JIND	0.00
10	KAITHAL	6,809.48
11	KARNAL	8,025.60
12	KURUKSHETRA	4,817.00
13	MAHENDRAGARH	2.85
14	MEWAT (NUH)	0.00
15	PALWAL	5,788.03
16	PANCHKULA	4,069.27
17	PANIPAT	5,472.20
18	REWARI	2,224.05
19	ROHTAK	0.00
20	SIRSA	20,921.60
21	SONIPAT	5,367.24
22	YAMUNANAGAR	15,778.50
	Total	**1,29,521.11**


FLOOD AFFECTED AREAS IN HIMACHAL PRADESH
N
76°0'0"E
77°0'0"E
78°0'0"E
79°0'0"E
34°0'0"N
33°0'0"N
32°0'0"N
31°0'0"N
30°0'0"N
CHAMBA
LAHUL & SPITI
KANGRA
KULLU
KINNAUR
HAMIRPUR
MANDI
UNA
BILASPUR
SOLAN
SHIMLA
SIRMAUR
Bairra Nala
Seul Nala
Chanju Nala
Saho Nala
Tundah Nala
Miyar Nala
Jankar Nala
Chharap Nala
Parang or Pare Chu
Spiti River
Pin River
Ravi River
Jabbar Khad
Gaj Khad
Bunar Khad
Neogal Khad
Phajioti Nal
Parbati River
Uhl river
Rana Khad
Sun Khad
Suketi Khad
Bakhli Khad
Tirthan River
Kunah Khad
Tumkhar Khad
Soan river
Sir Khad
Seni Khad
Nauti Khad
Nogli Khad
Satluj
Talli Garang
Ropa Gad
Pabar Nadi
Rupin
Shalwi Gad
Kawali Nal
Sirsa Nadi
Giri River
Bata Nadi
Legend
District Boundary
Flood Affected Areas
River/WB
0 15 30 60 90 120
Km
Flood Affected Areas = 0.172 Mha

Flood Affected Areas in Himachal Pradesh

Sl. No.	Name of the District	Flood Affected Areas in ha
1	BILASPUR	6,166.67
2	CHAMBA	14,153.61
3	HAMIRPUR	4,103.87
4	KANGRA	23,626.17
5	KINNAUR	47,349.44
6	KULLU	6,357.53
7	LAHAUL & SPITI	32,192.10
8	MANDI	5,929.21
9	SHIMLA	7,479.04
10	SIRMAUR	12,129.97
11	SOLAN	3,783.71
12	UNA	8,328.06
	Total	**1,71,599.38**

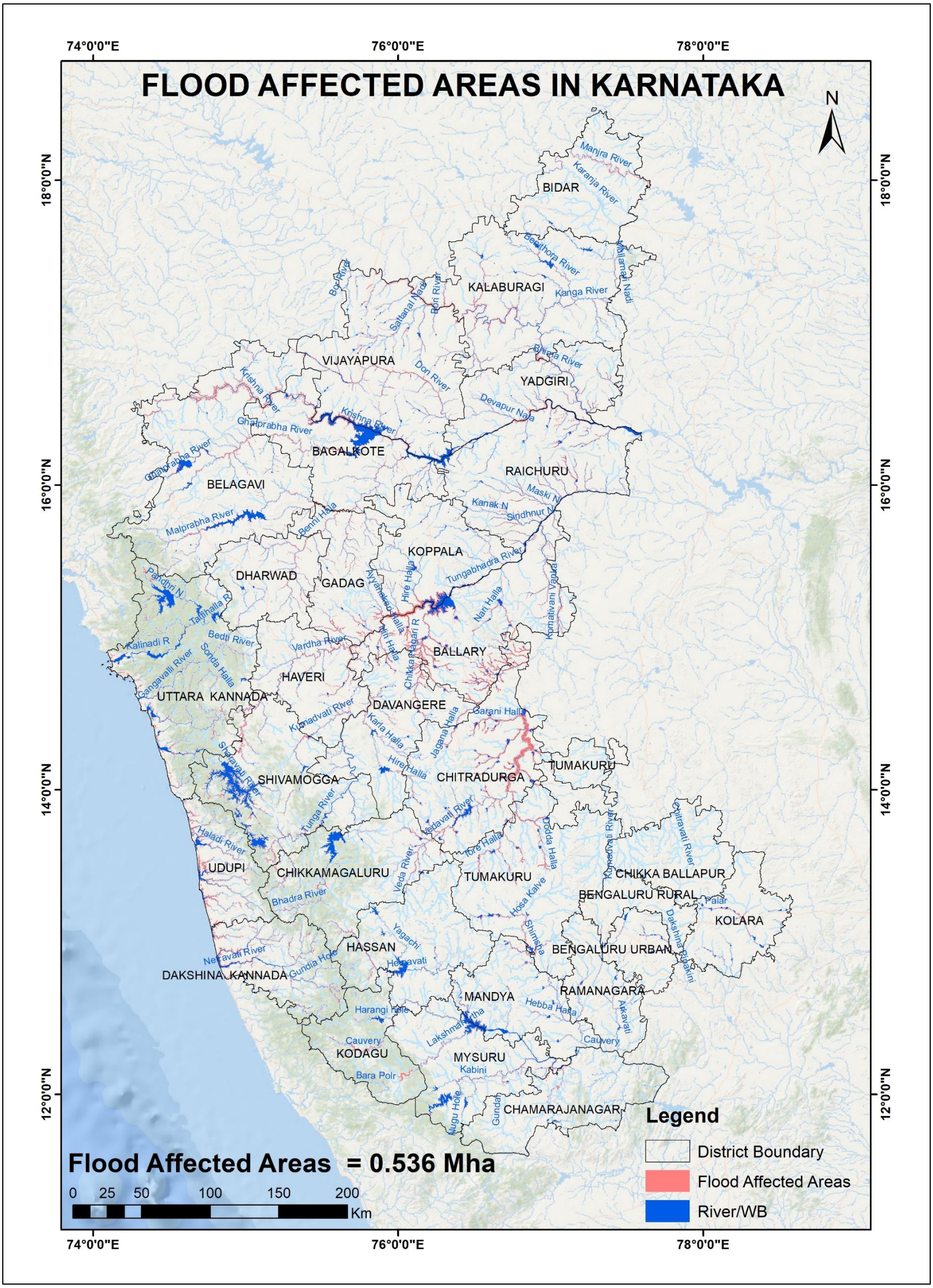
FLOOD AFFECTED AREAS IN JHARKHAND



Flood Affected Areas in Jharkhand

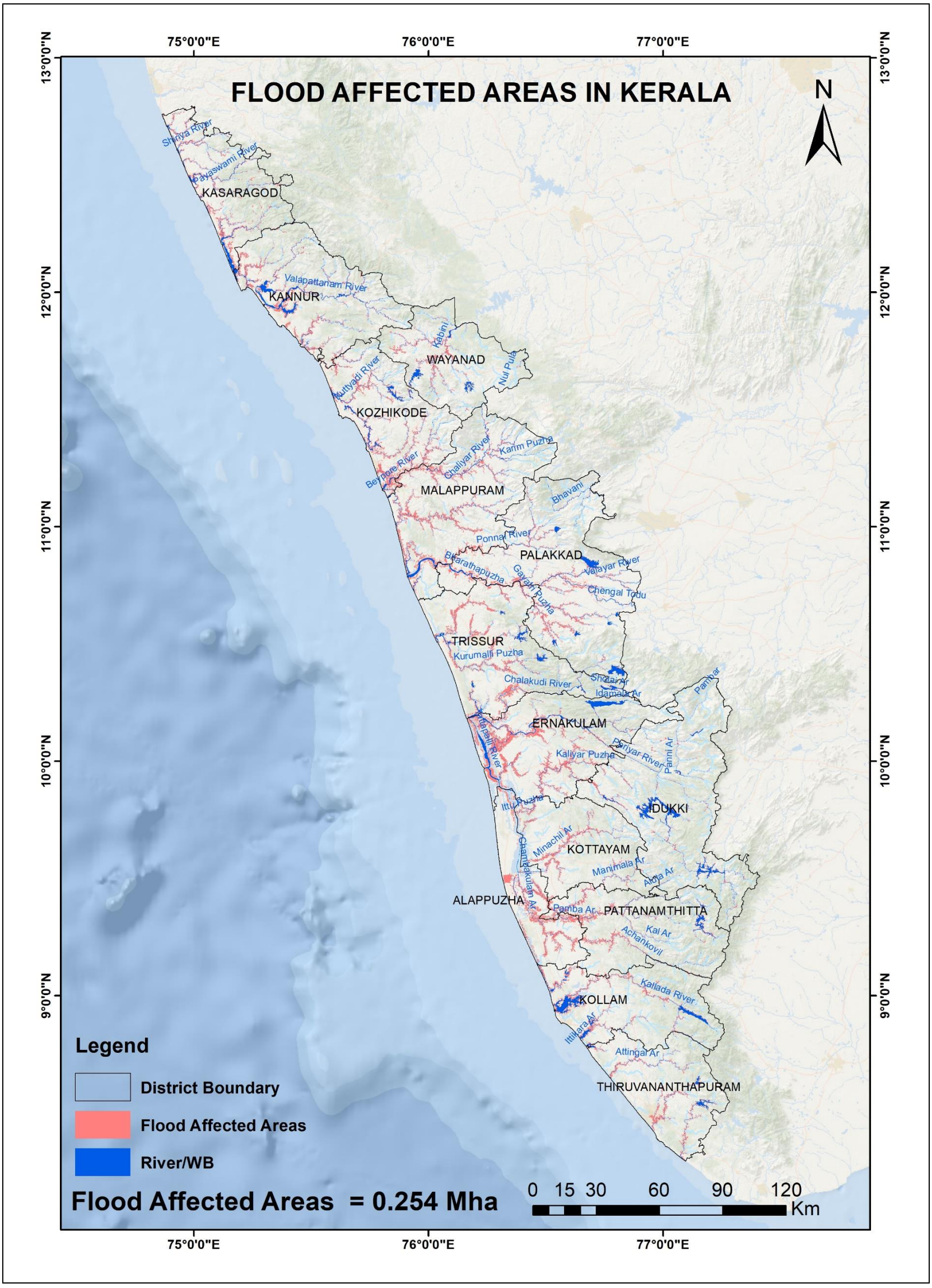
Sl. No.	Name of the District	Flood Affected Areas in ha
1	BOKARO	19,224.52
2	CHATRA	16,043.68
3	DEOGHAR	24,186.16
4	DHANBAD	13,575.01
5	DUMKA	22,248.39
6	EAST SINGHBHUM	16,294.22
7	GARHWA	13,441.11
8	GIRIDIH	61,391.75
9	GODDA	14,293.74
10	GUMLA	11,213.68
11	HAZARIBAGH	25,735.37
12	JAMTARA	12,856.26
13	KHUNTI	8,560.37
14	KODARMA	12,140.58
15	LATEHAR	11,669.34
16	LOHARDAGA	3,141.84
17	PAKUR	9,851.40
18	PALAMU	15,592.19
19	RAMGARH	8,842.04
20	RANCHI	16,679.10
21	SAHIBGANJ	23,643.29
22	SARAIKELA-KHARSAWAN	16,957.61
23	SIMDEGA	11,172.05
24	WEST SINGHBHUM	24,166.66
	Total	**4,12,920.37**

FLOOD AFFECTED AREAS IN KARNATAKA



Flood Affected Areas in Karnataka

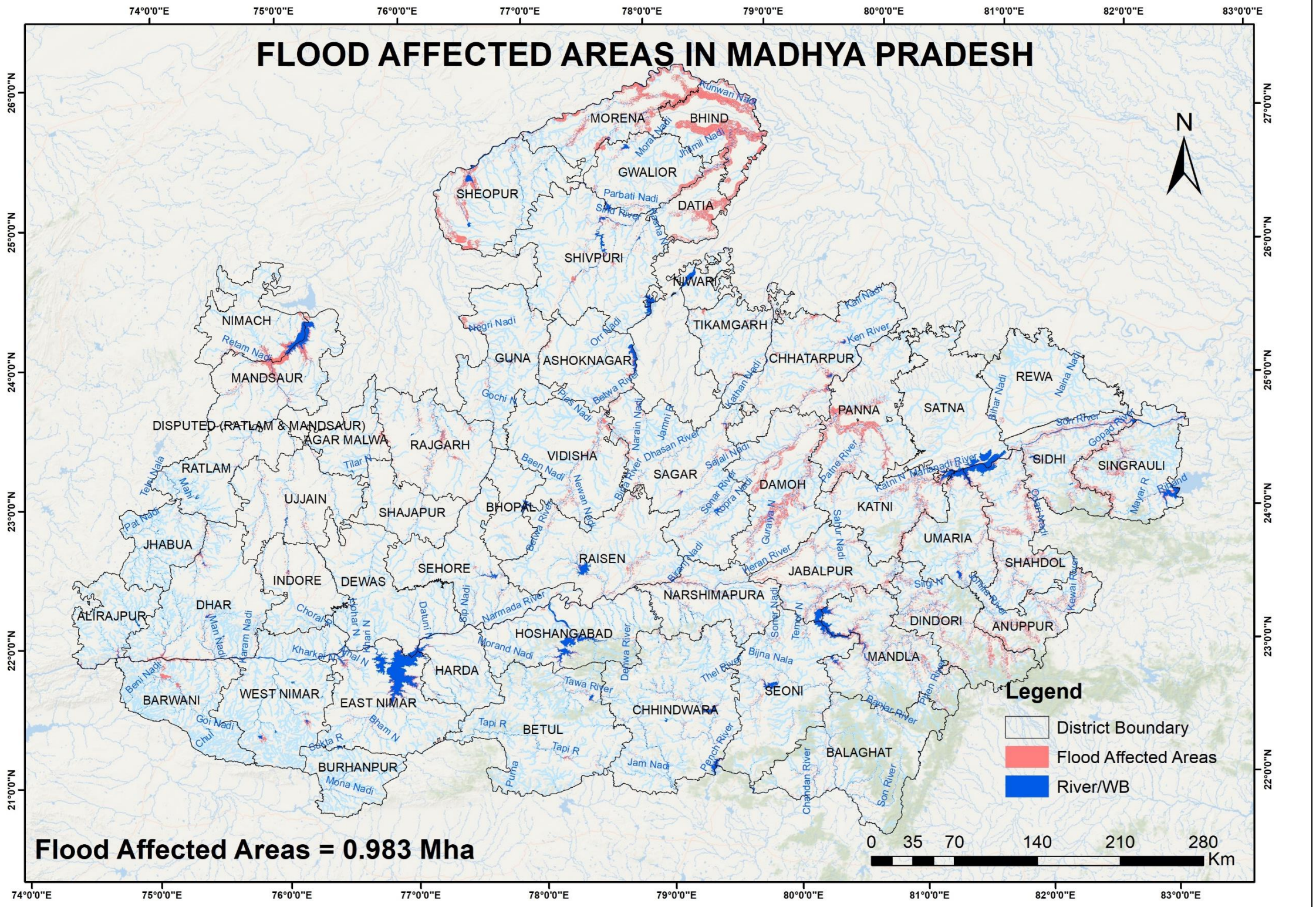
Sl. No.	Name of the District	Flood Affected Areas in ha
1	BAGALKOTE	22,724.66
2	BALLARY	55,970.50
3	BELAGAVI	37,240.98
4	BENGALURU RURAL	678.67
5	BENGALURU URBAN	2,359.94
6	BIDAR	6,624.44
7	CHAMARAJANAGAR	4,602.29
8	CHIKKA BALLAPURA	71.08
9	CHIKKAMAGALURU	15,289.82
10	CHITRADURGA	54,294.41
11	DAKSHINA KANNADA	20,682.52
12	DAVANGERE	19,694.19
13	DHARWAD	10,296.31
14	GADAG	17,221.53
15	HASSAN	7,089.53
16	HAVERI	14,836.36
17	KALABURAGI	27,185.77
18	KODAGU	8,014.86
19	KOLARA	4,387.46
20	KOPPALA	16,095.47
21	MANDYA	8,767.37
22	MYSURU	11,685.98
23	RAICHURU	26,009.34
24	RAMANAGARA	3,798.80
25	SHIVAMOGGA	27,864.31
26	TUMAKURU	16,406.42
27	UDUPI	21,276.47
28	UTTARA KANNADA	27,517.93
29	VIJAYAPURA	33,090.17
30	YADGIRI	13,861.96
	Total	**5,35,639.56**


FLOOD AFFECTED AREAS IN KERALA
N
75°0'0"E
76°0'0"E
77°0'0"E
13°0'0"N
12°0'0"N
11°0'0"N
10°0'0"N
9°0'0"N
KASARAGOD
KANNUR
WAYANAD
KOZHIKODE
MALAPPURAM
PALAKKAD
TRISSUR
ERNAKULAM
IDUKKI
KOTTAYAM
ALAPPUZHA
PATTANAMTHITTA
KOLLAM
THIRUVANANTHAPURAM
Shiriya River
Payaswami River
Valapattanam River
Kabini
Nul Puza
Kuttyadi River
Beypore River
Chaliyar River
Karim Puzha
Bhavani
Ponnai River
Bharathapuzha
Gayathri Puzha
Valayar River
Chengal Todu
Kurumalli Puzha
Chalakudi River
Shalayar
Idamalayar
Panbar
Periyar River
Pannai Ar
Kaliyar Puzha
Ittu Puzha
Minachil Ar
Chambakulam Ar
Manimala Ar
Achankovil
Kallada River
Ittikara Ar
Attingal Ar
Legend
District Boundary
Flood Affected Areas
River/WB
Flood Affected Areas = 0.254 Mha
0 15 30 60 90 120
Km

Flood Affected Areas in Kerala

Sl. No.	Name of the District	Flood Affected Areas in ha
1	ALAPPUZHA	18,680.61
2	ERNAKULAM	35,341.44
3	IDUKKI	9,455.63
4	KANNUR	19,123.22
5	KASARAGOD	14,284.06
6	KOLLAM	13,877.25
7	KOTTAYAM	11,526.16
8	KOZHIKODE	21,698.02
9	MALAPPURAM	28,408.68
10	PALAKKAD	24,123.57
11	PATTANAMTHITTA	15,201.47
12	THIRUVANANTHAPURAM	9,986.20
13	THRISSUR	23,249.27
14	WAYANAD	8,185.62
	Total	**2,53,141.19**

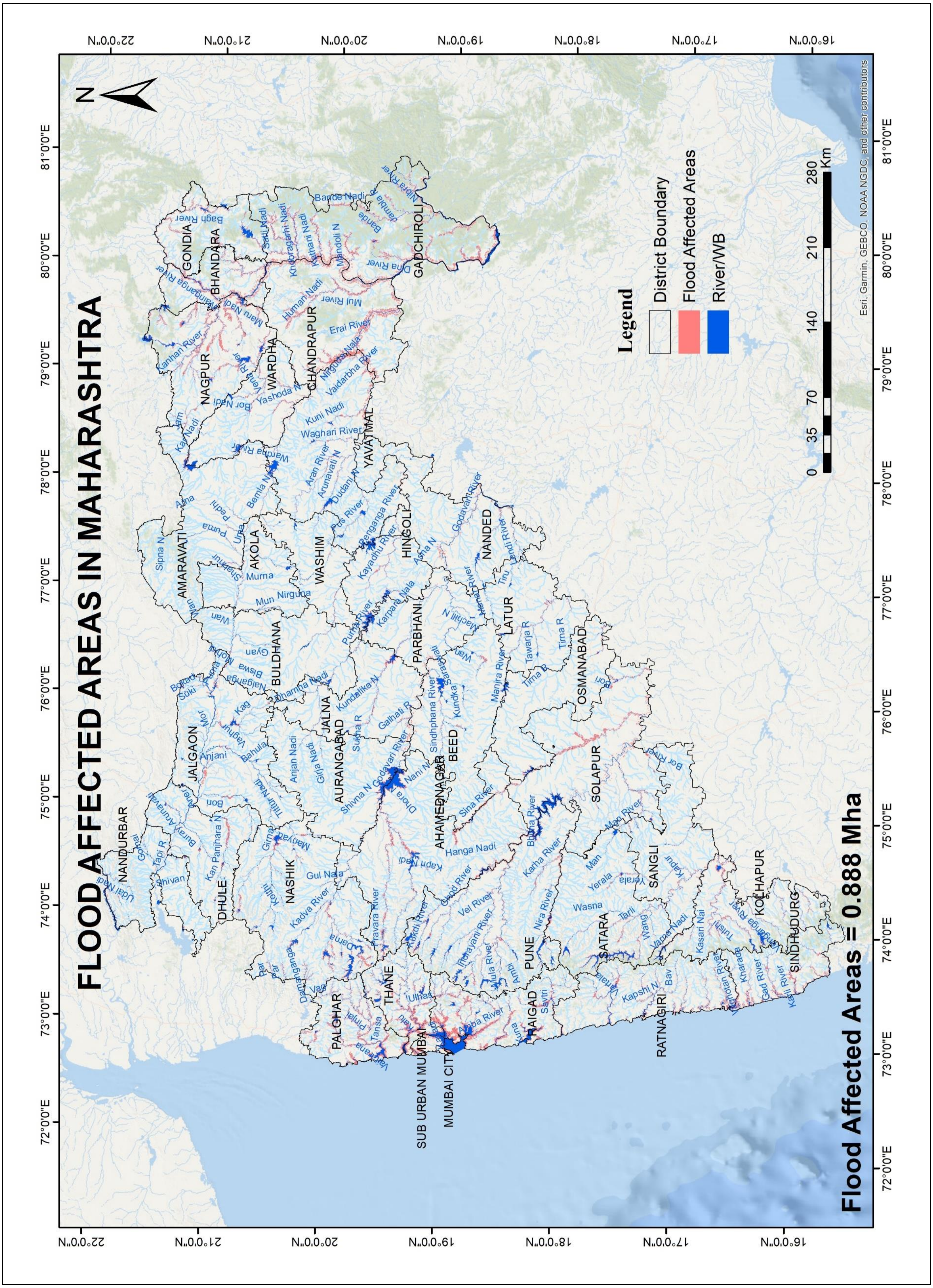
FLOOD AFFECTED AREAS IN MADHYA PRADESH



Flood Affected Areas in Madhya Pradesh

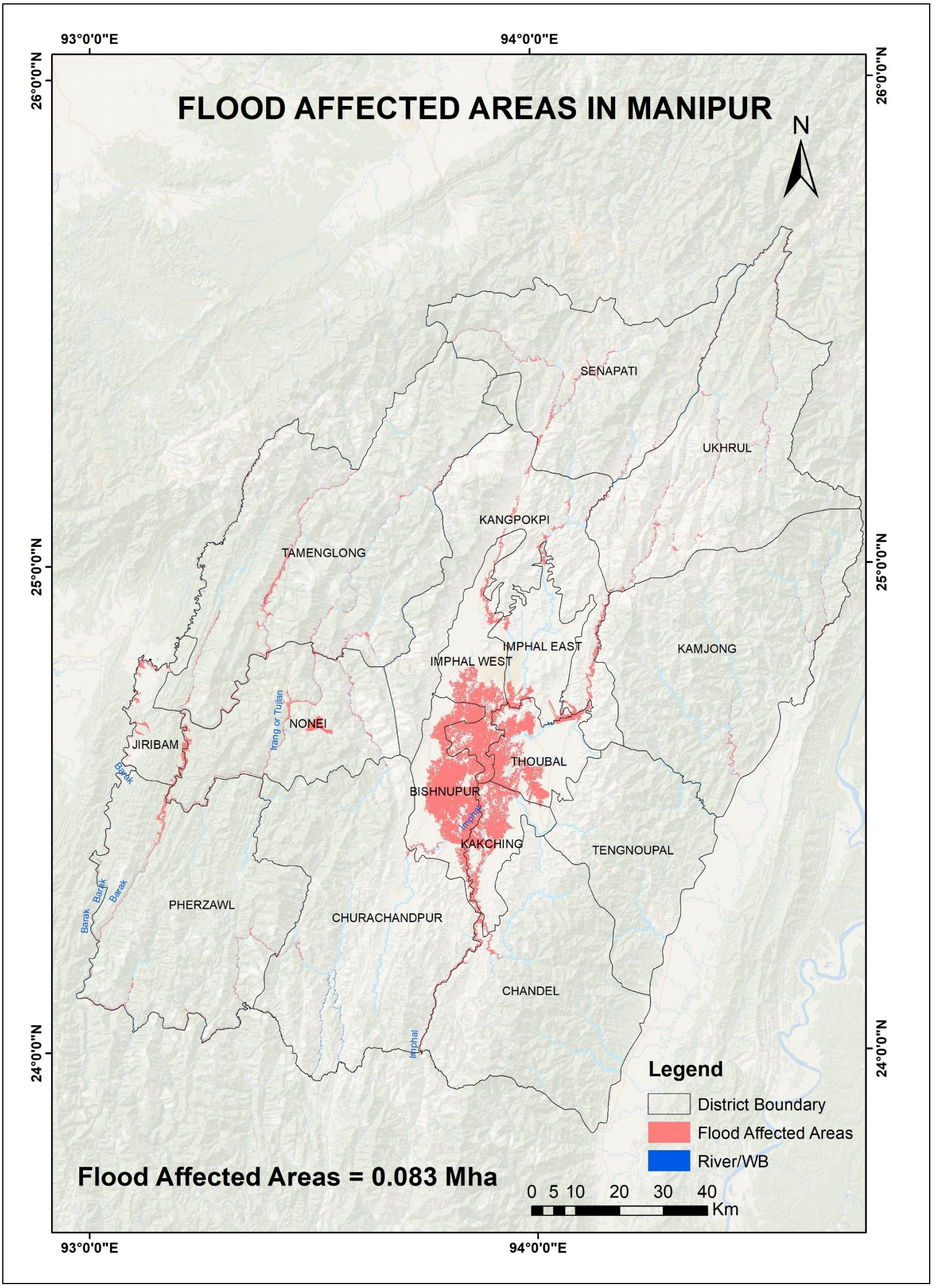
Sl. No.	Name of the District	Flood Affected Areas in ha
1	AGAR MALWA	4,061.03
2	ALIRAJPUR	1,495.34
3	ANUPPUR	30,600.10
4	ASHOKNAGAR	7,738.07
5	BALAGHAT	10,630.48
6	BARWANI	10,244.02
7	BETUL	5,740.53
8	BHIND	1,15,094.62
9	BHOPAL	132.68
10	BURHANPUR	774.03
11	CHHATARPUR	22,569.98
12	CHHINDWARA	13,228.51
13	DAMOH	55,090.27
14	DATIA	41,043.01
15	DEWAS	2,805.96
16	DHAR	13,796.33
17	DINDORI	39,801.44
18	DISPUTED (RATLAM & MANDSAUR)	15.66
19	EAST NIMAR (KHANDWA)	12,592.82
20	GUNA	8,772.57
21	GWALIOR	13,957.53
22	HARDA	3,407.68
23	HOSHANGABAD (NARMADAPURAM)	9,462.75
24	INDORE	2,581.91
25	JABALPUR	26,317.38
26	JHABUA	2,995.06
27	KATNI	22,746.83
28	MANDLA	35,158.69
29	MANDSAUR	25,197.14
30	MORENA	74,709.29

Sl. No.	Name of the District	Flood Affected Areas in ha
31	NARSINGHPUR	14,615.71
32	NEEMUCH	14,184.85
33	NIWARI	1,734.07
34	PANNA	53,651.35
35	RAISEN	15,426.69
36	RAJGARH	15,411.30
37	RATLAM	3,879.34
38	REWA	680.24
39	SAGAR	20,771.54
40	SATNA	3,592.63
41	SEHORE	6,108.45
42	SEONI	12,260.92
43	SHAHDOL	36,696.75
44	SHAJAPUR	3,015.87
45	SHEOPUR	35,442.31
46	SHIVPURI	13,627.81
47	SIDHI	34,324.68
48	SINGRAULI	30,467.24
49	TIKAMGARH	6,216.05
50	UJJAIN	9,336.39
51	UMARIA	17,702.65
52	VIDISHA	14,591.28
53	WEST NIMAR (KHARGONE)	5,608.67
	Total	**9,82,108.48**


FLOOD AFFECTED AREAS IN MAHARASHTRA
N
Legend
District Boundary
Flood Affected Areas
River/WB
0 35 70 140 210 280
Km
Flood Affected Areas = 0.888 Mha
Esri, Garmin, GEBCO, NOAA NGDC, and other contributors
NANDURBAR
DHULE
JALGAON
AMARAVATI
AKOLA
BULDHANA
WASHIM
NAGPUR
WARDHA
BHANDARA
GONDIA
CHANDRAPUR
GADCHIROLI
YAVATMAL
HINGOLI
NANDED
PARBHANI
JALNA
AURANGABAD
NASHIK
PALGHAR
THANE
SUB URBAN MUMBAI
MUMBAI CITY
RAIGAD
PUNE
AHAMEDNAGAR
BEED
LATUR
OSMANABAD
SOLAPUR
SATARA
SANGLI
RATNAGIRI
KOLHAPUR
SINDHUDURG

Flood Affected Areas in Maharashtra

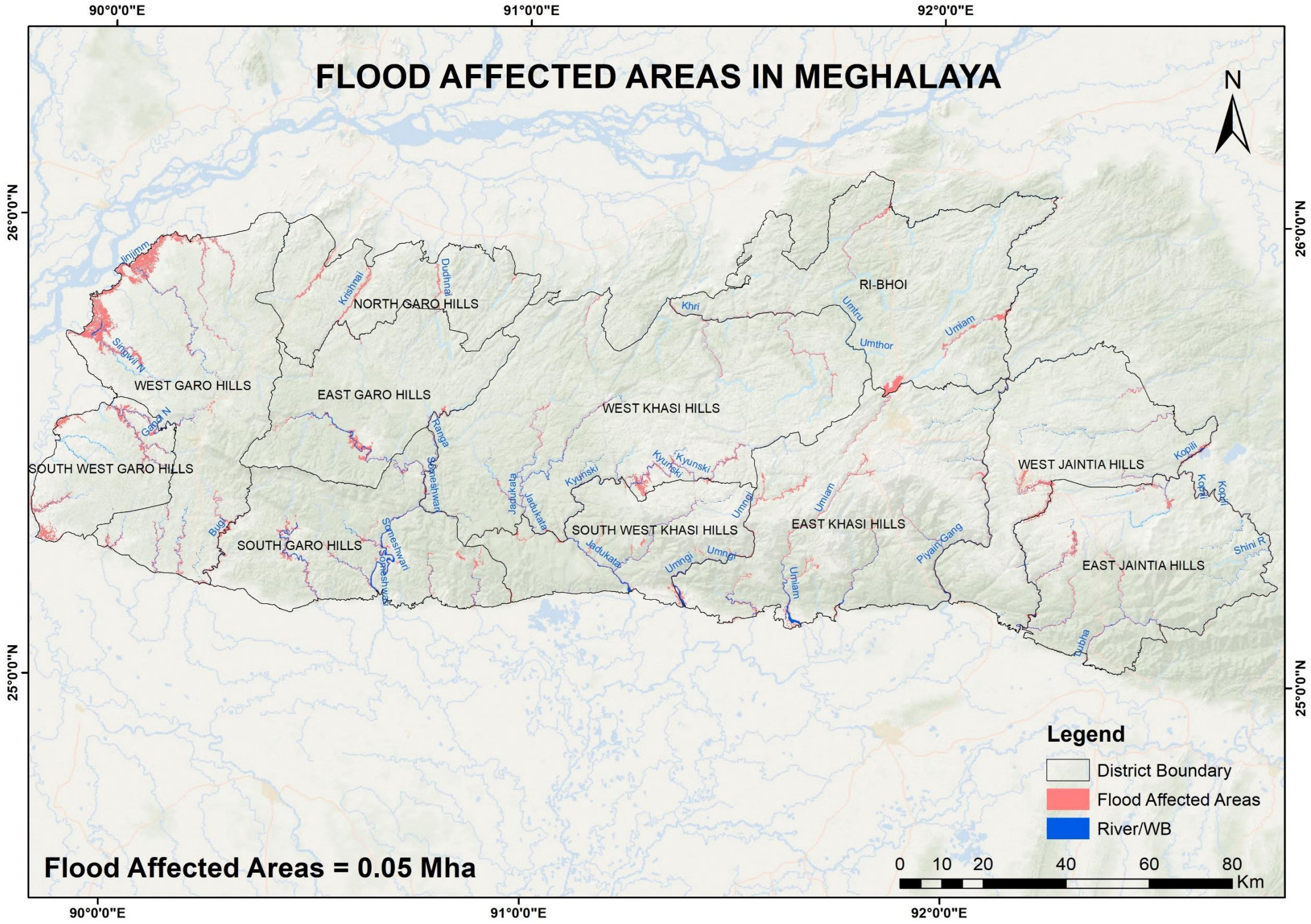
Sl. No.	Name of the District	Flood Affected Areas in ha
1	AHMEDNAGAR	39,126.16
2	AKOLA	4,860.30
3	AMARAVATI	10,311.04
4	AURANGABAD	7,170.63
5	BEED	13,687.31
6	BHANDARA	23,591.51
7	BULDHANA	5,363.06
8	CHANDRAPUR	71,902.38
9	DHULE	11,587.18
10	GADCHIROLI	96,162.95
11	GONDIA	18,721.62
12	HINGOLI	8,408.65
13	JALGAON	18,884.47
14	JALNA	13,686.16
15	KOLHAPUR	28,680.45
16	LATUR	7,527.19
17	MUMBAI CITY	1,481.72
18	MUMBAI SUB URBAN	6,512.42
19	NAGPUR	56,874.39
20	NANDED	17,989.54
21	NANDURBAR	5,693.84
22	NASHIK	37,095.65
23	OSMANABAD	4,886.01
24	PALGHAR	39,971.74
25	PARBHANI	8,349.70
26	PUNE	42,614.51
27	RAIGAD	66,326.01
28	RATNAGIRI	27,250.22
29	SANGLI	11,842.76
30	SATARA	19,570.10
31	SINDHUDURG	25,558.32
32	SOLAPUR	41,997.89
33	THANE	38,906.91
34	WARDHA	14,574.66
35	WASHIM	4,607.13
36	YAVATMAL	35,863.21
	Total	**8,87,637.78**


FLOOD AFFECTED AREAS IN MANIPUR
93°0'0"E
94°0'0"E
26°0'0"N
25°0'0"N
24°0'0"N
N
SENAPATI
UKHRUL
KANGPOKPI
TAMENGLONG
IMPHAL EAST
IMPHAL WEST
KAMJONG
NONEI
JIRIBAM
Irang or Tuijan
Barak
THOUBAL
BISHNUPUR
Imphal
KAKCHING
TENGNOUPAL
PHERZAWL
CHURACHANDPUR
CHANDEL
Legend
District Boundary
Flood Affected Areas
River/WB
Flood Affected Areas = 0.083 Mha
0 5 10 20 30 40
Km

Flood Affected Areas in Manipur

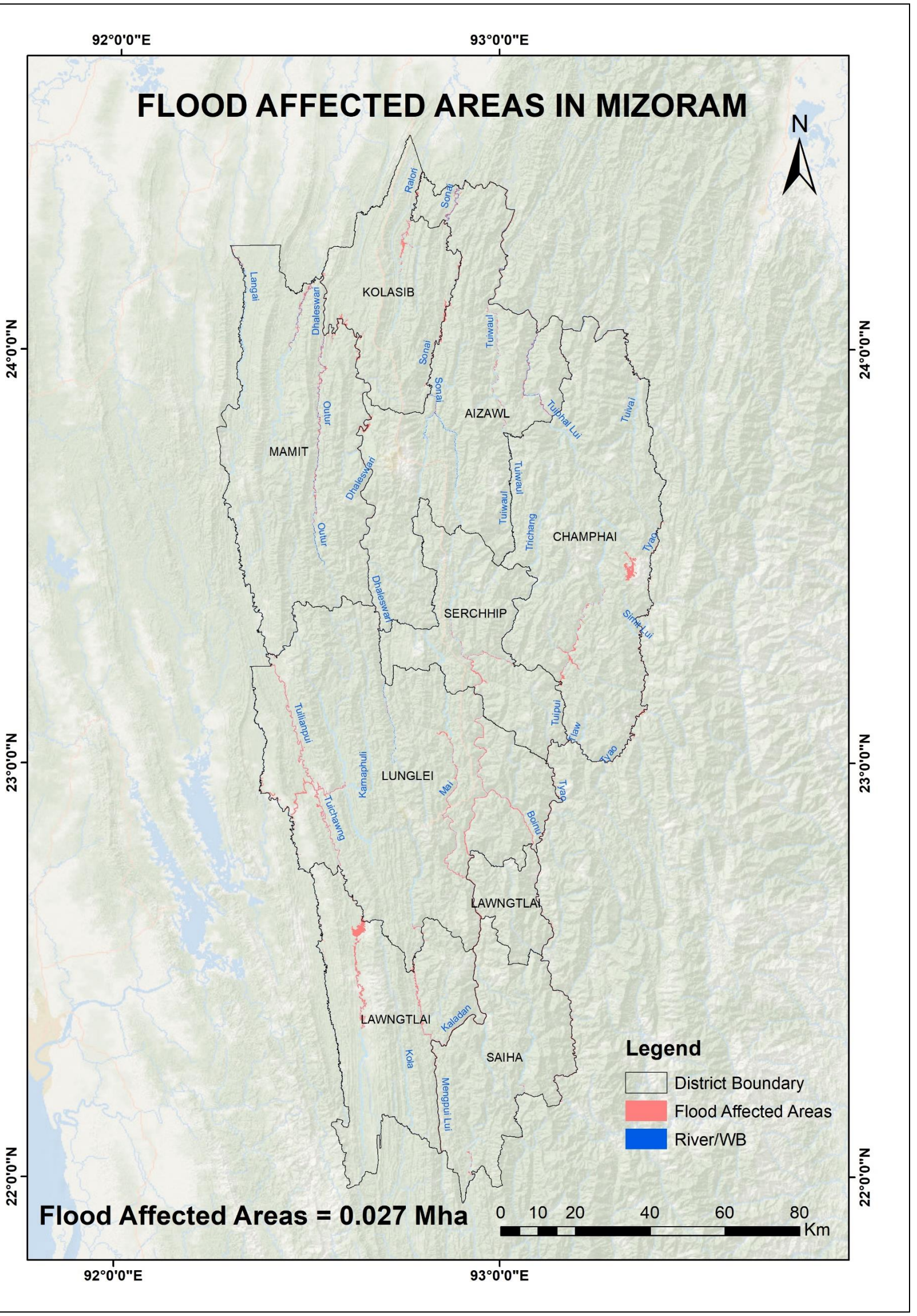
Sl. No.	Name of the District	Flood Affected Areas in ha
1	BISHNUPUR	22,632.06
2	CHANDEL	1,272.74
3	CHURACHANDPUR	704.21
4	IMPHAL EAST	2,335.92
5	IMPHAL WEST	14,140.44
6	JIRIBAM	1,764.52
7	KAKCHING	9,741.69
8	KAMJONG	897.67
9	KANGPOKPI	2,601.71
10	NONEY	4,211.47
11	PHERZAWL	2,666.83
12	SENAPATI	1,909.93
13	TAMENGLONG	3,862.64
14	TENGNOUPAL	0.00
15	THOUBAL	11,518.05
16	UKHRUL	2,531.59
	Total	**82,791.46**

FLOOD AFFECTED AREAS IN MEGHALAYA



Flood Affected Areas in Meghalaya

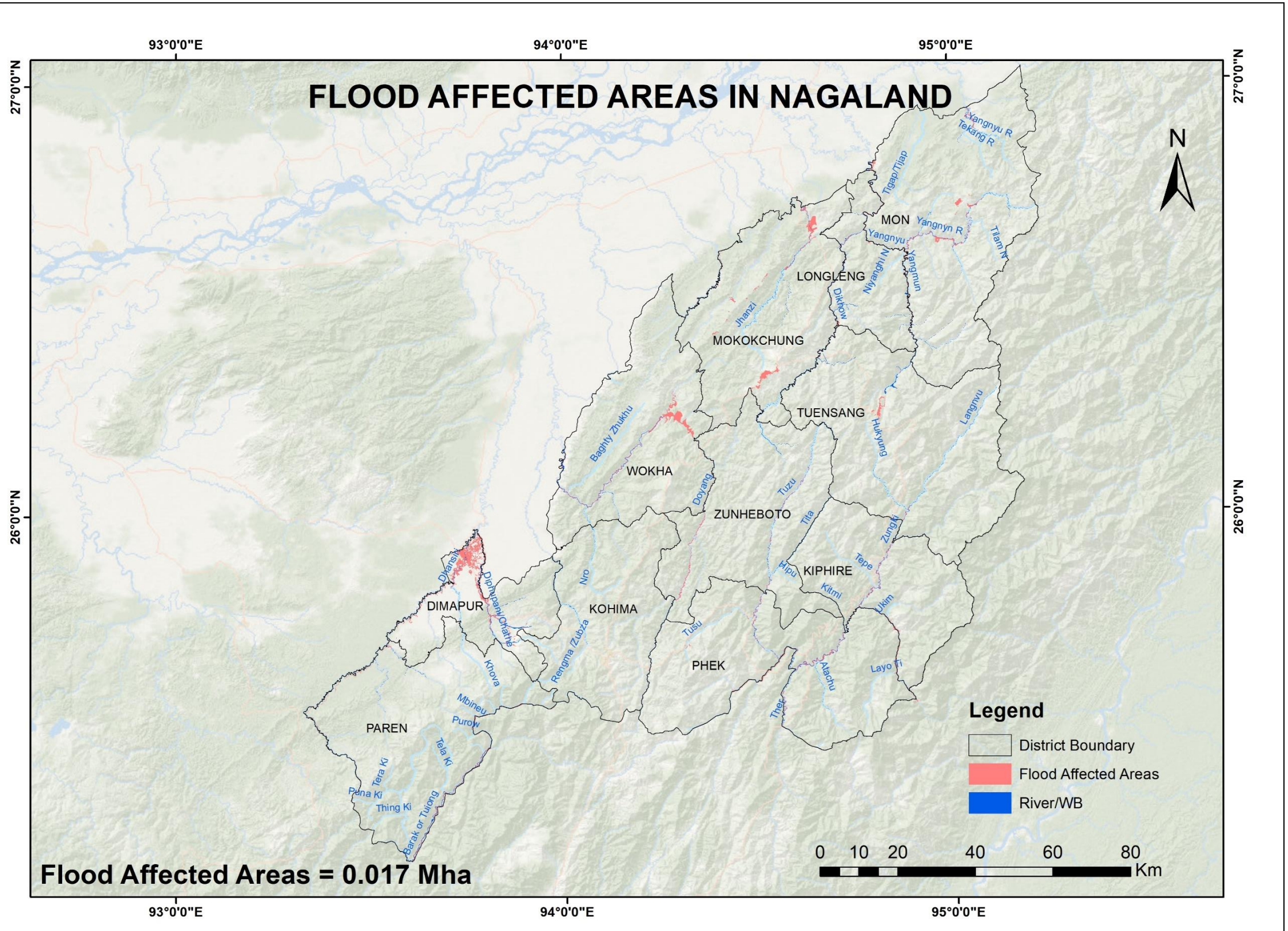
Sl. No.	Name of the District	Flood Affected Areas in ha
1	EAST GARO HILLS	1,970.81
2	EAST JAINTIA HILLS	3,792.59
3	EAST KHASI HILLS	5,448.82
4	NORTH GARO HILLS	1,922.95
5	RI-BHOI	3,382.67
6	SOUTH GARO HILLS	4,534.18
7	SOUTH WEST GARO HILLS	3,950.30
8	SOUTH WEST KHASI HILLS	2,766.00
9	WEST GARO HILLS	13,083.30
10	WEST JAINTIA HILLS	2,851.33
11	WEST KHASI HILLS	5,427.15
	Total	**49,130.10**


FLOOD AFFECTED AREAS IN MIZORAM
N
92°0'0"E
93°0'0"E
24°0'0"N
23°0'0"N
22°0'0"N
KOLASIB
AIZAWL
MAMIT
CHAMPHAI
SERCHHIP
LUNGLEI
LAWNGTLAI
LAWNGTLAI
SAIHA
Ralon
Sonai
Langai
Dhaleswari
Tuiwaul
Tuiphai Lui
Tuivai
Tuivaul
Trichang
Tyao
Sirhmui Lui
Tuilianpui
Tuichawng
Kamaphuli
Mai
Tuipui
Tlaw
Boinu
Kaladan
Kola
Mengpui Lui
Legend
District Boundary
Flood Affected Areas
River/WB
Flood Affected Areas = 0.027 Mha
0 10 20 40 60 80
Km

Flood Affected Areas in Mizoram

Sl. No.	Name of the District	Flood Affected Areas in ha
1	AIZAWL	3,108.32
2	CHAMPHAI	3,539.15
3	KOLASIB	2,237.26
4	LAWNGTLAI	4,594.88
5	LUNGLEI	6,954.02
6	MAMIT	2,640.41
7	SAIHA	2,051.43
8	SERCHHIP	1,182.61
	Total	**26,308.08**

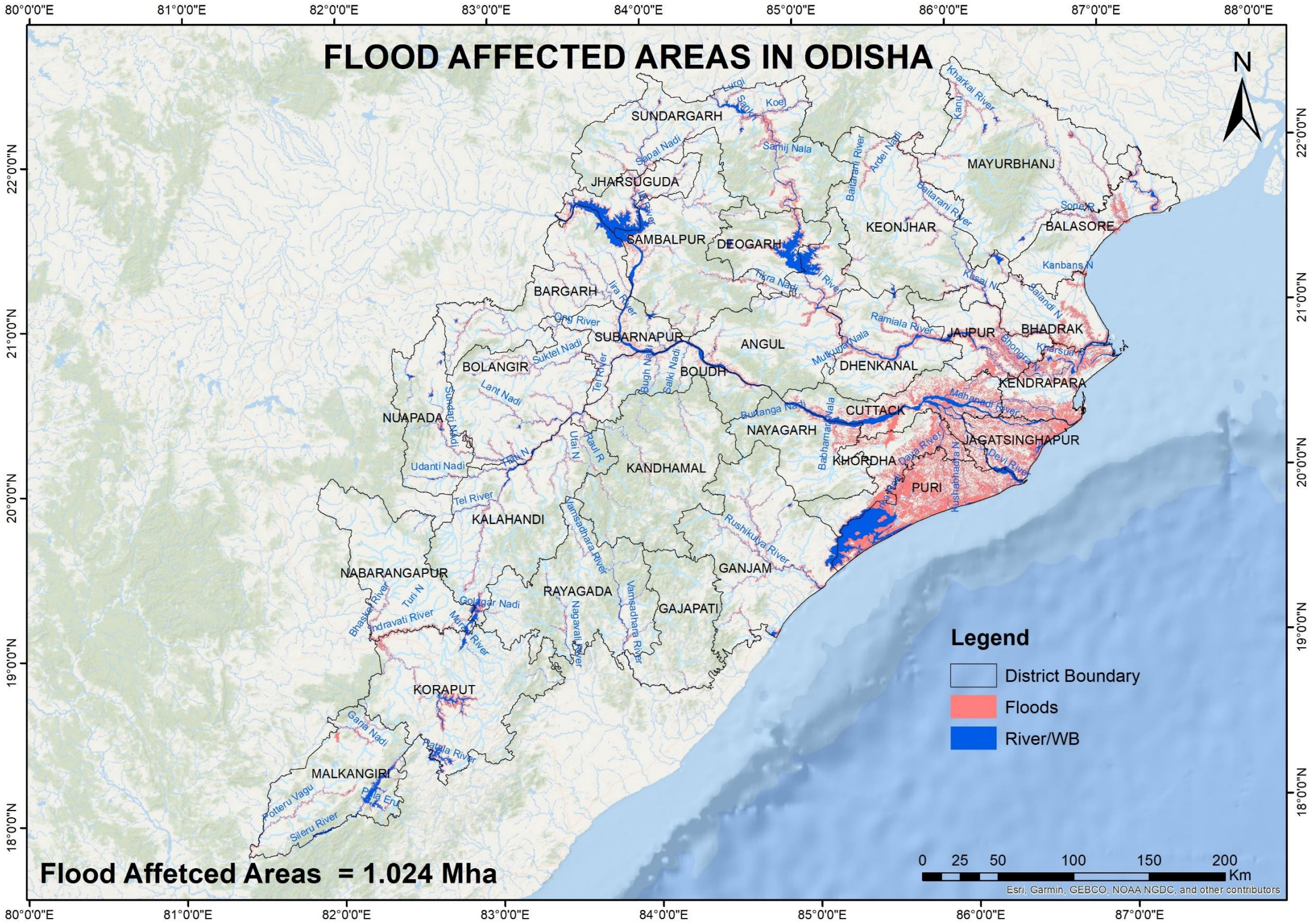
FLOOD AFFECTED AREAS IN NAGALAND



Flood Affected Areas in Nagaland

Sl. No.	Name of the District	Flood Affected Areas in ha
1	DIMAPUR	4,106.99
2	KIPHIRE	839.22
3	KOHIMA	53.45
4	LONGLENG	858.48
5	MOKOKCHUNG	2,006.03
6	MON	1,755.30
7	PEREN	886.53
8	PHEK	1,520.75
9	TUENSANG	540.91
10	WOKHA	2,360.71
11	ZUNHEBOTO	1,100.57
	Total	**16,028.93**

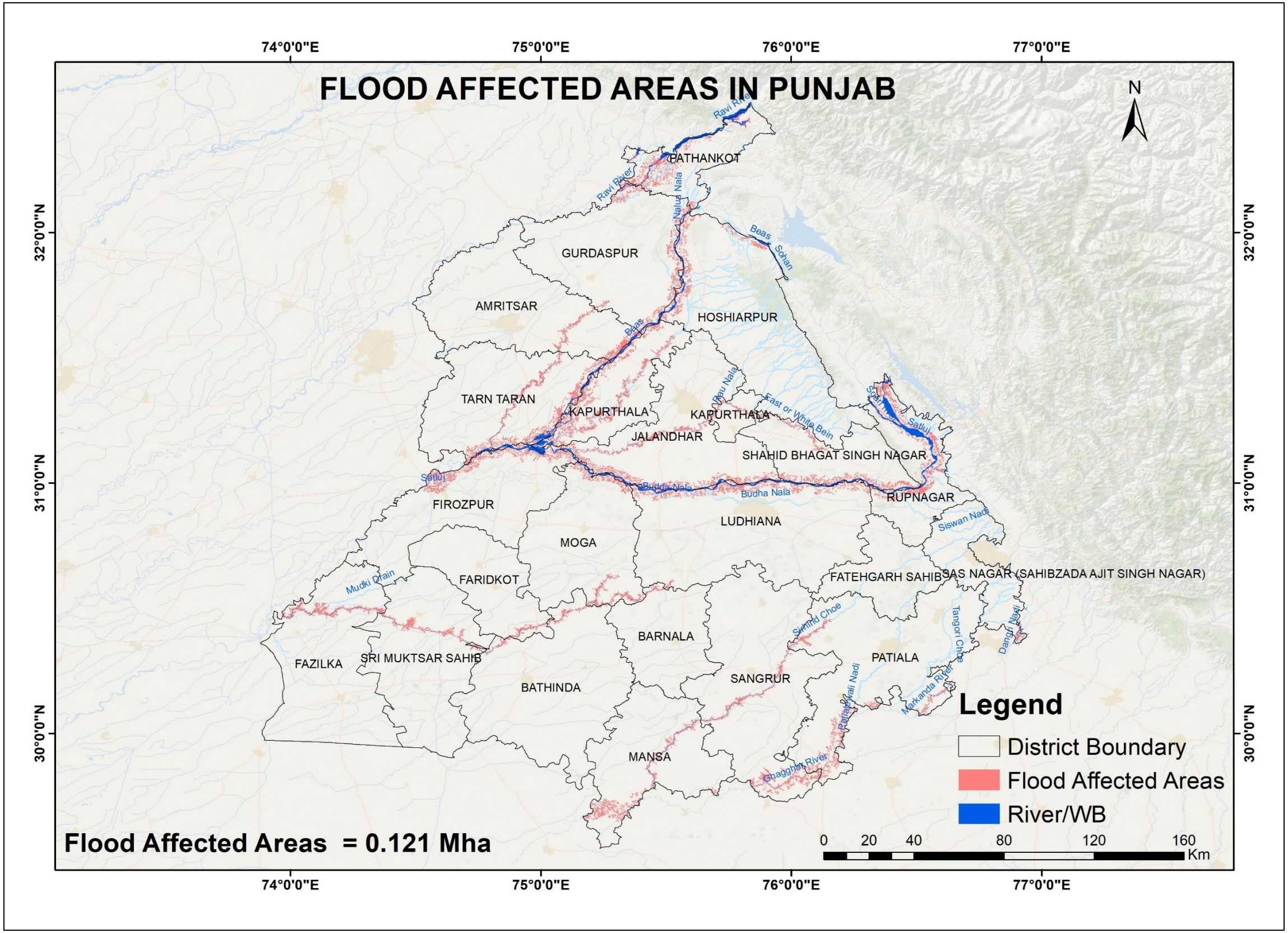
FLOOD AFFECTED AREAS IN ODISHA



Flood Affected Areas in Odisha

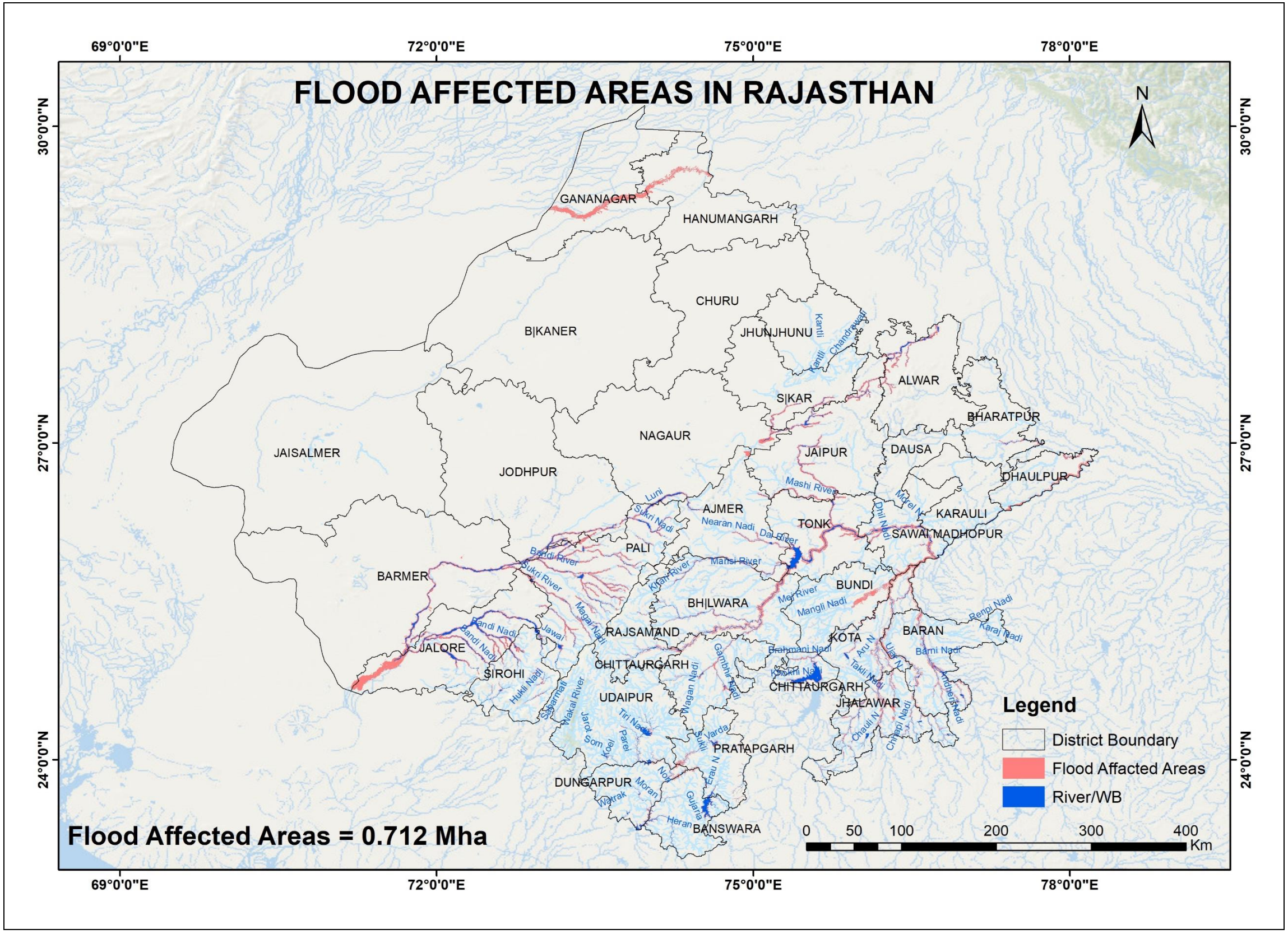
Sl. No.	Name of the District	Flood Affected Areas in ha
1	ANGUL	27,038.93
2	BALASORE (BALESWAR)	25,798.89
3	BARGARH	20,322.67
4	BHADRAK	29,846.29
5	BOLANGIR (BALANGIR)	25,002.85
6	BOUDH (BAUDA)	11,984.30
7	CUTTACK	1,02,349.50
8	DEOGARH (DEBAGARH)	14,274.61
9	DHENKANAL	26,988.46
10	GAJAPATI	1,417.48
11	GANJAM	22,260.33
12	JAGATSINGHAPUR	74,588.59
13	JAJPUR	49,040.19
14	JHARSUGUDA	15,712.88
15	KALAHANDI	23,526.43
16	KANDHAMAL	7,910.77
17	KENDRAPARA	81,311.84
18	KEONJHAR (KENDUJHAR)	23,791.05
19	KHORDHA	73,876.47
20	KORAPUT	27,683.03
21	MALKANGIRI	18,224.04
22	MAYURBHANJ	28,038.49
23	NABARANGAPUR	11,545.50
24	NAYAGARH	14,374.27
25	NUAPADA	9,288.92
26	PURI	1,70,248.70
27	RAYAGADA	10,508.78
28	SAMBALPUR	21,040.07
29	SUBARNAPUR	14,241.97
30	SUNDARGARH	41,138.88
	Total	**10,23,375.17**

FLOOD AFFECTED AREAS IN PUNJAB



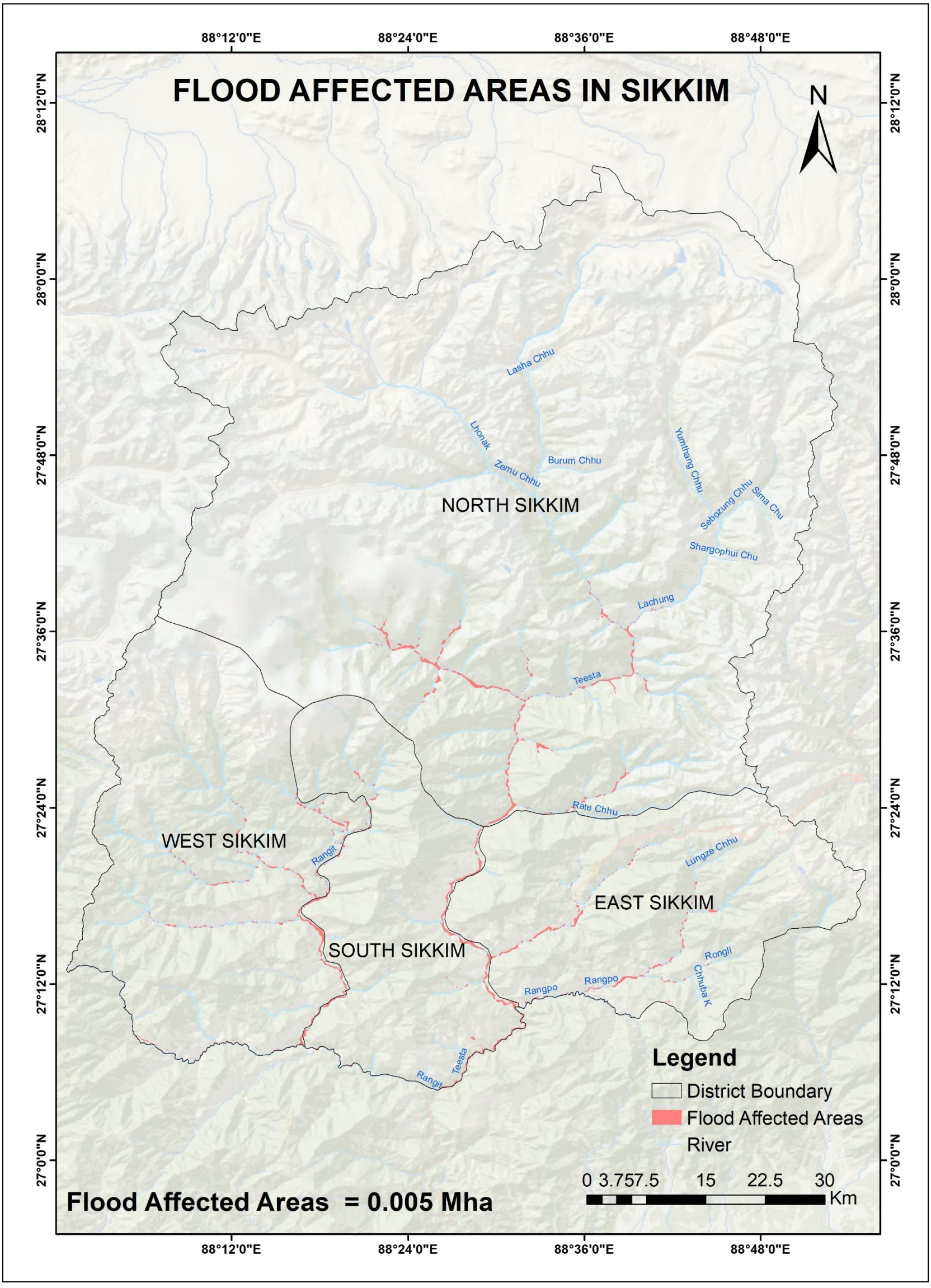
Flood Affected Areas in Punjab

Sl. No.	Name of the District	Flood Affected Areas in ha
1	AMRITSAR	3,650.94
2	BARNALA	634.04
3	BATHINDA	2,688.67
4	FARIDKOT	1,489.76
5	FATEHGARH SAHIB	0.00
6	FAZILKA	4,820.72
7	FIROZPUR	7,209.28
8	GURDASPUR	4,459.17
9	HOSHIARPUR	5,038.65
10	JALANDHAR	10,725.74
11	KAPURTHALA	14,285.57
12	LUDHIANA	6,806.84
13	MANSA	6,682.17
14	MOGA	5,251.82
15	PATHANKOT	5,340.41
16	PATIALA	6,655.83
17	RUPNAGAR	7,072.61
18	SANGRUR	7,547.81
19	SAS NAGAR (SAHIBZADA AJIT SINGH NAGAR)	718.19
20	SHAHEED BHAGAT SINGH NAGAR	5,045.88
21	SRI MUKTSAR SAHIB	4,198.09
22	TARN TARAN	10,594.90
	Total	**1,20,917.07**


FLOOD AFFECTED AREAS IN RAJASTHAN
69°0'0"E
72°0'0"E
75°0'0"E
78°0'0"E
30°0'0"N
27°0'0"N
24°0'0"N
N
GANANAGAR
HANUMANGARH
CHURU
B|KANER
JHUNJHUNU
Kantli
Chandrawati
ALWAR
S|KAR
BHARATPUR
NAGAUR
JAISALMER
JAIPUR
DAUSA
JODHPUR
DHAULPUR
Luni
Sukri Nadi
AJMER
Nearan Nadi
Dai River
TONK
KARAULI
SAWAI MADHOPUR
PALI
Bandi River
Sukri River
Mansi River
Khan River
BARMER
BUNDI
Mer River
Mangli Nadi
BHILWARA
Renpi Nadi
Karai Nadi
RAJSAMAND
KOTA
BARAN
Bandi Nadi
Jawai
Magai Nadi
JALORE
Brahmani Nadi
Bami Nadi
CHITTAURGARH
SIROHI
Hukli Nadi
Gambhiri Nadi
Wagan Nadi
Takli Nadi
Andheri Nadi
Sabarmati
Wakal River
UDAIPUR
Jarot
Som
Koel
Parel
Tiri Nadi
Sukli
Varda
Chauli N
Chirpi Nadi
PRATAPGARH
DUNGARPUR
Moran
Warak
Erau N
Gujaria
Heran
BANSWARA
Flood Affected Areas = 0.712 Mha
Legend
District Boundary
Flood Affacted Areas
River/WB
0
50
100
200
300
400
Km

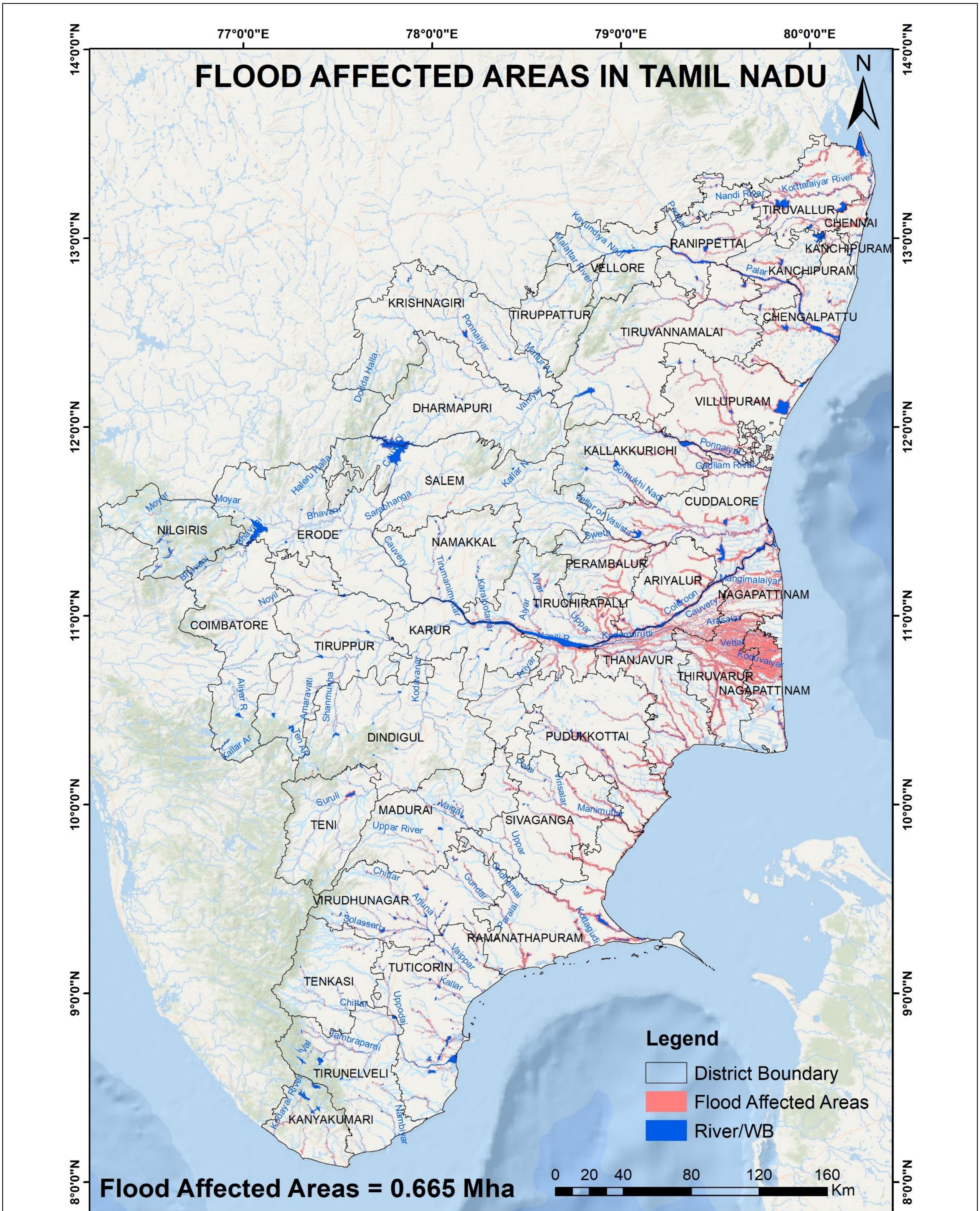
Flood Affected Areas in Rajasthan

Sl. No.	Name of the District	Flood Affected Areas in ha
1	AJMER	17,828.47
2	ALWAR	19,334.80
3	BANSWARA	8,007.27
4	BARAN	33,360.64
5	BARMER	33,283.29
6	BHARATPUR	3,195.52
7	BHILWARA	39,398.13
8	BIKANER	0.00
9	BUNDI	18,016.88
10	CHITTORGARH	20,240.86
11	CHURU	0.00
12	DAUSA	0.00
13	DHOLPUR	15,485.14
14	DUNGARPUR	7,510.85
15	GANGANAGAR	40,543.55
16	HANUMANGARH	20,147.64
17	JAIPUR	41,322.34
18	JAISALMER	0.00
19	JALORE	88,310.77
20	JHALAWAR	34,520.91
21	JHUNJHUNU	0.00
22	JODHPUR	19,112.05
23	KARAULI	1,454.15
24	KOTA	31,373.79
25	NAGAUR	11,668.35
26	PALI	91,384.38
27	PRATAPGARH	9,449.45
28	RAJSAMAND	6,486.31
29	SAWAI MADHOPUR	27,670.17
30	SIKAR	8,800.82
31	SIROHI	12,229.12
32	TONK	44,032.33
33	UDAIPUR	7,402.55
	Total	**7,11,570.53**


FLOOD AFFECTED AREAS IN SIKKIM
N
88°12'0"E
88°24'0"E
88°36'0"E
88°48'0"E
28°12'0"N
28°0'0"N
27°48'0"N
27°36'0"N
27°24'0"N
27°12'0"N
27°0'0"N
Lasha Chhu
Lhonak
Zemu Chhu
Burum Chhu
NORTH SIKKIM
Yumthang Chhu
Sebozung Chhu
Sima Chu
Shargophui Chu
Lachung
Teesta
Rate Chhu
WEST SIKKIM
Rangit
Lungze Chhu
EAST SIKKIM
SOUTH SIKKIM
Rongli
Chhuba K
Rangpo
Rangpo
Rangit
Teesta
Legend
District Boundary
Flood Affected Areas
River
0 3.757.5 15 22.5 30
Km
Flood Affected Areas = 0.005 Mha

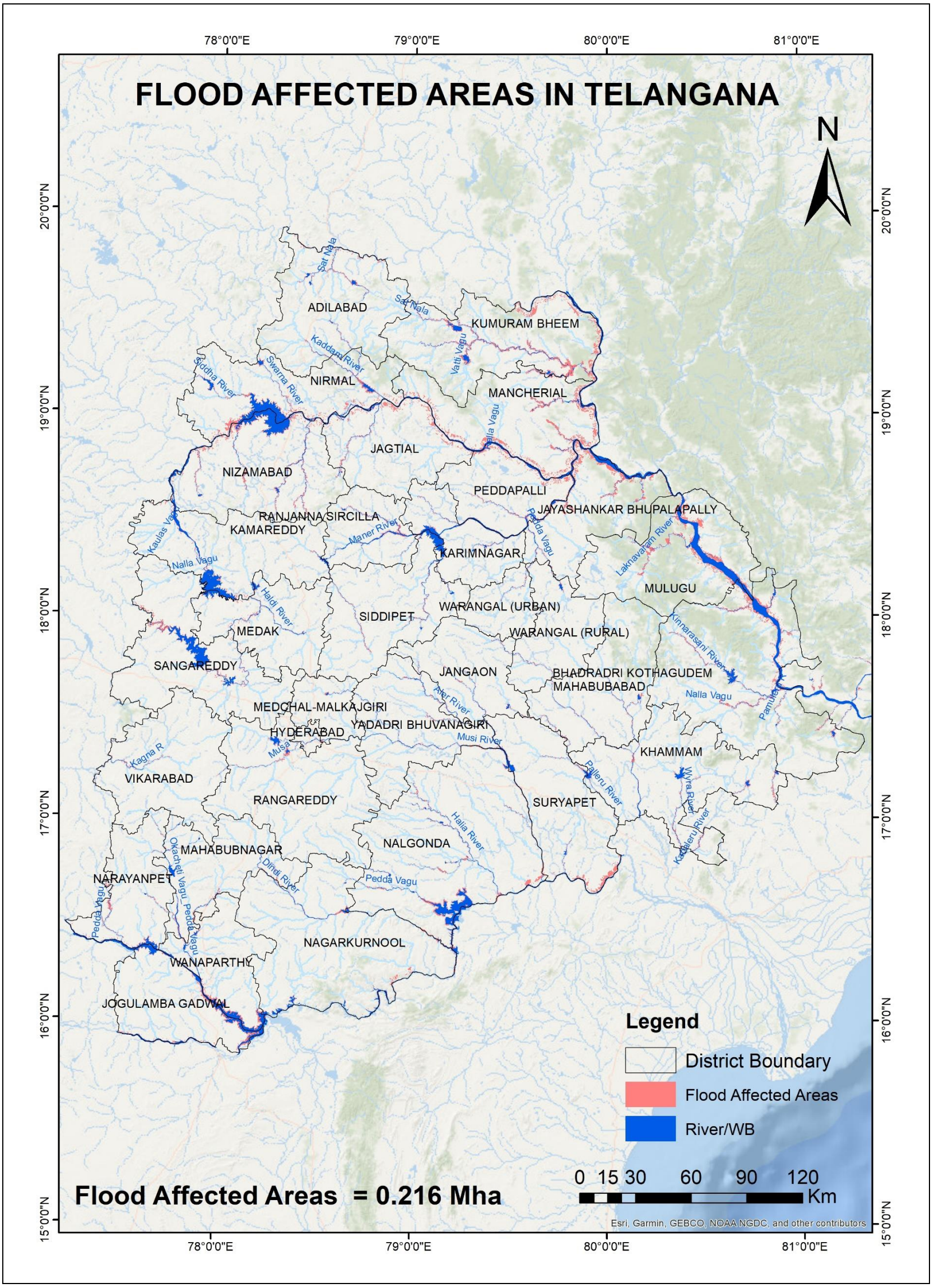
Flood Affected Areas in Sikkim

Sl. No.	Name of the District	Flood Affected Areas in ha
1	EAST SIKKIM	748.84
2	NORTH SIKKIM	1,705.77
3	SOUTH SIKKIM	1,110.11
4	WEST SIKKIM	1,175.86
	Total	**4,740.58**


FLOOD AFFECTED AREAS IN TAMIL NADU
77°0'0"E
78°0'0"E
79°0'0"E
80°0'0"E
14°0'0"N
13°0'0"N
12°0'0"N
11°0'0"N
10°0'0"N
9°0'0"N
8°0'0"N
N
TIRUVALLUR
CHENNAI
RANIPPETTAI
KANCHIPURAM
VELLORE
KRISHNAGIRI
TIRUPPATTUR
CHENGALPATTU
TIRUVANNAMALAI
DHARMAPURI
VILLUPURAM
KALLAKKURICHI
SALEM
CUDDALORE
NILGIRIS
ERODE
NAMAKKAL
PERAMBALUR
ARIYALUR
NAGAPATTINAM
TIRUCHIRAPALLI
COIMBATORE
KARUR
TIRUPPUR
THANJAVUR
THIRUVARUR
DINDIGUL
PUDUKKOTTAI
MADURAI
TENI
SIVAGANGA
VIRUDHUNAGAR
RAMANATHAPURAM
TUTICORIN
TENKASI
TIRUNELVELI
KANYAKUMARI
Legend
District Boundary
Flood Affected Areas
River/WB
Flood Affected Areas = 0.665 Mha
0 20 40 80 120 160
Km

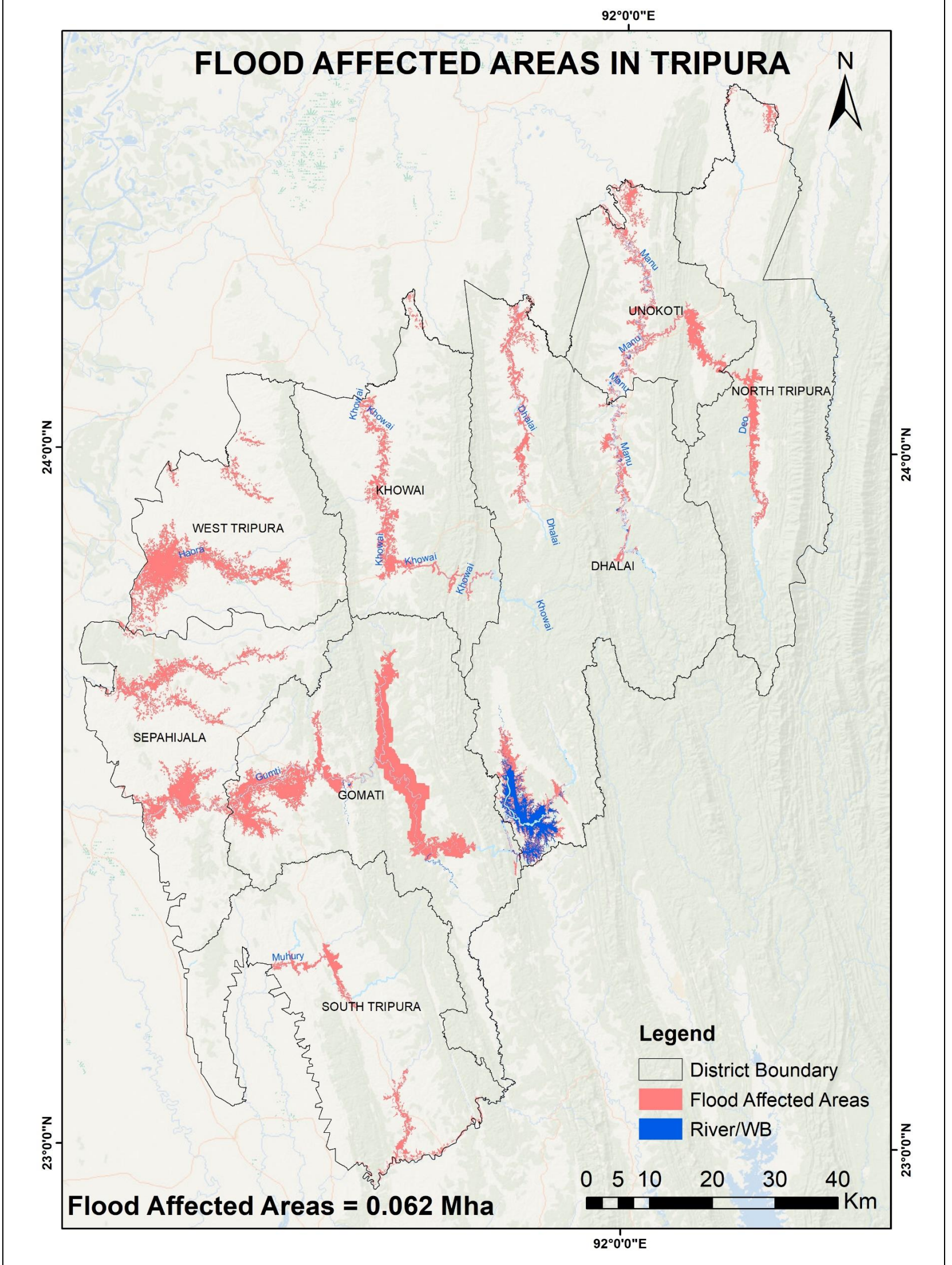
Flood Affected Areas in Tamil Nadu

Sl. No	Name of the District	Flood Affected Areas in ha
1	ARIYALUR	19,663.67
2	CHENGALPATTU	16,827.97
3	CHENNAI	5,754.49
4	COIMBATORE	7,391.13
5	CUDDALORE	38,901.16
6	DHARMAPURI	5,285.03
7	DINDIGUL	6,865.83
8	ERODE	6,098.91
9	KALLAKURICHI	16,309.35
10	KANCHIPURAM	11,126.98
11	KANNIYAKUMARI	4,633.82
12	KARUR	8,302.62
13	KRISHNAGIRI	6,078.37
14	MADURAI	8,371.51
15	NAGAPATTINAM	74,122.54
16	NAMAKKAL	3,467.99
17	NILGIRIS	2,231.75
18	PERAMBALUR	15,168.49
19	PUDUKKOTTAI	29,054.92
20	RAMANATHAPURAM	32,613.80
21	RANIPET	9,883.16
22	SALEM	5,917.46
23	SIVAGANGA	21,548.94
24	TENKASI	4,049.62
25	THANJAVUR	59,800.93
26	THENI	4,592.07
27	THIRUVARUR	77,194.84
28	TIRUCHIRAPPALLI	30,899.45
29	TIRUNELVELI	8,734.59
30	TIRUPPATTUR (TIRUPATHUR)	2,444.83
31	TIRUPPUR	8,287.33
32	TIRUVALLUR	31,535.07
33	TIRUVANNAMALAI	16,786.79
34	TUTICORIN (THOOTHUKUDI)	18,729.12
35	VELLORE	2,420.16
36	VILLUPPURAM	28,816.47
37	VIRUDHUNAGAR	14,803.92
	Total	**6,64,715.06**


FLOOD AFFECTED AREAS IN TELANGANA
N
78°0'0"E
79°0'0"E
80°0'0"E
81°0'0"E
20°0'0"N
19°0'0"N
18°0'0"N
17°0'0"N
16°0'0"N
15°0'0"N
ADILABAD
KUMURAM BHEEM
NIRMAL
MANCHERIAL
JAGTIAL
NIZAMABAD
PEDDAPALLI
JAYASHANKAR BHUPALAPALLY
RANJANNA SIRCILLA KAMAREDDY
KARIMNAGAR
MULUGU
WARANGAL (URBAN)
SIDDIPET
MEDAK
WARANGAL (RURAL)
SANGAREDDY
JANGAON
BHADRADRI KOTHAGUDEM
MAHABUBABAD
MEDCHAL-MALKAJGIRI
YADADRI BHUVANAGIRI
HYDERABAD
KHAMMAM
VIKARABAD
RANGAREDDY
SURYAPET
NALGONDA
MAHABUBNAGAR
NARAYANPET
NAGARKURNOOL
WANAPARTHY
JOGULAMBA GADWAL
Sat Nala
Kaddam River
Swarna River
Siddha River
Vatti Vagu
Maner River
Kaulas Vagu
Nalla Vagu
Haldi River
Peddavagu
Laknavaram River
Kinnarasani River
Pamuleru
Aler River
Musi River
Kagna R
Palleru River
Wyra River
Kattaleru River
Halia River
Dindi River
Pedda Vagu
Okacheti Vagu
Legend
District Boundary
Flood Affected Areas
River/WB
0 15 30 60 90 120
Km
Flood Affected Areas = 0.216 Mha
Esri, Garmin, GEBCO, NOAA NGDC, and other contributors

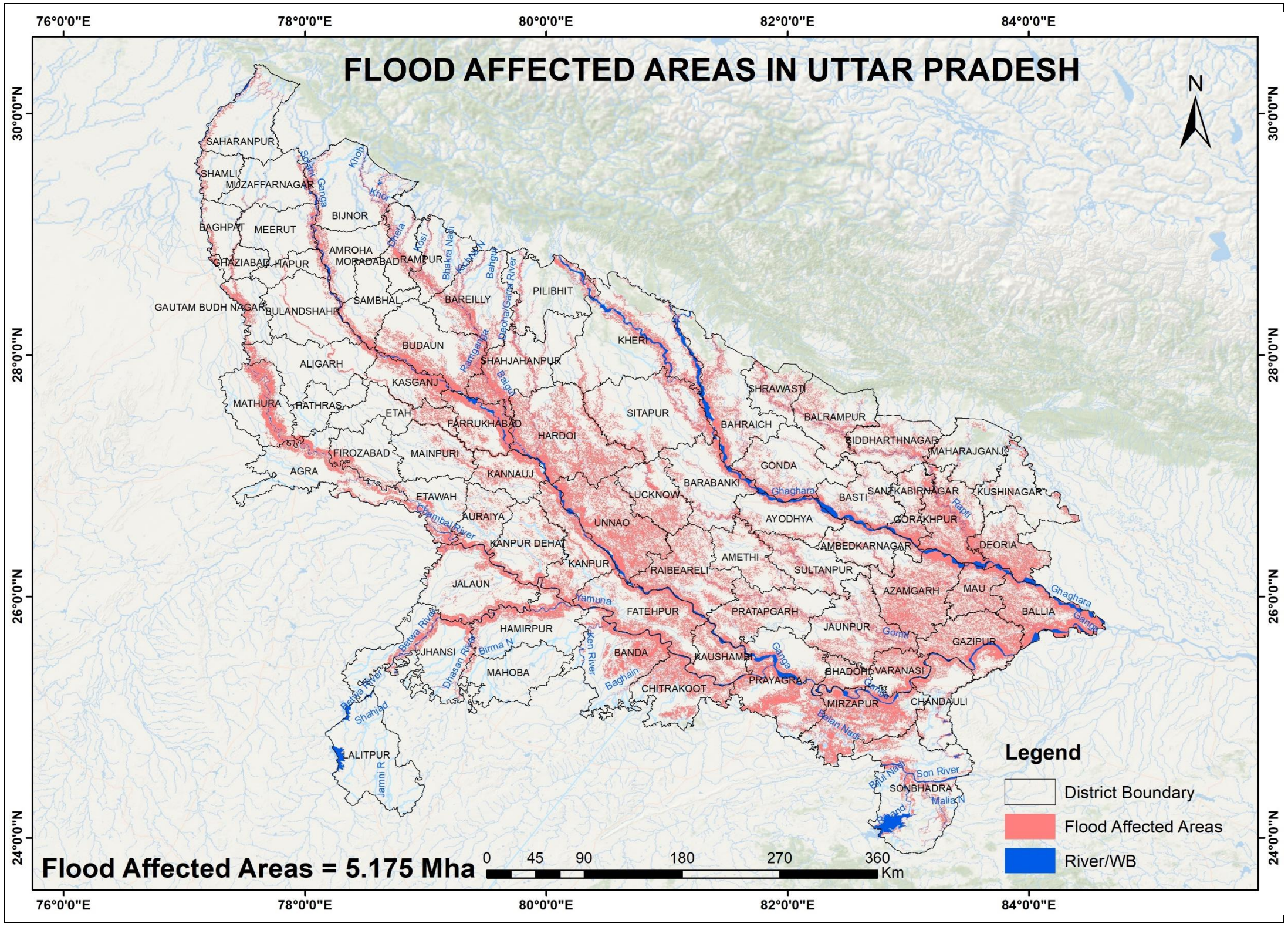
Flood Affected Areas in Telangana

Sl. No.	Name of the District	Flood Affected Areas in ha
1	ADILABAD	4,329.45
2	BHADRADRI KOTHAGUDEM	16,115.62
3	HYDERABAD	304.66
4	JAGTIAL	7,455.15
5	JANGAON	2,471.02
6	JAYASHANKAR BHUPALAPALLY	12,174.01
7	JOGULAMBA GADWAL	6,105.36
8	KAMAREDDY	3,456.19
9	KARIMNAGAR	2,351.23
10	KHAMMAM	6,169.51
11	KUMURAM BHEEM ASIFABAD	21,261.36
12	MAHABUBABAD	3,535.92
13	MAHABUBNAGAR	3,217.42
14	MANCHERIAL	20,768.85
15	MEDAK	3,046.46
16	MEDCHAL-MALKAJGIRI	695.87
17	MULUGU	14,617.46
18	NAGARKURNOOL	4,245.66
19	NALGONDA	13,253.55
20	NARAYANPET	4,251.06
21	NIRMAL	12,303.23
22	NIZAMABAD	12,587.51
23	PEDDAPALLI	6,917.46
24	RANGAREDDY	2,171.19
25	RANJANNA SIRCILLA	2,960.19
26	SANGAREDDY	6,726.01
27	SIDDIPET	3,477.70
28	SURYAPET	7,030.12
29	VIKARABAD	1,387.98
30	WANAPARTHY	4,991.02
31	WARANGAL RURAL	1,211.37
32	WARANGAL URBAN (HANAMKONDA)	611.32
33	YADADRI BHUVANAGIRI	3,630.79
	Total	**2,15,831.69**


FLOOD AFFECTED AREAS IN TRIPURA
N
92°0'0"E
24°0'0"N
23°0'0"N
UNOKOTI
NORTH TRIPURA
KHOWAI
WEST TRIPURA
DHALAI
SEPAHIJALA
GOMATI
SOUTH TRIPURA
Manu
Khowai
Dhalai
Deo
Haora
Gumti
Muhury
Legend
District Boundary
Flood Affected Areas
River/WB
0 5 10 20 30 40
Km
Flood Affected Areas = 0.062 Mha

Flood Affected Areas in Tripura

Sl. No.	Name of the District	Flood Affected Areas in ha
1	DHALAI	7,896.46
2	GOMATI	17,841.35
3	KHOWAI	5,045.21
4	NORTH TRIPURA	3,132.94
5	SEPAHIJALA	9,408.54
6	SOUTH TRIPURA	3,184.59
7	UNAKOTI	5,646.03
8	WEST TRIPURA	9,776.10
	Total	**61,931.21**

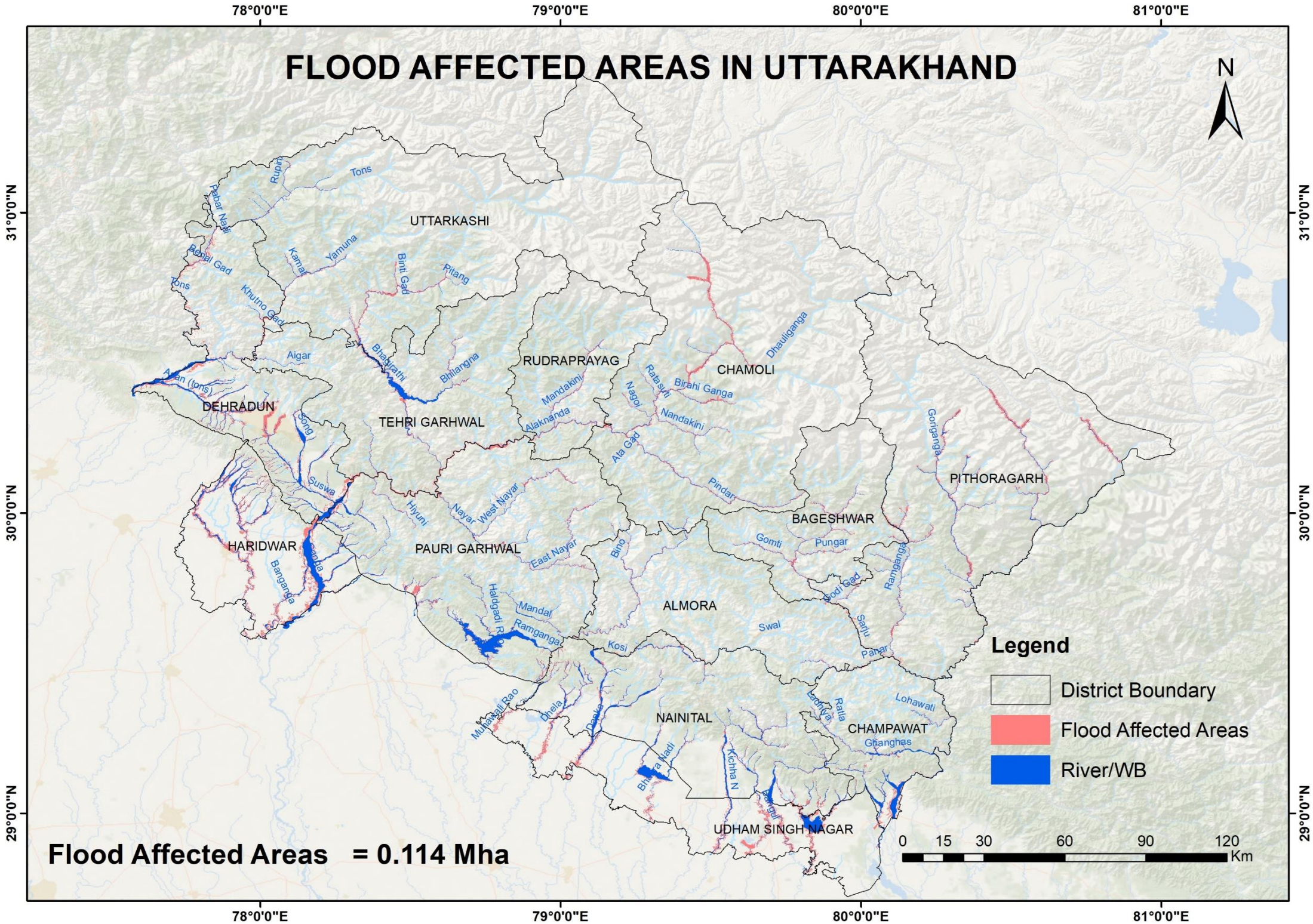

FLOOD AFFECTED AREAS IN UTTAR PRADESH
N
76°0'0"E
78°0'0"E
80°0'0"E
82°0'0"E
84°0'0"E
30°0'0"N
28°0'0"N
26°0'0"N
24°0'0"N
SAHARANPUR
SHAMLI
MUZAFFARNAGAR
BAGHPAT
MEERUT
BIJNOR
GHAZIABAD
HAPUR
AMROHA
MORADABAD
RAMPUR
GAUTAM BUDH NAGAR
BULANDSHAHR
SAMBHAL
BAREILLY
PILIBHIT
BUDAUN
KHERI
ALIGARH
SHAHJAHANPUR
KASGANJ
MATHURA
HATHRAS
ETAH
FARRUKHABAD
HARDOI
SITAPUR
SHRAWASTI
BAHRAICH
BALRAMPUR
SIDDHARTHNAGAR
MAHARAJGANJ
FIROZABAD
MAINPURI
AGRA
KANNAUJ
GONDA
BARABANKI
LUCKNOW
BASTI
SANTKABIRNAGAR
KUSHINAGAR
ETAWAH
AURAIYA
UNNAO
AYODHYA
GORAKHPUR
AMBEDKARNAGAR
DEORIA
KANPUR DEHAT
KANPUR
AMETHI
RAIBEARELI
SULTANPUR
JALAUN
AZAMGARH
MAU
BALLIA
FATEHPUR
PRATAPGARH
JAUNPUR
HAMIRPUR
GAZIPUR
JHANSI
BANDA
KAUSHAMBI
MAHOBA
BHADOHI
VARANASI
PRAYAGRAJ
CHITRAKOOT
MIRZAPUR
CHANDAULI
LALITPUR
SONBHADRA
Ganga
Yamuna
Ghaghara
Gomti
Son River
Rapti
Legend
District Boundary
Flood Affected Areas
River/WB
Flood Affected Areas = 5.175 Mha
0
45
90
180
270
360
Km

Flood Affected Areas in Uttar Pradesh

Sl. No.	Name of the District	Flood Affected Areas in ha
1	AGRA	67,461.01
2	ALIGARH	22,910.08
3	AMBEDKAR NAGAR	42,028.04
4	AMETHI	34,157.37
5	AMROHA	27,575.44
6	AURAIYA	36,263.08
7	AYODHYA	41,624.39
8	AZAMGARH	1,90,126.37
9	BADAUN	1,14,737.59
10	BAGHPAT	11,751.03
11	BAHRAICH	84,888.96
12	BALLIA	1,60,417.21
13	BALRAMPUR	56,846.26
14	BANDA	1,13,928.58
15	BARABANKI	60,811.54
16	BAREILLY	75,560.24
17	BASTI	45,373.97
18	BHADOHI (SANT RAVIDAS NAGAR)	32,415.22
19	BIJNOR	36,255.30
20	BULANDSHAHR	20,505.23
21	CHANDAULI	50,293.21
22	CHITRAKOOT	1,01,911.65
23	DEORIA	1,05,048.16
24	ETAH	29,857.74
25	ETAWAH	45,776.65
26	FARRUKHABAD	95,309.41
27	FATEHPUR	1,50,372.86
28	FIROZABAD	23,583.57
29	GAUTAM BUDH NAGAR	26,100.23
30	GHAZIABAD	8,883.51
31	GHAZIPUR	1,61,477.47
32	GONDA	66,358.01
33	GORAKHPUR	1,46,750.43
34	HAMIRPUR	72,761.80
35	HAPUR	8,357.78
36	HARDOI	2,40,318.27
37	HATHRAS	2,192.71
38	JALAUN	85,069.90
39	JAUNPUR	1,13,556.37
40	JHANSI	57,237.11

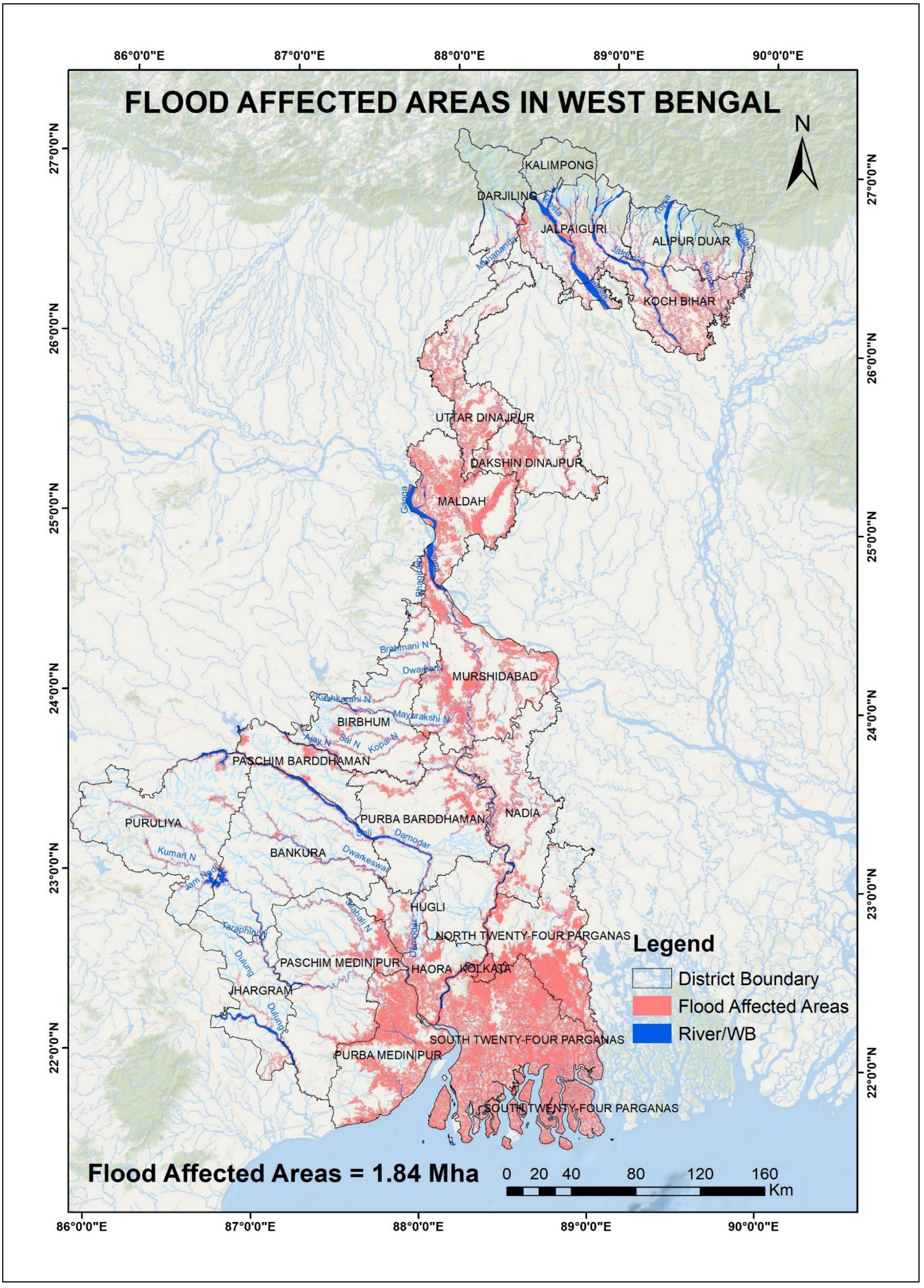
Sl. No	Name of the District	Flood Affected Areas in ha
41	KANNAUJ	55,550.31
42	KANPUR DEHAT	52,096.51
43	KANPUR NAGAR	1,00,047.49
44	KASGANJ	68,029.10
45	KAUSHAMBI	64,032.75
46	KUSHINAGAR	23,862.89
47	LAKHIMPUR KHERI	98,488.54
48	LALITPUR	1,178.98
49	LUCKNOW	69,990.77
50	MAHARAJGANJ	18,367.80
51	MAHOBA	3,730.28
52	MAINPURI	24,516.61
53	MATHURA	93,864.67
54	MAU	81,250.17
55	MEERUT	14,685.38
56	MIRZAPUR	1,99,693.74
57	MORADABAD	36,774.25
58	MUZAFFARNAGAR	11,051.85
59	PILIBHIT	38,075.71
60	PRATAPGARH	86,156.73
61	PRAYAGRAJ	1,73,443.34
62	RAE BARELI	1,34,376.54
63	RAMPUR	29,606.09
64	SAHARANPUR	19,420.03
65	SAMBHAL	22,595.84
66	SANT KABIR NAGAR	50,924.11
67	SHAHJAHANPUR	98,944.81
68	SHAMLI	8,595.94
69	SHRAVASTI	34,959.75
70	SIDDHARTHNAGAR	61,062.83
71	SITAPUR	93,064.57
72	SONBHADRA	89,649.89
73	SULTANPUR	48,293.00
74	UNNAO	2,34,880.98
75	VARANASI	65,956.65
	Total	**51,74,072.66**

FLOOD AFFECTED AREAS IN UTTARAKHAND



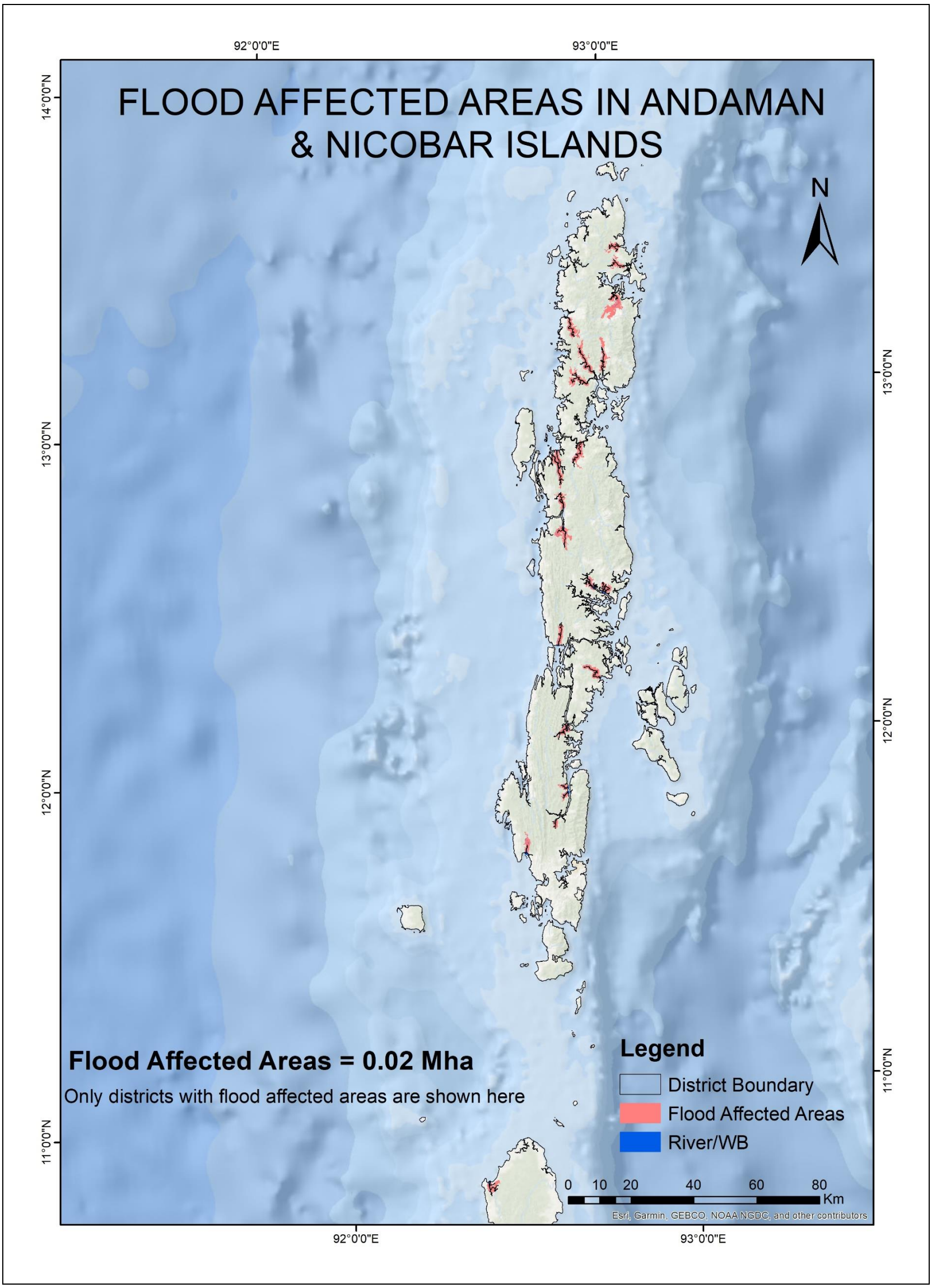
Flood Affected Areas in Uttarakhand

Sl. No.	Name of the District	Flood Affected Areas in ha
1	ALMORA	2,924.88
2	BAGESHWAR	3,937.38
3	CHAMOLI	10,129.79
4	CHAMPAWAT	4,507.86
5	DEHRADUN	15,327.83
6	HARIDWAR	16,818.02
7	NAINITAL	9,774.88
8	PAURI GARHWAL	12,699.35
9	PITHORAGARH	12,893.17
10	RUDRAPRAYAG	1,985.59
11	TEHRI GARHWAL	5,111.76
12	UDHAM SINGH NAGAR	13,084.67
13	UTTARKASHI	4,709.29
	Total	**1,13,904.48**


FLOOD AFFECTED AREAS IN WEST BENGAL
N
86°0'0"E
87°0'0"E
88°0'0"E
89°0'0"E
90°0'0"E
27°0'0"N
26°0'0"N
25°0'0"N
24°0'0"N
23°0'0"N
22°0'0"N
KALIMPONG
DARJILING
JALPAIGURI
ALIPUR DUAR
KOCH BIHAR
UTTAR DINAJPUR
DAKSHIN DINAJPUR
MALDAH
MURSHIDABAD
BIRBHUM
PASCHIM BARDDHAMAN
PURULIYA
PURBA BARDDHAMAN
NADIA
BANKURA
HUGLI
NORTH TWENTY-FOUR PARGANAS
PASCHIM MEDINIPUR
HAORA KOLKATA
JHARGRAM
SOUTH TWENTY-FOUR PARGANAS
PURBA MEDINIPUR
SOUTH TWENTY-FOUR PARGANAS
Mahananda
Teesta
Torsa
Jaldhaka
Raidak
Kalijani
Ganga
Bhagirathi
Damodar
Dwarkeswar
Dulung
Kumari N
Jam Nadi
Brahmani N
Dwarka N
Kushkarani N
Mayurakshi N
Ajay N
Sal N
Kopai N
Kunur
Silabati N
Taraphini N
Legend
District Boundary
Flood Affected Areas
River/WB
Flood Affected Areas = 1.84 Mha
0 20 40 80 120 160
Km

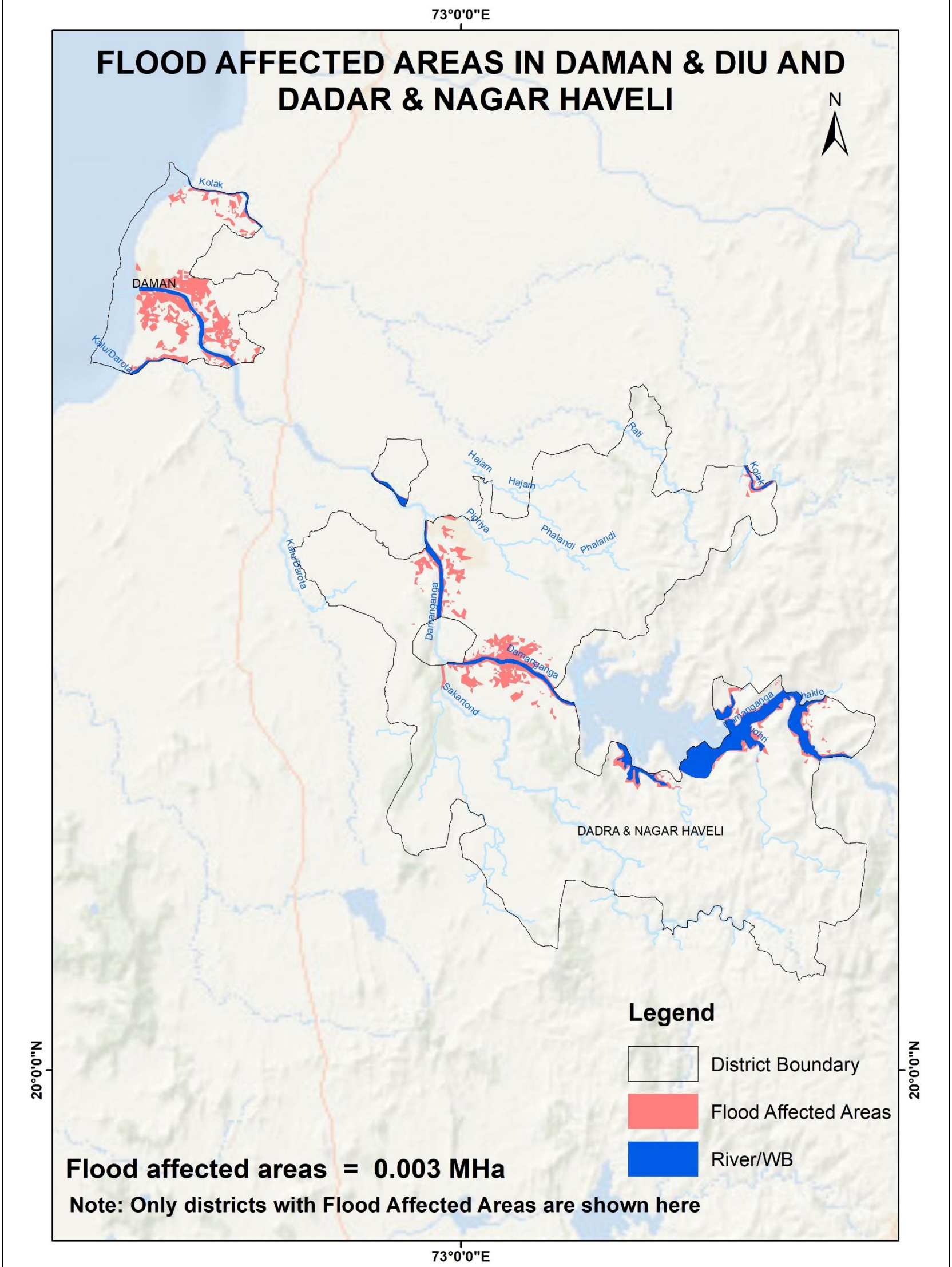
Flood Affected Areas in West Bengal

Sl. No.	Name of the District	Flood Affected Areas in ha
1	ALIPURDUAR	25,303.29
2	BANKURA	29,887.82
3	BIRBHUM	43,022.40
4	COOCH BEHAR	98,493.21
5	DAKSHIN DINAJPUR	49,776.04
6	DARJEELING	7,192.96
7	HOOGHLY	32,772.63
8	HOWRAH	51,047.27
9	JALPAIGURI	48,111.33
10	JHARGRAM	14,470.17
11	KALIMPONG	1,536.83
12	KOLKATA	15,821.65
13	MALDA	1,29,936.70
14	MURSHIDABAD	1,51,680.86
15	NADIA	56,253.47
16	NORTH 24 PARGANAS	1,49,468.03
17	PASCHIM BARDHAMAN	18,976.02
18	PASCHIM MEDINIPUR	63,021.94
19	PURBA BARDHAMAN	59,262.90
20	PURBA MEDINIPUR	1,64,724.76
21	PURULIA	29,308.18
22	SOUTH 24 PARGANAS	5,14,703.90
23	UTTAR DINAJPUR	84,781.82
	Total	**18,39,554.21**


FLOOD AFFECTED AREAS IN ANDAMAN & NICOBAR ISLANDS
92°0'0"E
93°0'0"E
14°0'0"N
13°0'0"N
12°0'0"N
11°0'0"N
N
Flood Affected Areas = 0.02 Mha
Only districts with flood affected areas are shown here
Legend
District Boundary
Flood Affected Areas
River/WB
0 10 20 40 60 80
Km
Esri, Garmin, GEBCO, NOAA NGDC, and other contributors

Flood Affected Areas in Andaman & Nicobar Islands

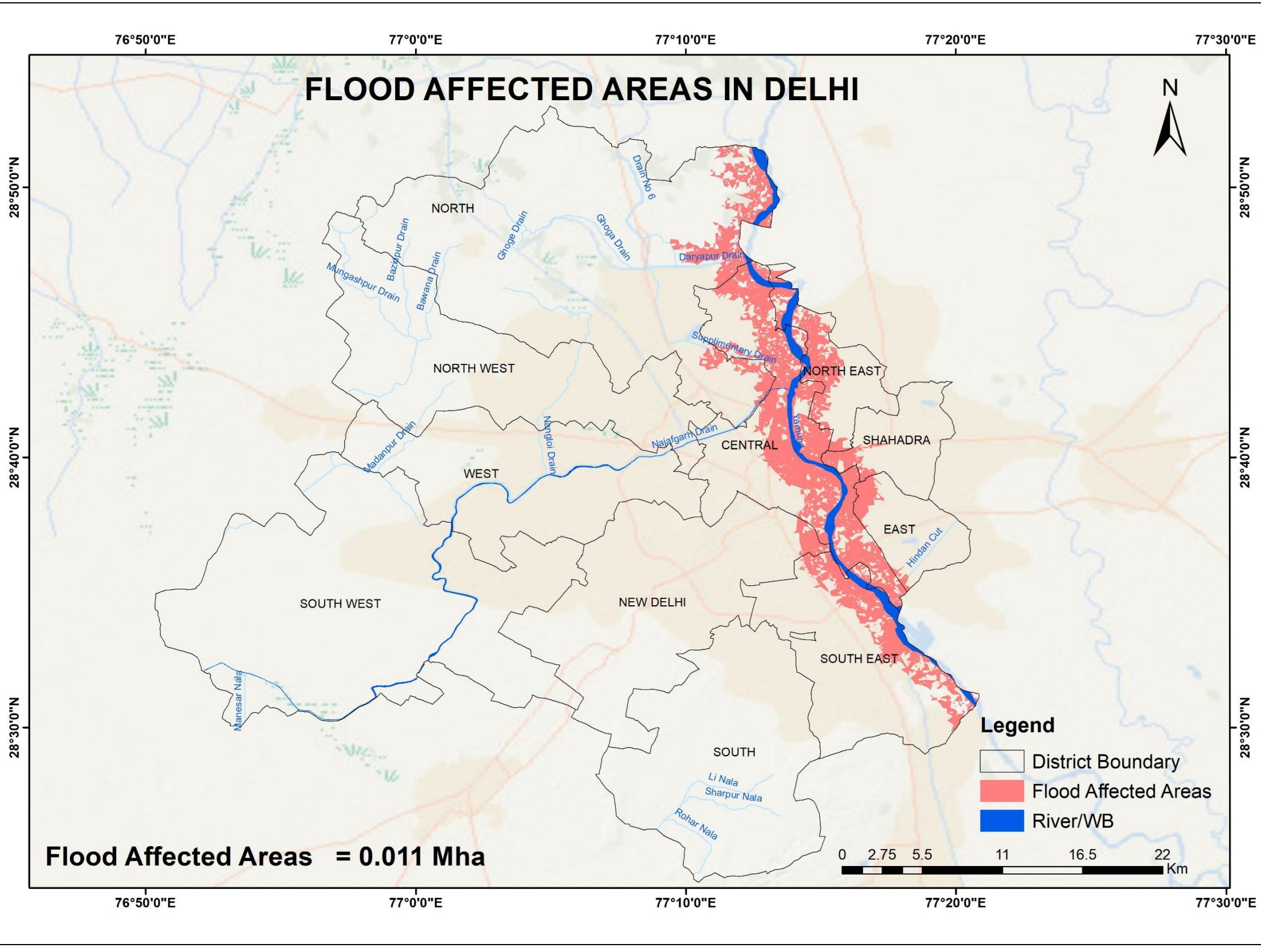
Sl. No.	Name of the District	Flood Affected Areas in ha
1	NICOBAR	0.00
2	NORTH & MIDDLE ANDAMAN	16,306.93
3	SOUTH ANDAMAN	2,957.70
	Total	**19,264.63**


73°0'0"E
FLOOD AFFECTED AREAS IN DAMAN & DIU AND DADAR & NAGAR HAVELI
N
Kolak
DAMAN
Kalu/Darota
Rati
Hajam
Hajam
Kolak
Pipriya
Phalandi
Phalandi
Kalu/Darota
Damanganga
Damanganga
Sakartond
Damanganga
Vohni
DADRA & NAGAR HAVELI
20°0'0"N
20°0'0"N
Legend
District Boundary
Flood Affected Areas
River/WB
Flood affected areas = 0.003 MHa
Note: Only districts with Flood Affected Areas are shown here
73°0'0"E

Flood Affected Areas in Daman, Diu and Dadar & Nagar Haveli

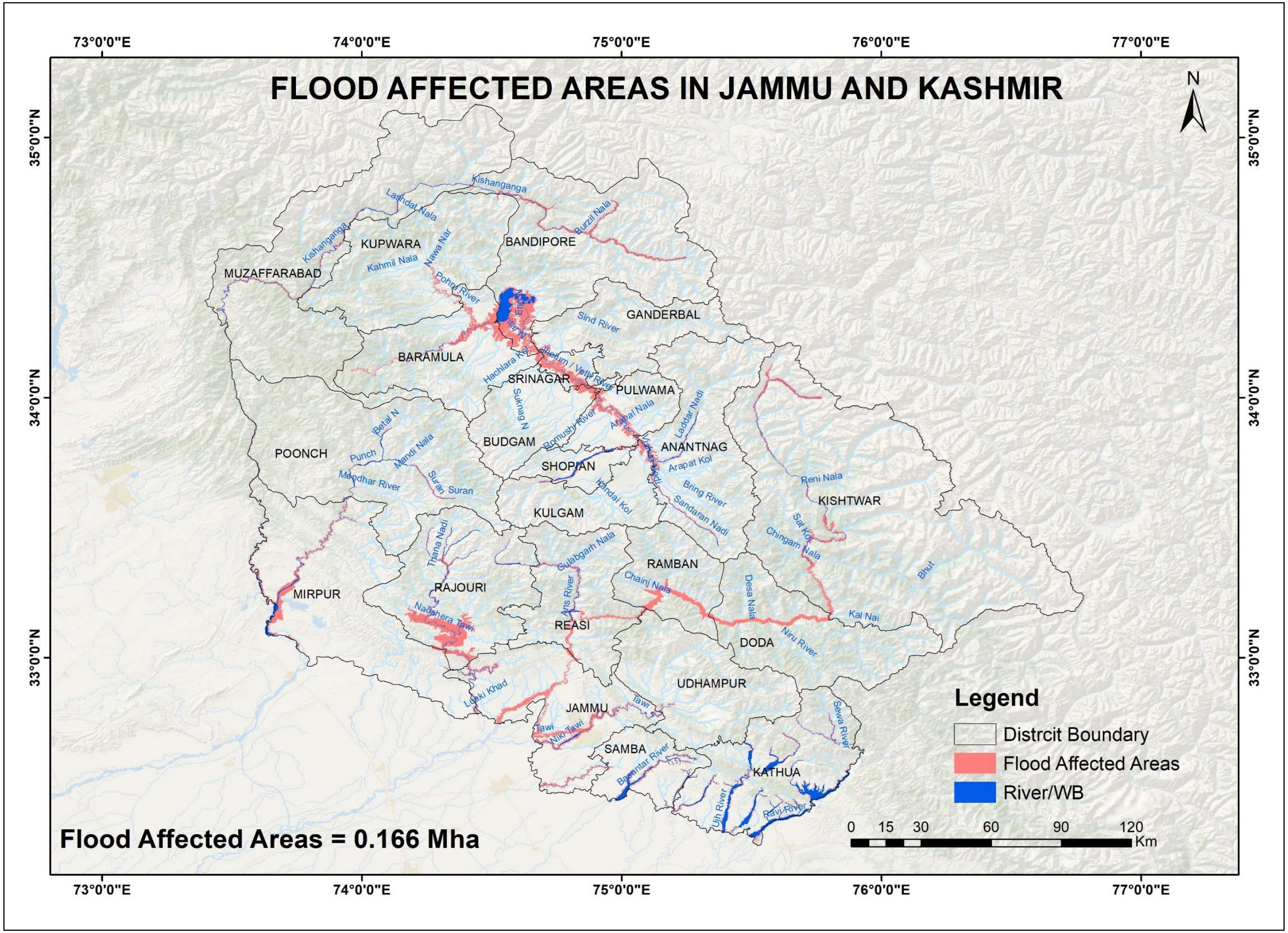
Sl. No.	Name of the District	Flood Affected Areas in ha
1	DAMAN	1,193.60
2	DIU	0.00
3	DADRA & NAGAR HAVELI	1,348.84
	Total	**2,542.45**

FLOOD AFFECTED AREAS IN DELHI



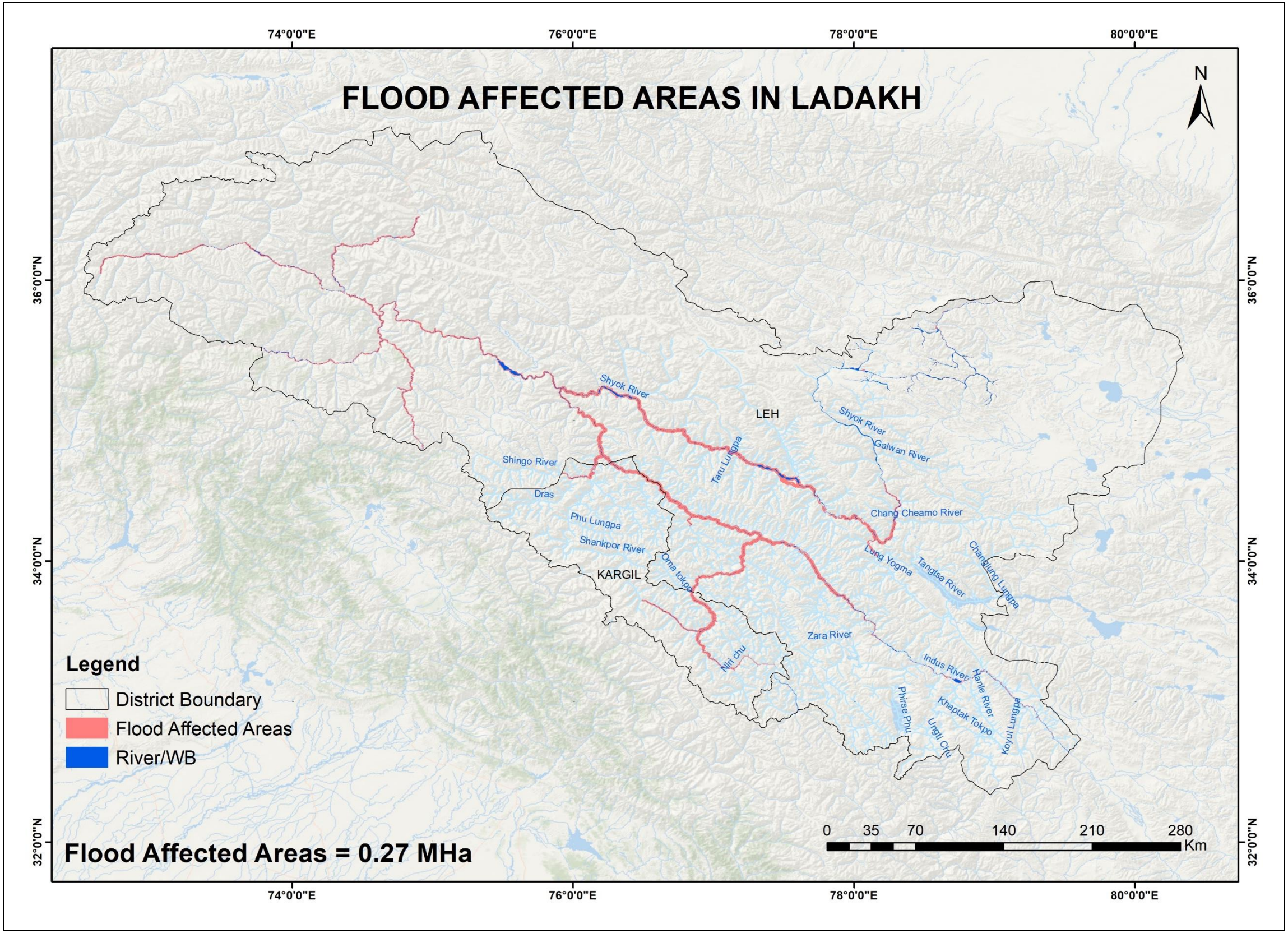
Flood Affected Areas in Delhi

Sl. No.	Name of the District	Flood Affected Areas in ha
1	CENTRAL DELHI	4,762.40
2	EAST DELHI	349.70
3	NEW DELHI	250.72
4	NORTH DELHI	1,777.74
5	NORTH EAST DELHI	1,171.92
6	NORTH WEST DELHI	0.00
7	SHAHADRA	319.12
8	SOUTH DELHI	0.00
9	SOUTH EAST DELHI	1,711.13
10	SOUTH WEST DELHI	0.00
11	WEST DELHI	0.00
	Total	**10,342.73**


FLOOD AFFECTED AREAS IN JAMMU AND KASHMIR
N
73°0'0"E
74°0'0"E
75°0'0"E
76°0'0"E
77°0'0"E
35°0'0"N
34°0'0"N
33°0'0"N
KUPWARA
BANDIPORE
MUZAFFARABAD
BARAMULA
GANDERBAL
SRINAGAR
PULWAMA
BUDGAM
POONCH
ANANTNAG
SHOPIAN
KULGAM
KISHTWAR
RAMBAN
RAJOURI
MIRPUR
REASI
DODA
UDHAMPUR
JAMMU
SAMBA
KATHUA
Kishanganga
Lashdat Nala
Kahmil Nala
Nawa Nar
Pohru River
Sind River
Hachlara Kol
Sukhnag N
Romushi River
Arapal Nala
Laddar Nadi
Betal N
Punch
Mandi Nala
Mendhar River
Suran Suran
Arapat Kol
Bring River
Sandaran Nadi
Kandal Kol
Reni Nala
Sar Kol
Chingam Nala
Bhut
Thana Nadi
Gulabgarh Nala
Chainj Nala
Desa Nala
Kal Nai
Niru River
Nadshera Tawi
Ans River
Lukki Khad
Tawi
Niki Tawi
Sewa River
Basantar River
Ujh River
Ravi River
Burzil Nala
Legend
Distrcit Boundary
Flood Affected Areas
River/WB
0 15 30 60 90 120
Km
Flood Affected Areas = 0.166 Mha

Flood Affected Areas in Jammu & Kashmir

Sl. No.	Name of the District	Flood Affected Areas in ha
1	ANANTNAG	4,000.55
2	BANDIPORE	24,937.97
3	BARAMULLA	11,982.92
4	BUDGAM	2,120.05
5	DODA	6,867.40
6	GANDERBAL	944.79
7	JAMMU	19,095.36
8	KATHUA	8,219.23
9	KISHTWAR	10,980.00
10	KULGAM	2,009.16
11	KUPWARA	2,239.23
12	MIRPUR	11,724.88
13	MUZAFFARABAD	4,624.64
14	POONCH	2,642.52
15	PULWAMA	6,756.38
16	RAJOURI	20,383.73
17	RAMBAN	7,122.52
18	REASI	6,655.73
19	SAMBA	3,495.64
20	SHOPIAN	1,101.57
21	SRINAGAR	7,022.73
22	UDHAMPUR	739.99
	Total	**1,65,667.00**

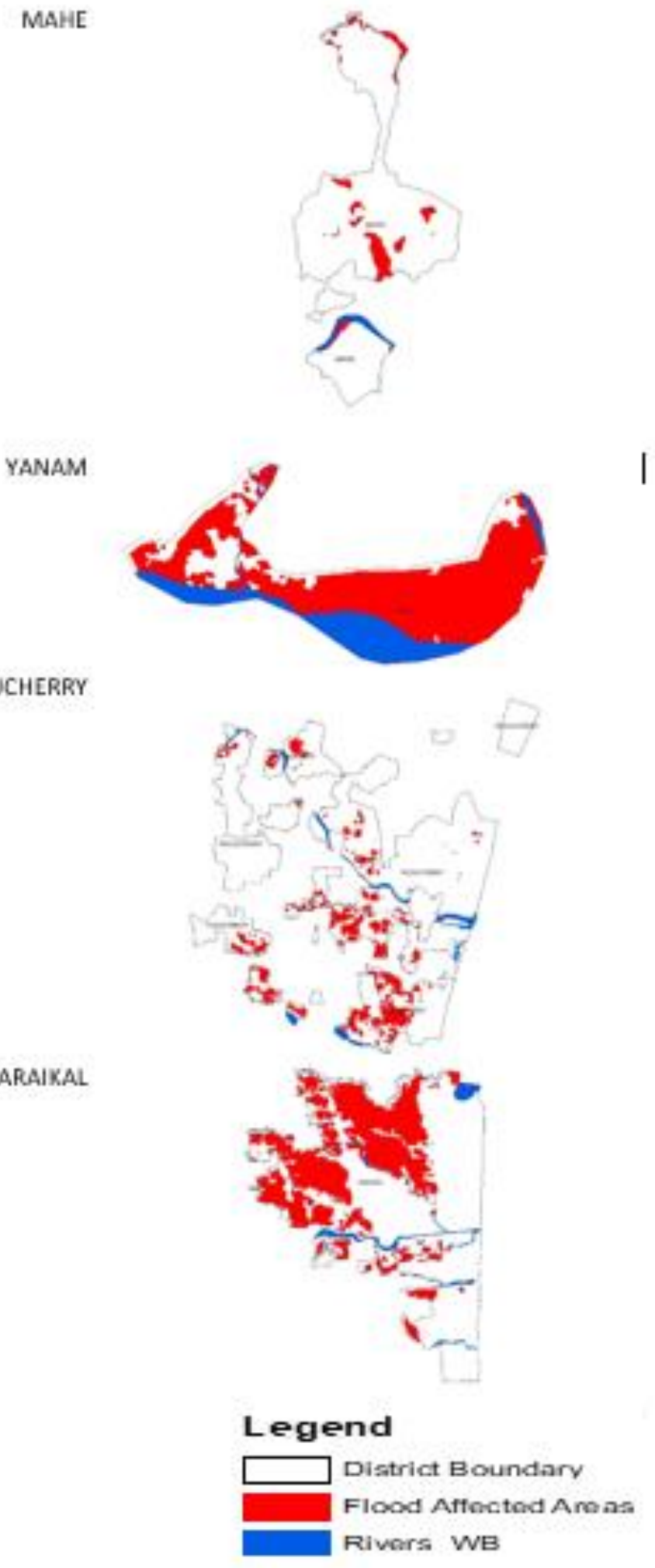

FLOOD AFFECTED AREAS IN LADAKH
N
74°0'0"E
76°0'0"E
78°0'0"E
80°0'0"E
36°0'0"N
34°0'0"N
32°0'0"N
LEH
KARGIL
Shyok River
Shyok River
Galwan River
Shingo River
Dras
Phu Lungpa
Shankpor River
Oma tokpo
Taru Lungpa
Chang Cheamo River
Lung Yogma
Tangtsa River
Changlung Lungpa
Zara River
Niri chu
Indus River
Hanle River
Phirse Phu
Khaplak Tokpo
Ungti Chu
Koyul Lungpa
Legend
District Boundary
Flood Affected Areas
River/WB
0 35 70 140 210 280
Km
Flood Affected Areas = 0.27 MHa

Flood Affected Areas in Ladakh

Sl. No.	Name of the District	Flood Affected Areas in ha
1	LEH	2,32,597.66
2	KARGIL	37,427.12
	Total	**2,70,024.78**

Flood Affected Areas in Puducherry

(*Not to the Scale)



Union Territory Area = 0.048 Mha
Flood Affected Areas = 0.009 Mha

Legend

- District Boundary
- Flood Affected Areas
- Rivers WB

Flood Affected Areas in Puducherry

Sl. No.	Name of the District	Flood Affected Areas in ha
1	KARAIKAL	3,943.46
2	MAHE	60.85
3	PUDUCHERRY	2,303.40
4	YANAM	2,035.09
	Total	**8,342.80**

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CWC publication number: CWC/2024/89